THE WALDEN ECOSYSTEM:

". . . a perennial spring in the midst of pine and oak woods. . . ."[1]

Edmund A. Schofield, Ph.D.

Introduction: Definition, Delineation, and Description of the Walden Ecosystem

The "Walden Ecosystem"[2] is a 2,680-acre (1,000-hectare or ca. 4-square-mile)[3] tract of woodland, wetland, and other habitats lying east of the Sudbury River in the contiguous towns[4] of Lincoln and Concord, Middlesex County, Massachusetts, approximately fifteen miles west northwest of the State House in Boston. Its geographic coordinates are 42°27′ north latitude, 71°20′ west longitude. The Lincoln–Concord town line bisects the ecosystem along a southwest–northeast axis. About 1,500 acres lie in Lincoln, 1,180 acres in Concord. The prevailing elevation of the ecosystem is 45 to 90 meters (about 150 to 300 feet) above mean sea level, with extreme elevations of approximately 35 meters (about 110 feet) on its western edge along the Sudbury River and 105 meters (nearly 350 feet) on the summits of Fairhaven Hill and Pine Hill. Several till-covered hills rise above the general level of the terrain, Fairhaven Hill in Concord and the Pine Hill–Bear Hill[5] complex in Lincoln being the highest of them, and there are a number of wetlands, streams, ponds, and pools within and on the edges of the ecosystem.

With reference to current place names on the United States Geological Survey's map of the Maynard quadrangle (1987),[6] the Walden Ecosystem's approximate boundary can be described as follows[1]:—

---

[1]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), page 175.

[2]The terms "Walden Ecosystem," "Historic Walden Woods," and "Walden Woods" are employed as approximate synonyms in this report, the term used in any instance depending upon the requirements of the immediate context and purpose of discussion. All three of the terms refer to exactly the same geographic area, or "landscape unit," but from different conceptual perspectives. Two similar, related terms, "Walden Northern Pine–Oak Forest" and "Walden Sand Plain Community," are not synonymous with the others because the sand plain (or kame–delta complex) on which the forest community has developed does not encompass the entire ecosystem as defined herein; it forms only one (albeit the larger) part of it.

For all intents and purposes the latter two terms are synonymous with the "Walden Pond Unit" of the Walden Ecosystem (see below). Even within the sand-plain sector, however, there are smaller "islands" of different habitats, or biotic communities: a different type of forest on till-covered hills (*e.g.*, Fairhaven Hill), for example; streams; wetlands and ponds in depressions, etc. These distinct habitat types should still be considered parts of the overall Walden Ecosystem, however, because they are due to interaction among the same set of basic natural elements (surficial geology, hydrology, etc.) that give rise to the other habitats and biotic communities. Thus, the various habitats of the Walden Ecosystems may be thought of as "variations on a common theme."

[3]The areas of the Walden Ecosystem and its subunits were determined from Carl Koteff's map of the surficial geology of the *Concord* Quadrangle (Washington, D. C., 1964) by Mr. Herbert C. Heidt of Mapworks, Inc., Norwell, Massachusetts, on a Macintosh II computer with a Mapgraphics digital planimeter (GIS), which calculates areas to 0.01 acre.

[4]In New England land-survey usage, the word "town" is roughly equivalent to the term "township" as it is used in most other regions of the United States. Thoreau uses both terms in *Walden* and elsewhere, although only occasionally in the case of "township."

[5]The usage "Bear Hill" is taken from Thoreau's *Journal*. It applies to a hill near the southwestern corner of Sandy Pond that usually is called "Ridge Hill," or "Great Ridge Hill" (see, for example, Kerry Glass and Elizabeth A. Little. *Lincoln, County of Middlesex, in His Majesty's Province of Massachusetts Bay in New England, 1775 Anno Domini—in the 15th Year of the Reign of King George the Third* [Map] [Lincoln, Massachusetts, 1975], where it is called "Great Ridge Hill").

[6]Geological Survey. *Maynard, Massachusetts 42071–D3–TM–025*. 7.5 x 15 Minute Series (Topographic). 1:25,000. Reston, Virginia: Geological Survey, 1987.

from the westernmost point of the 45-meter contour line southeast of that section of Sudbury Road lying between the Sudbury River and State Route 2, northeastward along the same contour line, across Route 2 to the Concord–Carlisle High School; thence through the High School complex and grounds to the junction of Thoreau Street with Walden Street; thence northeastward to the western and northern shores of Fairyland Pond and on to the Cambridge Turnpike; thence east southeasterly, parallel to and north of the Cambridge Turnpike, nearly to the latter's junction with Route 2; thence northeastward parallel to but west of the Concord–Lincoln town line to, or nearly to, the southern boundary of Minuteman National Historical Park; thence trending southward and south-southwestward into Lincoln, along and then beyond the western flank of Smith's Hill, southward as far as the northern shore of Sandy Pond; thence southward along the western shore of Sandy Pond to the vicinity of the Pumping Station; thence southward to the junction of Baker Bridge Road with Sandy Pond Road; thence, curving gradually southward and southwestward, to the vicinity of Saint Anne's Church, near the junction of Codman Road with State Route 126; thence southwestward along the stream that flows south of Mount Misery into Farrar's Pond, as far as State Route 117; thence westward along Route 117 to the 36-meter contour line; thence northward about 200 meters (600 to 650 feet) to the eastern shore of the Sudbury River, just south of Fairhaven Bay; thence into Concord, in a generally northerly direction, along the eastern shore of the river, including the smaller wetlands and the river meadows, to the point on the 36-meter contour line at which the western flank of Fairhaven Hill comes nearest to the river; thence approximately along the 36-meter contour line to the vicinity of the first-mentioned point; and connecting finally with that point.

Most of the area delineated bears the green overlay indicating woodland, there being large nonwooded tracts in the vicinity of Baker Bridge, however. The boundary as described delineates the geological features that, in concert with certain other elements of the natural environment (to be identified and discussed below), have given rise to and determined the character of the Walden Ecosystem. Together, these natural elements constitute a discrete, functionally integrated, and self-contained landscape (or physiographic) unit that is easily recognizable because of the distinctive nature of its surficial geology, hydrological regime, and vegetation.

Most of the Walden Ecosystem lies within the Concord River watershed, which in turn is part of the Merrimack River watershed.[2] The rest of the ecosystem (that portion immediately surrounding Sandy Pond) is part of the Charles River watershed. The surface of Sandy Pond (also called "Flint's Pond"), whose western shoreline marks the eastern boundary of Walden Woods, is 70.5 meters (230 feet) above sea level, while the surface of Walden Pond, located near the center of the ecosystem, is at approximately 48.5 meters (160 feet). As noted above, the surface of the Sudbury River is 35 meters (about 110 feet) above sea level. There is thus an east-to-west elevational sequence—Sandy Pond at 70.5 meters elevation, Walden Pond at 48.5 meters, and the Sudbury River at 35 meters—which suggests an east-to-west hydrological gradient. Indeed, hydrological studies[3] have shown nearly all groundwater in the Walden Ecosystem to flow radially outward into surrounding ecosystems, as will be shown.

---

[1]Proceeding clockwise from the northwestern corner of the ecosystem, in Concord, thence into Lincoln, and back into Concord.

[2]Town of Lincoln. *Lincoln's Aquifers* [Map] (No place, no date); Town of Lincoln. *Wetlands Map* [Map] (Lincoln, Massachusetts, 1973); Eugene H. Walker. Walden's way revealed. *Man and Nature* (December 1971), pages 11 to 20; Eugene H. Walker, S. William Wandle, Jr., and William W. Caswell. *Hydrology and Water Resources of the Charles River Basin, Massachusetts*. Hydrologic Investigations Atlas HA-554 (1975); Eugene H. Walker, William W. Caswell, and S. William Wandle, Jr. *Water Resources of the Charles River Basin, Massachusetts*. Hydrologic-Data Report 19 (Boston, 1977).

[3]*E.g.*, Town of Concord. *Depth to Water Table* ([Concord, Massachusetts], no date); Town of Lincoln. *Lincoln's Aquifers* [Map] [Base map prepared by American Air Surveys, Inc., from aerial photo survey of 1 December 1968] (map in the offices of the Lincoln Conservation Commission, Lincoln, Massachusetts).

On the basis of surficial geology,[1] the Walden Ecosystem consists of two units, or components—a larger and geologically fairly homogeneous "Walden Pond Unit," in Concord and Lincoln (the "Walden Sand Plain"), and a related but geologically more diverse "Sandy Pond Unit," which lies entirely within the Town of Lincoln. The Concord portion of the Walden Ecosystem consists solely of the Walden Pond Unit, whereas the Lincoln portion is divided about evenly between the Walden Pond Unit and the Sandy Pond Unit.

The Walden Pond Unit of the ecosystem is essentially synonymous with the "sand plain" of the early geomorphologists[2] and later ecologists.[3] About three quarters of it (1,182 acres) lie in Concord and one quarter (478 acres) in Lincoln. It consists of an ice-contact glaciolacustrine (glacial-lake) feature (a kame delta complex—the "sand plain") plus included till-covered hills (Fairhaven Hill, Mount Misery, Emerson's Cliff, *etc*.), ponds (Walden Pond, Goose Pond, and Little Goose Pond, which are kettle lakes[4]), and wetlands. The sand plain, or kame delta complex, supports Northern Pine–Oak Forest,[5] a fire-mediated subclimax community, in various stages of ecological succession. The wetlands occur in depressions ("included wetlands") and in other low sites ("peripheral wetlands") where the water table and the surface of the ground intersect. Because these wetlands are determined by the same geological (or physiographic) and hydrological factors that govern the sand plain community, they are considered to be parts of the Walden Ecosystem.[6] At present their floras and soils differ from those of the nearby forest, but originally, in early post-glacial times, their soils, or the parent materials within which the soils developed, were the same as those of the areas on which the forest developed. With the passage of time, however, different plant communities developed on the upland and lowland sites, primarily as a result of hydrological differences (depth to water table), giving rise to soils with different characteristics.

The Sandy Pond Unit of the Walden Ecosystem (about 1,025 acres, in Lincoln only) consists of glaciofluvial (glacial-stream, or meltwater) features related to Glacial Lake Sudbury, plus included areas of shallow till over bedrock (Pine Hill and Bear Hill). Most of its soils are very stony to extremely stony, wet, and/or steep-sloped (hence unsuitable or less desirable for most types of agriculture). Some of them are very dry or

---

[1]Carl Koteff. *Surficial Geology of the Concord Quadrangle, Massachusetts*. Map GQ-133 (Washington, D. C., 1964).

[2]*E.g.,* James Walter Goldthwait. The sand plains of glacial Lake Sudbury. *Bulletin Museum of Comparative Zoölogy*, Volume 42, pages 263 to 301 (1905); Warren Upham. Walden, Cochituate, and other lakes enclosed by modified drift. *Proceedings of the Boston Society of Natural History*, Volume 25, pages 228 to 242 (1891).

[3]*E.g.*, Stanley W. Bromley. The original forest types of southern New England. *Ecological Monographs*, Volume 5, Number 1 (January 1935), pages 70 (Figure 1), 77 (Figure 2); George E. Nichols. A working basis for the ecological classification of plant communities. Part II. *Ecology*, Volume 4, Number 2 (April 1923), page 177; Neil Jorgensen. *A Sierra Club Naturalist's Guide to Southern New England* (San Francisco, 1978), pages 192, 238 to 248.

[4]In Robert L. Bates and Julia A. Jackson, editors. *Dictionary of Geological Terms*, Third edition, (Garden City, New York, 1984), a "kettle" is defined (page 281) as

> A depression in glacial drift, esp. in outwash and a kame field, formed by the melting of a detached block of stagnant ice that was buried in the drift. It often contains a lake or swamp; *Thoreau's Walden Pond is an example* [italics supplied].

Walden is thus a "kettle lake"—possibly the best known kettle lake on earth, considering that Bates and Jackson give it as the single example in their *Dictionary of Geological Terms*. A "kame field" is "A group of closely spaced kames, interspersed in places with kettles and eskers, and having a characteristic hummocky topography" (*ibid.*, page 279).

[5]John C. Kricher. *A Field Guide to Eastern Forests [of] North America*. (Boston, 1988), pages 18, 35, 39, 65 to 67, 125, Plate 13; George E. Nichols. A working basis for the ecological classification of plant communities. Part II. *Ecology*, Volume 4, Number 2 (April 1923), page 177; Neil Jorgensen. *A Sierra Club Naturalist's Guide to Southern New England* (San Francisco, 1978), pages 192, 238 to 248.

[6]These wetlands might be termed "dependent," or "contingent," communities if the forests (woodlands) are considered the primary biotic communities of the Walden Ecosystem. Bromley (*Ecological Monographs*, Volume 5, Number 1 [January 1935], page 164) points out that a physiographic unit "might be described as a physiographically determined habitat-complex: it represents a complex of habitats linked together by physiographic development, and therefore [is] to be regarded as a unit in its relation to the physiographic features of the region in which it occurs."

droughty, however, like those of the Walden Pond Unit; others are very wet.[1] The groundwater of this Unit, which appears to originate in Sandy Pond, flows predominantly southwestward onto the Fairhaven Bay stretch of the Sudbury River (defining the "Southern Sector of the Sandy Pond Unit of the Walden Ecosystem") and northwestward into the Concord River watershed via Mill Brook (defining the "Northern Sector of the Sandy Pond Unit of the Walden Ecosystem").

The Walden Pond Unit—*i.e.*, the sand plain, or kame delta complex—is dominated by a hydrological regime centered on or in the vicinity of Walden Pond: groundwater flows radially away from Walden Pond in all directions except eastward and southeastward. In an analogous manner, the Sandy Pond Unit is dominated by streams and groundwater flowing northwestward and southwestward away from Sandy Pond or its vicinity.

These two physical environmental factors, physiography (surficial geology) and hydrology,[2] originally determined and continue to control the character of the Walden Ecosystem.

Approach to Determining the Boundaries of the Walden Ecosystem

Despite marked fluctuations in its borders due to logging and shifting socioeconomic pressures, the Walden Ecosystem (Walden Woods) has retained its ecological integrity and identity virtually from Colonial times. Its principal biotic community is Northern Pine–Oak Forest. Maps dating to the early nineteenth century and possibly earlier, legal records (*e.g.*, deeds and wills), published and unpublished literary references, drawings, photographs, and other documents attest to its permanence as a dominant feature of the landscape.

The boundaries of Walden Woods differ somewhat from map to map, in most cases only slightly, depending upon the decade in which the map was made. A great variety of literary references and legal records contribute to defining the full and proper boundaries of Walden Woods. All of these more traditional ways of defining geographic boundaries can be brought into sharper focus through a study of the unique ecosystem known as Walden Woods. Such a study provides insights into and explanations for those geographic boundaries. The literary, legal, and other records demonstrate that indeed there *has been* an entity known as Walden Woods for the past three centuries or more; the ecosystem approach—in addition to providing a rational, logical, and scientifically based method for precisely delimiting that ecological entity—reveals *how* and *why* that entity has endured in the face of vigorous long-term settlement and widespread agriculture. Even at the height of agriculture in New England a century and a half ago, there was a Walden Woods.

Determining the "full and proper" boundaries of Walden Woods presents some challenges. For example, since nearly all of New England was covered by forest when the European settlers arrived in the early seventeenth century, it would seem, on first examination, to be difficult to distinguish the minuscule remnant we call Walden Woods from the vast, now changed forest of which it used to be a part. In addition, the settlers and those who have followed them have altered the composition and condition of Walden Woods vegetation. The "minuscule remnant" of the original forest may be woodland now as it was then, but it is not the same woodland.

---

[1] W. J. Latimer and M. O. Lanphear. *Soil Survey of Middlesex County, Massachusetts* (Washington, D. C., 1929); W[ork]. P[rojects]. A[dministration]. *Soil Classification*. *Town of Concord* [Map] (Boston, 1939); W[ork]. P[rojects]. A[dministration]. *Soil Classification*. *Town of Lincoln* [Map] (Boston, 1937); Soil Conservation Service, United States Department of Agriculture. *Detailed Soil Map, Town of Lincoln, Middlesex County, Massachusetts* ([Acton, Massachusetts?], no date); R. Work and E. L. Francis. *Soils and Their Interpretations for Various Land Uses: Town of Concord, Middlesex County, Massachusetts* (No place, 1966); Soil Conservation Service, United States Department of Agriculture. *Middlesex County, Massachusetts, Interim Soil Survey Report*. Second edition (Acton, Massachusetts, 1986); Soil Conservation Service, United States Department of Agriculture. *Soils and Their Interpretations for Various Land Uses: Town of Lincoln, Massachusetts* (No place, 1971); and [Soil Conservation Service, United States Department of Agriculture]. [*Soils of Walden Woods and Vicinity, Concord and Lincoln, Massachusetts*] [Map]. (Acton, Massachusetts, no date).

[2] As used herein, "hydrology" means "the hydrology of an area or district" (Robert L. Bates and Julia A. Jackson, editors. *Dictionary of Geological Terms*. Third edition [Garden City, New York, 1984], page 245), as opposed to the broader definition of the term (*viz.*, "The science that deals with global water [both liquid and solid], its properties, circulation, and distribution, on and under the earth's surface and in the atmosphere, from the moment of its precipitation until it is returned to the atmosphere through evapotranspiration or is discharged into the ocean" [*ibid.*]); that is, the term is used here in the narrower, site-specific sense.

The great plant geographer A. W. Küchler distinguishes these changes by establishing several categories of vegetation, based on the extent to which human beings have affected vegetation.[1] Küchler distinguishes "actual," "original," "natural," and "cultural" vegetation from each other. "Actual vegetation" he defines as "that vegetation which actually exists [on a site] at the time of observation, regardless of the character, condition, and stability of its component communities." He distinguishes "original vegetation" from "natural vegetation." The former, he says, exists in a landscape before man significantly affects it, but, "As much of the surface of the earth has been populated for a long time, the original vegetation is often chiefly of historical interest."

"Natural vegetation" is the vegetation that exists in the landscape unaffected by man. "It is," Küchler says, "in balance with the abiotic and biotic forces of its site. The biotic forces include man, as long as his activities do not alter the vegetation basically. As of when such a change is basic can be determined only in an arbitrary way or by agreement."

In some parts of the world (*e.g.*, high-altitude areas and high-latitude areas) the original natural vegetation and the actual natural vegetation coincide, implying that man has played no significant role there.

In a crucial passage, Küchler establishes yet another category, the "potential natural vegetation":

> Usually, man has become very active, destroying natural plant communities, changing them or replacing them with others. Hence we can speak only of the *potential natural vegetation*. This, however, is most important, and in order to obtain it, two assumptions are necessary: (1) that man be removed from the scene, and (2) that the resulting succession of plant communities be telescoped into a single moment in order to exclude the effects of climatic changes. This, then, is the potential natural vegetation of today. In it, man's past activities may remain a factor. It is essentially the same as the climax vegetation. . . .

Frank E. Egler[2] says that a plant community "is a spatial phenomenon, a relative continuity between relative discontinuities (or 'ecotones'), in whatever terms the community is defined. As a spatial phenomenon, the community has borders, edges, or margins." The "most desirable" kind of border, "from the standpoint of a tidy Vegetation science," he continues, "is one that is an abrupt and sudden change in predominant species. . . ." In the case of Walden Woods, "abrupt and sudden change in predominant species" along certain of its borders—and, indeed, within Walden Woods itself—is due to centuries of human intervention and is not a reflection of natural (*i.e.*, nonhuman) influences.

It is tempting, in trying to delineate the full and proper boundaries of Walden Woods, to use abrupt spatial changes in vegetation (from, say, woodland to farmland) as the criterion; but the long history of human—especially European—influence on Walden Woods and the fluctuation of such abrupt changes from decade to decade make this approach less than desirable. What Egler calls "A Site Border," however, serves our present purpose very well. With respect to this type of plant-community border Egler says (page 93):

> There are times when the Vegetation itself forms no obvious and distinct [and, we might add, with respect to Walden Woods, no permanent or stable] borders, but the site itself does. *This site border may be in terms of soil, or rock substratum, of water table, or of some other feature of the environment*. For example, a sterile acid sand may lie sharply demarcated from a heavy limestone-derived soil. In such instances it may be reasonable and just to demarcate the community in terms of the environment. *If the present Vegetation does not show a distinction, it would be reasonably certain that the history of the area had been different, and that the potentialities for such as timber or forage would be different* [emphases added].

Egler defines and discusses[3] another kind of border that applies to Walden Woods, the "Anthropic" border—*i.e.*, a border due to, and reflecting, the uses to which the land has been put by human beings. As

---

[1]A. W. Küchler. *Vegetation Mapping* (New York, 1967), pages 22 to 26.

[2]Frank E. Egler. *The Nature of Vegetation, Its Management and Mismanagement: An Introduction to Vegetation Science*. Limited edition (Norfolk, Connecticut, 1977), page 93.

[3]Frank E. Egler. *The Nature of Vegetation, Its Management and Mismanagement: An Introduction to Vegetation Science*. Limited edition (Norfolk, Connecticut, 1977), page 94.

examples of anthropic borders Egler mentions fence lines, highways, and powerline rights-of-way. "Even in newly settled North America," he points out, "anthropic borders may be the leading key to comprehension of Community Composition, even of old forests more than one hundred years old."

Clearly, differences in the species composition of various parts of Walden Woods reflect anthropic factors, given the three and one-half centuries of European influence on the land and the several millennia of previous Indian influence[1]; similarly, anthropic factors must be included in any attempt to determine the borders of Walden Woods. With respect to Walden Woods, however, it is abundantly clear that the anthropic factors have been strongly influenced, or controlled, by site factors: that is, surficial geology and hydrologic regime have had an overriding influence on the uses to which people have been able to put the land (farming *versus* forestry, for the most part). Thus, while the borders of Walden Woods must be established largely with respect to fluctuating or ephemeral anthropic factors, the anthropic factors in turn must be interpreted strictly in reference to such permanent site factors (which they reflect) as surficial geology, soil properties, and depth to groundwater.

Thus, the mere presence or absence of trees at any one site at any particular time is probably the least reliable criterion for establishing the exact boundaries of Historic Walden Woods. Ecological relationships, which are perennial and for all intents and purposes permanent, and which transcend the caprices of economic trends, are far more useful for that task: surficial geology, hydrological relationships, and certain soil characteristics are stable environmental factors.

Cartographic Evidence

Walden Woods appears as wooded terrain on maps drafted or published over the past two centuries or more[2], although it is named on only one of the maps. It is a perennial and persistent feature of such maps, although its borders fluctuate with the ebb and flow of socioeconomic forces. On no map on which woodland is designated is Walden Woods absent; on the contrary, it is a conspicuous feature of all known maps that depict vegetative cover or the presence or absence of woodland.

In his history of Lincoln,[3] John C. MacLean indicates (map, page 55) that there were woodlots along what is now the Lincoln–Concord town line, between Fairhaven Bay and Walden Pond, in the seventeenth century. He states (page 155) that "the west part of Lincoln—from Walden Pond to the area around Flint's [or Sandy] Pond—contained numerous woodlots of pine, chestnut, and other trees."

Concord was settled in 1635 by persons attracted by the abundance of meadow hay along the rivers, by the rich lowland soils derived from a glacial lake (Glacial Lake Concord), and by its several untilled cornfields, recently abandoned by the sparse Indian population. Added resources were the abundance of virgin pine and hardwood timber: white oak on the flanks of the six or more hills and drumlins, chestnut on the acid gravels of glacial kames and drift, white pine in many stands throughout the town.

Shattuck[4] states (page 9) that the settlers established their farm lots "extending back from the road across the Great Fields and Great Meadows, and in front across the meadows on Mill Brook . . . because it contained land of easy tillage . . .," while (page 15) "The uplands, *which the first planters selected for cultivation*, proved to be of a poor quality. . ." [emphasis added].

Concord was predominantly a farming community based on cattle, hay, and grain for over two hundred years, gradually supplemented by sales of cordwood and market-garden produce to the growing Boston market.

---

[1]In this respect, however, European influence would differ from that of the Indians because, among other things, Indians did not divide the landscape into individual lots; thus, the impact of Indians would have been less diverse on a tract of land like Walden Woods than would that of that of Europeans.

[2]Or, in one case, on a map constructed from historical data two centuries after the fact.

[3]John C. MacLean. *A Rich Harvest: The History, Buildings, and People of Lincoln, Massachusetts* (Lincoln, Massachusetts, 1987), pages 55 and 155.

[4]Lemuel Shattuck. *A History of the Town of Concord; Middlesex County, Massachusetts, from Its Earliest Settlement to 1832; and of the Adjoining Towns, Bedford, Acton, Lincoln, and Carlisle; Containing Notices of County and State History Not Heretofore Published* (Boston and Concord, 1835), pages 9 and 15.

Thus, Concord became a compact village surrounded by scattered farms, with much arable land, pasture, and many woodlots, the last harvested in rotation without destroying woodland habitat.[1]

Ecological Evidence

Walden Woods consists primarily of mixed deciduous–coniferous woodland. It includes also smaller "peripheral" and "included," contingent habitats such as ponds, wetlands, and watercourses. Its configuration and characteristics are determined in the first instance by local and regional hydrological relationships, which are in turn determined primarily by surficial geology. Historic land-use patterns in the Walden Ecosystem have reflected the same controlling environmental influences, especially the hydrological relationships.

By definition, Walden Woods lies east of the Sudbury River (there are similar glacial-lake deposits west of the river). Its soils are acidic, indicating that evergreen trees (*viz*,, pines) played a dominant role in their development. On average, the water table of the Walden Pond Unit of the Walden Ecosystem is deep, lying at least 10 feet below the surface of the ground. The soils are very porous, permeable, rapidly draining (most of them being excessively rapidly draining) and are therefore "droughty"—*i.e.*, they are prone to desiccation during the hottest summer months (July, August). In most directions of the compass, the groundwater of the Walden Pond Unit flows away from Walden Pond in a radial or centrifugal pattern, like the spokes a wheel.

Walden Woods is best described, understood, and treated as a single, self-contained ecosystem. Its origins as an artifact of the retreating continental glacier, outward-flowing groundwater regime, and deep water table all confer unity and ecological coherence on it. Its internal integrity is reflected in the limited, woodland-dependent uses to which the Walden Ecosystem has been put since European settlement. Its distinctiveness is brought out sharply when its land-use history is compared with that of surrounding areas, especially the area to its north, in Concord, where historically land use has shifted abruptly from woodland to farmland. Because the Sudbury and Concord rivers did not provide enough waterpower for industry to develop along their banks, land use in Concord has been influenced almost exclusively by the land's potential for agriculture. Only in recent decades, and especially in the last decade, as the Lincoln–Concord area has become suburbanized to the point of urbanization, has land use in the Walden Woods area tended to become wholly "decoupled" from the land's agricultural potential.

The environmental factor that ultimately controls the character of the Walden Ecosystem is the vertical distance from the surface of the ground to the water table, which is well over ten feet in most parts of the ecosystem (excluding, of course, the ponds, streams, and wetlands and the zones immediately surrounding them). This great depth to groundwater is due, in its turn, to topographic relationships and, especially, to the highly permeable nature of the glaciolacustrine (glacial-lake) and glaciofluvial (glacial-stream) ice-contact deposits (kames, deltas, eskers, etc.) on which the Walden Ecosystem has persisted despite three and one-half centuries of intensive farming in Lincoln and (especially) Concord. The deep water table and highly permeable substrate create growing conditions that are inimical to farming.

By the same token, the deep water table and highly permeable soils of the Walden Sand Plain supported a distinct biotic community—the Northern Pine–Oak Forest—that differed significantly from the surrounding primeval Northern Transition Forest. In short, the environmental factors that have restricted and governed the uses to which the first English settlers and the other Europeans who came after them have been able to put the land in Walden Woods over the past three and one-half centuries are the very same factors that led originally to the development of the Northern Pine–Oak Forest on the sand plain during the millennia between the glacier's retreat and the arrival of the Europeans. Occasional fires, set by lightning or the Indians, maintained the distinctive Northern Pine–Oak Forest community for thousands of years. It was in that pine–oak forest community that Henry Thoreau lived during his two years near the pond, and it was in that forest that he discovered the causes of both primary and secondary ecological succession.

Biotic Communities

The biotic "community" is a key concept in modern ecology. "Everyone recognizes the differences between forests and fields," states Golley,

---

[1]Richard Jefferson Eaton. *A Flora of Concord* (Cambridge, Massachusetts, 1974), pages **00–00**.

and those who depend upon these natural systems, such as hunter–gatherers, foresters or range managers, recognize a variety of types of each. These types are termed communities and they are characterized as the complex of plants, animals, and microorganisms living together at a defined time and place.

Two fundamental problems of community ecology relate to studies of ecological succession. First, ecologists have asked if communities are distinct, real entities in nature or are they mental constructs? . . .

The second problem grows out of the first. If communities are real, how are they related to other natural systems?

Odum distinguishes two kinds of biotic communities, "major communities" and minor communities."[1] Major communities

are those which are of sufficient size and completeness of organization that they are relatively independent; that is, they need only to receive sun energy from the outside and are relatively independent of inputs and outputs from adjacent communities. *Minor communities* are those which are more or less dependent on neighboring aggregations.

This distinction can readily be applied to Walden Woods: the *major community* is the wooded part of the ecosystem (the oak and pine woods—formally designated the "Walden Northern Pine–Oak Forest"), which occurs on the higher and drier terrain, while the *minor communities* (plural) are the ponds, pools, streams, and wetlands that are interspersed within and around the woodland; they are functions, even "accidents," of topography (occurring—in the case of the ponds, pools, and wetlands—in depressions or other low areas, where the water table approaches or intersects the surface of the ground), and *which depend "more or less" upon the encompassing or adjacent woodland for,* e.g.*, their metabolic energy in the form of organic detritus*. In this report, these minor communities might be referred to as "contingent ecosystems" because they derive their existence and identities from the same geomorphological and hydrological factors as the woodland, and obtain nutrients and energy from the woodland itself.

Odum (1983) distinguishes the term "biotic community" from the term "ecosystem" as follows:

. . . [**C**]**ommunity**, in the ecological sense (sometimes designated as "biotic community"), includes all the populations occupying a given area. The community and the nonliving environment function together as an ecological system or **ecosystem**.[2]

A biotic community is the integrated expression or manifestation of a few fundamental controlling environmental factors: of climate (the availability of water over the course of a year, annual temperature regime, etc.); of geology (composition, texture, and *p*H of substrate; etc.); and so on. The distribution of plants and animals is anything but random; on the contrary, it is intimately related to and strongly determined by the physical environment; nor is the overall combination of organisms at a site—plants, animals, microorganisms, *etc.*—random or arbitrary. Certain animals (herbivores) and parasites feed only on certain plants (primary producers), some on only one or a few species of plants, others on many species; certain animals (primary carnivores) and parasites feed only on certain animals (again, some on only one or a few, others on many); and certain other animals (secondary and tertiary carnivores, or tertiary and quaternary herbivores) feed only on certain primary carnivores (yet again, some on only one or a few, others on many).

In this way, "food webs" are established among the plants, animals, and organisms of a biotic community, whose presence in the community was in turn determined by a few overriding environmental factors of climate, geology, hydrology, *etc*. Each stage, or node, of a food web is called a "trophic level," "trophic" being derived from the Greek words *τροφε* ("food") and *τροφειν* ("to feed"). The plants "feed," of course, on sunlight (solar energy), while the "decomposers"—bacteria, fungi, *etc.*—break down the organic matter excreted by or created upon the death of the producers and consumers.

In modern ecosystems science, this transfer of food from trophic level to trophic level is seen to consist of two linked phenomena: the flow of energy into, through, and out of an ecosystem ("energy flow") and the cycling of matter (minerals, water, *etc.*) within an ecosystem ("nutrient cycling"). This conceptual framework guides ecologists in measuring the energy flow and nutrient cycling of ecosystems and thus permits them to un-

[1]Eugene P. Odum. *Fundamentals of Ecology*. Third edition (Philadelphia, London, and Toronto, 1971), page 140.

[2]Eugene P. Odum. *Basic Ecology* (Philadelphia, New York, and elsewhere, 1983), page 4.

derstand how ecosystems function. The framework is derived from the infra-ecosystemic links among the organisms that compose the ecosystem; it also contributes to the realization that an ecosystem, which is composed of both biotic (living) and abiotic (nonliving) components, is a functional unity, not a disparate, random agglomeration of isolated, unconnected, or randomly juxtaposed components. Even in the face of prolonged perturbation by human beings, as in the case of the present Walden Ecosystem, the functional unity is perceivable in the form of the classic indicator species that occur there. Developmental community ecology tells us that were human interference to cease or moderate, a mature Northern Pine–Oak Forest would again occupy the Walden Sand Plain after the lapse of a few decades. If fires could be prevented altogether, the Northern Pine–Oak Forest probably would succeed to the regional climax, Oak–Hickory Forest, or Transition Forest.

Concept of the ecosystem

Bates and Jackson define an ecosystem as

> An ecologic system, composed of organisms and their environment. It is the result of interaction between biological, geochemical, and geophysical systems.[1]

Odum states that

> Any unit (a biosystem) that include all the organisms that function together (the biotic community) in a given area interacting with the physical environment so that a flow of energy leads to clearly defined biotic structures and cycling of materials between living and nonliving parts is an ecological system or **ecosystem**.
>
> The ecosystem is the basic functional unit in ecology, since it includes both organisms and abiotic environment, each influencing the properties of the other and both necessary for the maintenance of life as we have it on earth. . . .[2]

Smith (1970) states, with respect to the emerging science of ecosystem analysis, that

> Conceptually the ecosystem is viewed as a functional unit with recognizable boundaries and an internal homogeneity. Operationally, we first recognize that boundaries are arbitrary and that functional unity may exist like beauty only in the eye of the beholder. We have, therefore, defined the ecosystem as everything that exists and happens within a precisely bounded region. Two sets of criteria are used for the location of the boundary. For many purposes the region must be large enough to contain a full set of ecosystem processes and their interactions; secondly, the boundary should be placed where inputs and outputs across it are most easily measured.
>
> Once an ecosystem is defined by the location of its boundary (perimeter, roof, and floor), the next stage is to identify all its significant components. The air, land, and water can be subdivided into a number of components, and the plants and animals can be broken down to their species or to major species and groups of minor species. By lumping or splitting in various ways, the total number of components in an idealized ecosystem can vary from 5 to 50,000, the only restriction being that they must always add up to the whole ecosystem. . . . Hopefully, the total number of components needed to account for the significant ecosystem processes will not be more than several hundred.
>
> The four major groups of components are the producers, the consumers, the decomposers, and the abiotic environment.[3]

A "natural resource ecosystem" is

> an integrated ecological system, one element of which is a product of direct or indirect use to man. The product may be biological as in the case of forests, ranges, agricultural products, fish, and wildlife; physical as in the case of water, air, and soil; or both. In all cases, the distinguishing facet of a natural resource ecosystem is that man has a direct involvement in the complex set of ecological interactions.

---

[1] Robert L. Bates and Julia A. Jackson, editors. *Dictionary of Geological Terms*. Third edition (Garden City, New York, 1984), page 158.

[2] Eugene P. Odum. *Basic Ecology* (Philadelphia, New York, and elsewhere, 1983), page 13.

[3] Frederick E. Smith. Analysis of ecosystems. Pages 7 to 18 *in:* David E. Reichle, editor. *Analysis of Temperate Forest Ecosystems*. (New York, Heidelberg, and Berlin, 1970), page 7.

Management is defined as the manipulation of the ecosystem by man. Beneficial management involves manipulation to maximize the returns to man, while exploitation is management that results in the reduction of the productivity of the ecosystem to mankind over a period of time. The ecological principles of natural resource ecosystems are generally applicable regardless of the particular natural commodity. So, too, are the tools of management and the basic rules governing their application. The principles of ecosystem management apply equally to wilderness and to the urban environment, but they are most clearly understood today with regard to the wildland resources of forest, range, wildlife, and the like.[1]

Spurr (page 6) traces a major branch of the science of ecology, "synecology," "directly back" to eighteenth and nineteenth century naturalists, citing specifically only Thoreau and his work on the succession of forest trees, and Charles Darwin, both of whom lived worked during the nineteenth century. Synecology, Spurr notes, has developed along two major lines during the twentieth century: (1) along the lines of the American plant-succession school and (2) along the lines of the European plant-sociological school.

Odum[2] states that "Because outdoor ecosystems are complex, hard to delineate, and often difficult to study by traditional means of 'experiment and control,' many ecologists are turning to laboratory and field microecosystems which can have discrete boundaries and can be manipulated and replicated at will." He discusses several "outdoor ecosystems": an open-water pond, a watershed unit, and a meadow or old-field. With respect to the watershed unit, Odum says, among other things, that

it is the whole drainage basin, not just the body of water, that must be considered as the minimum ecosystem unit when it comes to man's interests [italics in original]. The ecosystem unit for practical management must then include for every square meter or acre of water at least 20 times an area of terrestrial watershed. . . . The entire drainage or catchment basin must be considered as the management unit. . . .[3]

The Walden Ecosystem

The Walden Ecosystem is analogous to a watershed unit (catchment, or drainage, basin), except that (1) it is topographically convex (an upland plain), not concave, and (2) water (groundwater) flows radially *outward* from its center (Walden Pond), like spokes from a hub, rather than into its center as does water in the drainage basins of ordinary ponds or streams. Because of its tight links to the local topography and surficial geology, the Walden Ecosystem is nearly as discrete, homogeneous, and easily delineated as is a lake or pond.

Harold F. Hemond, a hydrologist who was affiliated with the Department of Civil Engineering at the Massachusetts Institute of Technology, applied such principles to his study of Thoreau's Bog, or Gowing's Swamp, in Concord. Thoreau's Bog is a classic "floating-mat *Sphagnum* bog" that developed in a kettlehole in bottom deposits of Glacial Lake Concord.[4] Hemond applied most of the principles being used here to delineate, characterize, and understand the Walden Ecosystem: surficial geology, soils, hydrological regime, flora, etc.

Referring to Koteff's map of the surficial geology of the *Concord* quadrangle, Hemond notes that "the wetland basin was formed upon retreat of the ice front by the melting of a large buried ice mass. Revolutionary Ridge, which borders the bog to the southwest, is a kame delta formation deposited at the high stage of Lake Concord." Revolutionary Ridge is thus a Glacial Lake Concord analogue of the Walden Sand Plain, while Thoreau's Bog is a miniature analogue of Walden Pond. The bog lies in a kettlehole in *bottom* deposits of Glacial Lake Concord, however, while Walden Pond lies in a massive kettlehole in *ice-contact* deposits of Glacial Lake Sudbury. Despite these differences, the comparison is apt, especially with respect to characterizing and delineating the two ecosystems.

---

[1]Stephen H. Spurr. The natural resource ecosystem. Pages 3 to 7 *in:* George M. Van Dyne, editor. *The Ecosystem Concept in Natural Resource Management* (New York and London, 1969). Page 3.

[2]Eugene P. Odum. *Fundamentals of Ecology*. Third edition (Philadelphia, London, and Toronto, 1971), page 20.

[3]Eugene P. Odum. *Fundamentals of Ecology*. Third edition (Philadelphia, London, and Toronto, 1971), page 16.

[4]Harold F. Hemond. Biogeochemistry of Thoreau's Bog, Concord, Massachusetts. *Ecological Monographs*, Volume 50, Number 4, pages 507 to 526 (1980).

Hydrologically the ecosystems differ as well, since the groundwater is near or above the surface in the bog ecosystem but very deep in the Walden Ecosystem. Nonetheless, both ecosystems are describable and definable by reference to the same general phenomena or environmental factors, and by means of the same terminology. With respect to *hydrology*, for example, the bog is permanently *wet*, while Walden Woods is permanently *dry*, wetness and dryness being aspects of the same environmental factor. Hydrological relationships, which are modulated by surficial and bedrock geology, determine whether a site will be wet or dry. The wetness or dryness of a site, or habitat, along with other environmental factors, determines which plants and animals will be able to survive on the site.

Hemond notes that the "bog itself is part of a larger wetland complex, the bulk of which may best characterized as red maple swamp." Hence, in the terminology established in the present report, Thoreau's Bog is an *included* ecosystem of the larger Red Maple Swamp ecosystem. Hemond notes, for example (page 524), that

> the adjoining hummocky red maple swamp may contribute in a small but important way to the water balance of the bog, since it [the swamp] provides a catchment area which is physically separated from the upland and the mineral soil groundwater regime. This catchment becomes uncovered, and thus increases water input to the bog, during the driest months of the year. Although difficult to quantify precisely, the contribution of this catchment could effect a significant increase in surface and subsurface runoff, and thus have an impact on bog geochemistry. In turn, the surface runoff, being strongly stage dependent, acts as a regulation mechanism in maintaining mean annual bog stage (and perhaps, as a result, a constant growth rate of *Sphagnum* moss).

The 2,680-acre Walden Ecosystem consists of two linked "units," or subunits, *viz.*: (1) the "Walden Pond Unit" of 1,660 acres and (2) the "Sandy Pond Unit" of 1,020 acres. Except for its till-covered portions (Fairhaven Hill, Emerson's Cliff, Mount Misery, *etc.*), the Walden Pond Unit consists of sands and gravels deposited in Glacial Lake Sudbury along the edge of the receding glacier, the Sandy Pond Unit (except for its till-covered portions—Pine Hill and Bear Hill) of coarse sands and gravels deposited by torrents of glacial meltwater flowing into Glacial Lake Sudbury during the lake's very last stages. The till-covered portions were islands or peninsulas in Glacial Lake Sudbury and therefore were not covered by the sands and gravels carried in the glacial meltwater.[1]

An important link between the two units of the Walden Ecosystem is Pine Hill in Lincoln. While it is best assigned to the *Sandy Pond* Unit on the basis of surficial geology, Pine Hill is the principal source of groundwater for the *Walden Pond* Unit and therefore, on hydrological grounds, might reasonably be considered part of that unit. Both units are internally "integrated," or self-contained, but the Walden Pond Unit is hydrologically more tightly integrated and geologically more uniform than the Sandy Pond Unit. The Sandy Pond Unit might be said to consist of subunits differing in composition but sharing the same geological origins or relationships.

While it is ecologically integrated, the Walden Pond Unit is *not* homogeneous, even in its non-wetland portions. It does exhibit some degree of gradation (though not disjunction) along axes fanning outward (primarily southward) from the receding ice-contact source of glacial meltwater, the gradation being primarily in the particle-size distribution of the sand and gravel deposits (as is typical of deltas and other ice-contact, glacial-lake features), heavier particles of gravel and sand having been deposited closer to the edge of the ice than the lighter particles. This may explain why historically there have been a few enclaves of farming in the southern part of this unit (Baker Farm, *etc.*). Another reason may be that groundwater flowing southward from Walden Pond and southwestward from Sandy Pond and into Fairhaven Bay is forced nearer the surface of the ground by bedrock highs or topographic lows (the Sudbury River Aquifer, one of Lincoln's principal aquifers, lies beneath those farming enclaves).

An ecosystem consists of both (1) abiotic and (2) biotic elements, by definition. The Walden Pond Unit of the Walden Ecosystem thus consists of (1) the Walden Sand Plain (plus the related geological elements of the Sandy Pond Unit) *and* (2) the Northern Pine–Oak Forest. Without the former, the latter would not exist; given the former, the latter *must* be what it is. The sand plain is the *sine qua non* of the latter and completely determines those aspects of its character that are not determined by regional climate. *If* an arid sand plain, *then* a Northern Pine–Oak Forest.

---

[1] Actually, till that was laid down before Glacial Lake Sudbury formed behind the northward-retreating glacier remains, concealed underneath the sands and gravels that were deposited in Glacial Lake Sudbury.

The Sandy Pond Unit of the Walden Ecosystem, while related to the Walden Pond Unit through its common geological origins and hydrological regime, is not a "sand plain," or kame delta complex. (Koteff's map of the surficial geology of the *Concord* quadrangle[1] does, however, place a kame in the northern part of the Sandy Pond Unit.) It is less homogeneous than the Walden Pond Unit in terms of surficial geology, a large proportion of it (Pine Hill and Bear Hill) being till.

Soils of the Walden Ecosystem[2]

Although climate is largely responsible for the nature of the plant cover in a given area, soils and topographic relief are important also. For example, the effectiveness of rainfall may be offset by a very porous soil, or by marked relief that leads to rapid runoff. Ravines or river bottomlands may offer situations that are cooler and damper than all the surrounding region. Steep and rocky hillsides, coarse gravels, rocky outcrops, permanently wet depressions, subsoils exposed by erosion—all may inhibit local development of a vegetation that is widespread in the general vicinity. Plants need four essential services to become established in a particular soil: anchorage, a supply of water, mineral nutrients, and aeration of roots. Species of plants differ in the degree to which they require these "services." From this perspective, a soil has four major components: (1) mineral material derived from the parent rock; (2) organic substances added by plants and animals; (3) water; and (4) soil air. These components vary in amount and proportion from place to place, and the variation may be a significant factor in determining the occurrence of species and vegetation types.

Soils consist of (1) an inorganic, mineral component—the "matrix material," or "parent material"—and (2) an organic component consisting of still-living, dead, and partially decomposed organisms (plants, animals, and microorganisms). Under the influence of such climatic factors as temperature and precipitation and such local and site-specific factors as drainage and topography, soils develop on newly exposed matrix material, whether it be lava, water-laid sediments, or, as in the case of Walden Woods, glacial deposits.

Soil, the *Dictionary of Geological Terms* declares, is merely "The natural medium for the growth of land plants."[3] The Soil Conservation Service of the United States Department of Agriculture defines soil more expansively, as "A natural, three-dimensional body at the earth's surface . . . capable of supporting plants and [having] properties resulting from the integrated effect of climate and living matter [*i.e.*, organisms] acting on earthy parent material, as conditioned by relief [topography] over periods of time."[4] From an ecological point-of-view the second is the more meaningful and sophisticated definition, but it appears to contradict the cause-and-effect relationship between soils and plants described by Griscom. In fact, however, it does not, for soils and plants ("vegetation") have *reciprocal* cause-and-effect relationships, and both are influenced by climate (and topographic relief): soil and vegetation strongly affect, and even control the character of, each other, but local climate and topography modulate the way in which and the degree to which they do so. Topography affects vegetation indirectly by modifying other environmental factors, but it nevertheless has a significant influence upon all plant communities. The greatest differences in vegetation associated with local variations in topography can usually be correlated with moisture, either in respect to an excess or to a deficiency.[5]

Soil scientists distinguish two kinds of soils, *zonal soils* and *intrazonal*, or *azonal*, *soils*. Zonal soils occur over wide, more or less continuous areas of the so-called "general upland," while intrazonal, or zonal, soils occur on special or unusual sites—so-called "abnormal" areas. Climate, which varies with latitude and

---

[1]Carl Koteff. *Surficial Geology of the Concord Quadrangle, Massachusetts* (Washington, D. C., 1964), plate.

[2]This discussion of soils and their interaction with vegetation derives primarily from Frank E. Egler. *The Nature of Vegetation, Its Management and Mismanagement: An Introduction to Vegetation Science*. Limited edition (Norfolk, Connecticut, 1977); Henry J. Oosting. *The Study of Plant Communities*. Second edition (San Francisco and London, 1956); Wilfred T. Neill. *The Geography of Life* (New York and London, 1969);

[3]Robert L. Bates and Julia A. Jackson, editors. *Dictionary of Geological Terms*. Third edition (Garden City, New York, 1984), page 275.

[4]Soil Conservation Service, United States Department of Agriculture. *Middlesex County, Massachusetts, Interim Soil Survey Report*. Second edition (Acton, Massachusetts, 1986), page 148.

[5]Henry J. Oosting. *The Study of Plant Communities*. Second edition (San Francisco and London, 1956), pages 204 and 205.

longitude, includes the important factors in soil formation, especially temperature and rainfall. Within a climatic area, differences in parent material and topographic position often are reflected in soil variations, which may be chemical or physical. Such variations are most pronounced where parent rock is newly exposed or where soil materials have weathered but slightly, as below a receding glacier. After longer exposure the developing soils become much more alike, and the longer the time involved, the less noticeable will be differences related to local conditions. Evidence is sufficient to indicate that, within a climatic area, soil development progresses toward a a particular kind of soil and profile regardless of the origin or nature of the materials; likewise, that the ultimate soil group for similar climatic regions of the world will be similar to each other.

Since climatic conditions determine the activities and kinds of organisms of a region, it is not surprising that vegetation types and soil types are closely related. The development of a soil is paralleled by vegetational changes, the vegetation contributing to soil maturation an the soil controlling a progression of plant communities. Ultimately, the majority of the soils in a region and the communities they support attain a state of equilibrium with each other under the existing climate. The soils will then have similar mature profiles and the vegetation will be in climax condition. Likewise, the general area in which mature soil profiles are similar will coincide with the general range of a climax vegetation type.

Egler notes that there are striking correlations between the major physiognomic Vegetation regions [of North America] and the zonal soil groups."[1] In the humid, eastern half of North America there is a broad area of *gray–brown podzolic soils* that is correlated with the eastern deciduous forest. The Walden Ecosystem lies in the area of gray-brown podzolic (forest) soil.

Podzolization occurs typically in humid, cold temperate regions where rainfall exceeds evaporation and where vegetation produces acid humus. The acid decomposition products from the litter increase the solvent power of the plentiful percolating water so that soluble materials and colloids are almost completely removed from the surface soil, which is therefore, of single-grain structure at maturity. Although podzolization occurs under hardwood and pine forests, its strongest development takes place where spruce, fir, or hemlock are dominant. The process is partly the product of the vegetation, for the content of bases in the needles of these trees is notably low, and decomposition products of the litter they produce always give an acid reaction. Podzolization occurs in cool, moist temperate regions; it is typical of infertile acid soils with an upper gray silica layer and a lower layer rich in aluminum and iron.[2]

Laterization is characteristic of tropical conditions with high temperatures and abundant rainfall. It is essentially the leaching of silica from the surface soil. The low acidity produced by decomposition of tropical litter promotes the solution of silica as well as of alkaline materials. After laterization, the surface soil is high in iron and aluminum, which are not removed by the process. True laterites are red throughout. Laterization occurs in warm, moist regions, where the silica in the parent material is lost from the surface layers by leaching, and where the iron and aluminum accumulate above.[3] There are many American classifications of soils. One of the most commonly used is a binomial system that reflects both genetic and textural characteristics. For example, "Hinckley" is a *soil series*, including soils alike in parent material, climate, and horizon sequence. "Silt loam" is a *textural class*, indicating the textural nature of the upper soil horizons. "Hinckley silt loam" is a *soil type*.

There are close parallels between the concepts soil scientists have devised for describing and understanding soil development and those for the development of ecological communities. Soil scientists speak in terms of "mature" soils at steady state, for example, while ecologists recognize the "climax" communities that grow on and live in these same soils. (A climax community, the final stage in ecological succession, is stable, self-re-

[1] Egler, Frank E. *The Nature of Vegetation, Its Management and Mismanagement: An Introduction to Vegetation Science*. Limited edition (Norfolk, Connecticut, 1977), page 275.

[2] Podzols are a "group of zonal soils having an organic mat and a very thin organic–mineral layer overlying a gray, leached A2 horizon and a dark brown, illuvial B horizon enriched in iron oxide, alumina, and organic matter." They develop "under coniferous or mixed forests or under heath, in a cool to temperate moist climate."

[3] Latosols are a "great group of zonal soils characterized by deep weathering and abundant hydrous-oxide material. They are developed under forested humid tropical conditions." A laterite is a "highly weathered red subsoil or material rich in secondary oxides of iron, aluminum, or both, nearly devoid of bases and primary silicates, and commonly with quartz and kaolinate. It develops in a tropical or forested warm to temperate climate, and is a residual product of weathering."

placing, and in dynamic equilibrium with its environment.) These two components of the ecosystem—soils and vegetation—are intricately interrelated and interdependent; each strongly influences the other. *Except in forests and rain forests (in which there is a north–south, temperature-dependent gradation from podzols to lateritic forest soils), there is usually a one-to-one correspondence between types of vegetation and soils.*

Through the process of ecological succession a mature biotic community develops on a site in response to regional climatic and local geological factors. The community continues to occupy the site until some natural or manmade force (*e.g.*, fire, lumbering) intervenes. Similarly, the soil of a particular site develops in response to the plants that grow in it for centuries or millennia. Thus, the soil reflects its original natural vegetative cover, even after the vegetation has been removed, and it continues to do so for many decades or centuries. (Only the most severe catastrophe could obliterate altogether the vegetation's impact on the soil.) For this reason, perennial ecological factors and relationships, not the chance presence or absence of trees at the time a particular survey, map, or photograph was made, must be used to arrive at a full and accurate delineation of Walden Woods.

Even when ditched and drained, for example, a wetland soil is identifiable as a wetland soil. The thick layer of partially decomposed organic matter laid down over millennia in the wetland imparts certain diagnostic characteristics to the wetland's soil and remains after it has been exposed to the air, oxidizing gradually. By the same token, a soil developed in an arid site is recognizable as such long after it has been artificially flooded. It takes decades for a layer of organic matter to accumulate in the new wetland, just as it will take decades for that in the natural wetland to disappear through oxidation; even then a soil scientist probably could distinguish the developing soil from a natural wetland soil.

The same principle applies to farmed woodland soils: even after decades of farming, a woodland soil is identifiable as a woodland soil. Furthermore, one can even make reasonable inferences about the types of trees—deciduous *versus* evergreen, for example, or a mixture of both—that grew in a woodland soil before it was cleared for farming. Only after decades or centuries under the new environmental conditions do the original "telltale imprints" fade from a soil as the new conditions impose a different profile upon it. The soil profile is as much a record of a site's ecological or land-use history as are the written records that human beings habitually store in libraries and courthouses. One needs only to understand the "language" in which that record was set down—the meaning, for example, of a thick layer of partially decomposed organic matter, as in a wetland, of salinity, or of high acidity, as in other types of soils. Three and one-half centuries of use by Europeans have scarcely smudged the "ink" in which most such records were "written" on the earth's surface by vegetation and climatic factors.

The surficial geology of Concord indicates that there two separate major ice advances over the area.[1] As the Pleistocene glacier retreated from the Concord area about 14,000 years ago, it deposited some of the great load of material it had scraped from the land during its advance, laying down an unsorted mixture of mineral rubble, ranging in size from clay to boulders, known as "till."[2] In the vicinity of Walden Woods till is confined mainly to the uplands, where it covers the hills of the preglacial terrain.[3] The glacier deposited another kind of glacial drift in Concord, "glaciofluvial" (*i.e.*, glacial-river) and "glaciolacustrine" (*i.e.*, glacial-lake) deposits graded by flowing and pooling meltwater from the ice. Every summer, streams of water ran over the land and were ponded, sometimes in lakes covering many miles, against the ice front and the surrounding hills, and overflowed through spillways. The streams carried the mixed materials of till but dropped them in a more graded fashion than did the ice itself. These glacial deposits may be broadly sorted into two categories, outwash plains and bottom deposits. Outwash plains consist of gravels and coarse sands, while lower-lying lake-bottom deposits consist of fine sand and silt, and even a little clay (very little in the Concord area). Over ecological and geological spans of time (measured, respectively, in millennia and eons) these factors create conditions that favor certain species of organisms over others (this is so directly in the case of plants, indirectly in the case of

---

[1]Carl Koteff. *Surficial Geology of the Concord Quadrangle, Massachusetts*. Map GQ-133 (Washington, D. C., 1964).

[2]"Till" is defined as "Unstratified drift, deposited directly by a glacier without reworking by meltwater, and consisting of a mixture of clay, silt, sand, gravel, and boulders ranging widely in size and shape" (Robert L. Bates and Julia A. Jackson, editors. *Dictionary of Geological Terms*. Third edition [Garden City, New York, 1984], page 526). "Drift," a term generally applied to Pleistocene deposits in large regions that no longer contain glaciers, is defined as ". . . all rock material transported by glaciers and deposited directly from the ice or through the agency of meltwater" (*ibid.*, page 150).

[3]Carl Koteff. *Surficial Geology of the Concord Quadrangle, Massachusetts*. Map GQ-133 (Washington, D. C., 1964), page 1.

animals) and that limit the uses to which human beings are able to put the land. Even after generations of use by human beings the soil of a site—if it has not been physically disrupted by, say, massive earth-moving operations—retains the telltale imprint of the natural conditions under which the soil developed after the glacier retreated.

In the millennia that followed the glacier's retreat, first tundra plants and then forests reclothed the newly exposed landscape. The forest had returned within two thousand years of the ice's retreat, and have covered most of New England in one form or another ever since. They underwent a series of changes as a result of climatic shifts, the immigration of species, natural catastrophes, and (especially since the arrival of Europeans three hundred and fifty years ago) human impact. Beneath the forests, the processes of soil formation ("pedogenesis") created podzols, characteristic northern forest soils.[1]

This forest and the climate that supports it have worked together to produce a certain type of soil from the underlying material. These soils are classified as *spodosols*. Spodosols are formed by a combination of coarse, acidic parent materials, a moist, cool climate, and forest vegetation. They have very little stored fertility. They may support magnificent forests, but the system cycles nutrients slowly and stores little surplus. Thus, spodosols are quickly exhausted when put into crops unless they are very skillfully maintained (actually transformed) by soil-building practices.

The till in the Walden Woods area probably averages 15 feet thick, less in areas of abundant bedrock outcrops, although locally there are accumulations of till as much as 30 feet thick.[2] Kame deltas were built in contact with ice on one or more sides; many are connected with eskers or ice-channel fillings that acted as "feeders" to the kame deltas.[3] The esker in the Laurel Glen section of Walden Woods is an excellent example of such an esker.

In a highly formalized system of nomenclature, names denoting what are called soil "types," have been assigned to soils. Each type of soil has a unique combination of salient, distinguishing, and edaphically significant characteristics. These characteristics are not selected arbitrarily by soils scientists, but according to the information they provide about a soil's origins, environmental relationships, and—significantly in the present context—potential uses. A name efficiently conveys large blocks of information about the soil or soils of any one particular site. Thus, *p*H, chemical composition, amount of organic matter, color, water-holding capacity, cation exchange capacity, and other measurable or describable characteristics are employed to define a soil type; conversely, as a corollary, one immediately knows a good deal about a sample of soil to which one of the formal names has been applied: its approximate *p*H, for example, its organic-matter content, and its color. One also can make reasonable predictions about its uses by human beings: whether it is suitable for agriculture and, if it is, for what specific kinds of agriculture.

There is a certain amount of tautological reasoning in soil science. Soil science has been supported over most of the past century or two largely to serve agriculture. In recent decades engineering considerations have been taken increasingly into account. Hence, some (but not all) of the characteristics that routinely are used to characterize and distinguish among soil types are selected because of their relation to agriculture or engineering. Many of the characteristics have ecological significance in their own rights, however; that is to say, they have as much significance for the ecologist as they do for the agriculturist or building contractor. With respect to agriculture this may amount to a distinction without a difference, since agriculture deals principally with plants, and plants are arguably the most important components of ecosystems. Thus, it is neither surprising nor inappropriate that ecologically significant factors should have value as well for agriculture, nor that agriculturally significant factors should be of use or interest to ecological science.

---

[1]Brian Donahue. The forests and fields of Concord: An ecological history, 1750–1850. Pages 14 to 63 *in:* David Hackett Fischer, editor. *Concord: The Social History of a New England Town 1750–1850* (Waltham, Massachusetts, 1983), pages 15 to 20.

[2]Carl Koteff. *Surficial Geology of the Concord Quadrangle, Massachusetts*. Map GQ-133 (Washington, D. C., 1964), text page 1.

[3]Carl Koteff. *Surficial Geology of the Concord Quadrangle, Massachusetts*. Map GQ-133 (Washington, D. C., 1964), text page 2.

The soil map of the Walden Woods area[1] can be simplified somewhat, or generalized, as a means of interpreting and understanding the land-use history of the Walden Ecosystem. Generalization of this kind is an accepted procedure for interpreting the soils and constructing soil maps of an area.

There are two types of generalization, "cartographic generalization" and "categorical generalization." "Cartographic generalization" is

> the practice of omitting lines between soil bodies as shown on detailed soil maps to reduce the detail on the map—or between different taxonomic units if taxa of levels higher than the soil series are used to define and describe the basic map units. That is, it results in a lowering of the number of soil delineations. . . ,

whereas "categorical generalization" is

> the identification and description of soil map units in terms of taxa[2] at levels of abstraction higher than the soil series. That is, it involves use of taxonomic units from the family through the order levels to designate the mapping unit name and thus reduce the classification or taxonomic detail.[3]

Spodosols, occurring both on till and outwash, make up at least three-fourths of the soils of Concord and the overwhelming preponderance of soils in Walden Woods. The rest of the soils are *histosols*—water-dominated soils that contain varying high accumulations of incompletely decomposed organic matter: peats of the bogs and swamps, which can be nearly pure organic matter, the mucks of the river and brook meadows, which are fine sands and silts laced with a lesser amount of better-decomposed organic matter.

Peats form where accumulations of dead plant material gradually fill up ponds, developing into bogs. Such sites are usually kettleholes, or depressions, in outwash plains or kame delta complexes left by the melting of stranded pieces of ice. Mucks form where drainage is so slow that wetness impedes the full breakdown of organic matter. In their natural state, neither of these soils is very fertile because nutrients are locked in the coarser organic matter. When the swamps and meadows are drained, however, the organic matter oxidizes and decomposes, releasing nutrients, particularly nitrogen, and making these soils potentially the richest to be found in the area.[4]

The Soil Conservation Service describes Concord's soils as follows:

> The many different kinds of soil in Concord occupy the landscape in six natural, recurring groups called "general soil areas," or "soil associations." Each general soil area is named for the dominant or most prevalent kinds of soils which it contains. Less extensive soils are also present. The dominant soils in a general soil area may be similar to one another or have great differences, but generally they will have about the same degree of limitation for a particular use. For example, a general soil area may contain dominant soils that are droughty, have formed in sands or sands and gravel, have rapid permeability, and occur mainly on slopes of less than 15 percent. Each general soil area may contain one or more less extensive secondary soils that may have properties quite different from those of the dominant soils. Normally, the secondary soils occupy about 10 to 30 percent of the general soil area, but sometimes occupy as much as 40 percent.[5]
>
> The many different kinds of soil in a community occupy the landscape in natural recurring groups that are called "soil associations." Because soils occur on the landscape in such groups, it is possible to make a general

---

[1][Soil Conservation Service.] [*Soils of Walden Woods and Vicinity, Concord and Lincoln, Massachusetts*] (Acton, Massachusetts), no date [prepublication map of soil types, available as a blueprint from Soil Conservation Service, Acton, Massachusetts]; Soil Conservation Service. *Soils and Their Interpretations for Various Land Uses: Town of Lincoln, Massachusetts*. No place: Soil Conservation Service, United States Department of Agriculture, 1971. [iii] + [69] pages; R. Work and E. L. Francis. *Soils and Their Interpretations for Various Land Uses: Town of Concord, Middlesex County, Massachusetts*. No place: Soil Conservation Service, United States Department of Agriculture, 1966. iii + 56 pages.

[2]A "taxon" (plural: "taxa") is a unit of classification at any level, or rank. Taxonomy is the naming of taxa.

[3]S. W. Buol, F. D. Hole, and R. J. McCracken. *Soil Genesis and Classification*. (Ames, Iowa, 1973), page 312.

[4]Nyle C. Brady. *The Nature and Properties of Soils*. Eighth edition (New York, 1974), (quoted in Donahue, pages 17 and 18); Soil Survey Staff. *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys*. Agriculture Handbook No. 436 ([Washington, D. C.], 1975), pages .

[5]R. Work and E. L. Francis. *Soils and Their Interpretations for Various Land Uses: Town of Concord, Middlesex County, Massachusetts* (No place, 1966), page 3.

> soil map that delineates broad areas having the same kinds and combinations of soils. These areas are called "general soil areas."
>
> A general soil area is made up of a few dominant soils and several other soils of lesser extent. Each general soil area is named for the dominant or the more prevalent kinds of soils it contains. The soils within a general soil area may be similar to one another, or may have widely differing properties. Commonly, however, the properties of the dominant soils within a general soil area have about the same degree of limitation for a particular use. For example, a general soil may contain two dominant soils that occur primarily on 0 to 8 percent slopes. One of the soils is well drained and has formed in deep sand deposits; the other soil is excessively drained and has formed in deep gravelly deposits. These soils are similar to one another as both of them have a rapidly permeable substratum, and the seasonal high water table is many feet below the surface.
>
> Each general soil area may contain secondary, less extensive soils that constitute 10 to 30 percent of the area. These secondary soils may have properties and limitations either alike or greatly different from the dominant soils in the general soil area. It is the dominant soils that determine the overall suitability of the general soil area for a particular use, even though there are tracts of land containing secondary soils that have a completely different suitability for that use.[1]

The Windsor–Hinckley–Deerfield Association occupies about half of Concord. The landscape consists of nearly level plains bordered by short, steep escarpments and irregular, knobby, sandy, and gravelly hillocks. About 45 percent of the general soil area is droughty Windsor, 25 percent is droughty Hinckley, and 15 percent is moderately well drained Deerfield soils. Small scattered areas of muck soils, glacial till soils, and poorly drained sandy soils make up the remainder.

Droughty Windsor soils are in deep sand deposits. More than 60 percent of the Windsor soils occur on level or gently sloping tracts. Hinckley soils are also droughty and have formed in deep deposits of sands and gravel. They occupy most of the irregular land, and more than 50 percent of the Hinckley soils occur on slopes steeper than 15 percent. Deerfield soils are moderately well drained and have formed in sands and gravel. They occupy lower-lying, nearly level tracts. Because of their low topographic position, they are affected by a fluctuating water table, which rises to within 1.5 to 2 feet of the surface for four or five months, generally during the winter and early spring. In places in or near Concord Center, bedrock occurs about 5 feet below the surface of Deerfield soils.

Most of this general soil area has slight limitations for agricultural use, although supplemental irrigation is needed during most growing seasons to insure satisfactory crop yields.

Hinckley soils are droughty soils formed on deep deposits of sand and gravel. They are very sandy and gravelly and commonly contain layers of gravel within 1.5 feet of the surface. Hinckley soils are loose and porous to depths of many feet, and water moves through them rapidly. They have a very low moisture-holding capacity. The water table is generally more than 10 feet below the surface. Hinckley soils are stone-free but often contain cobbles.

Windsor soils are droughty soils formed in deep deposits of sand. They have a loamy-sand surface soil and subsoil which is underlain by sands. Windsor soils contain no stones or boulders, and have only a small amount of gravel within 3 or 4 feet of the surface. They are rapidly permeable. The water table in the Windsor soils is generally more than 10 feet below the surface.

Merrimac soils are well drained to somewhat droughty soils formed in sandy material underlain by layers of sand and gravel at a depth of about 2 feet. In places, the surface soil and the subsoil contain some gravel, but they do not contain stones or boulders. These soils are loose and porous, especially in the substratum. Surface soils and subsoils have moderately rapid or rapid permeability, and the underlying sand and gravel layers have rapid permeability. Water tables in these soils are generally more than 10 feet from the surface.

The soils of Concord can be summed up as follows: the mucks and peats of the meadows and swamps make up about 25 percent of the town; the fine, silty soils of the glacial lake bottoms, about 15 percent. These are physically well drained, but because they tend to be so low-lying are often subject to waterlogging from a high water table. Where this problem is controlled, the lake-bottom soils provide the best agricultural soils in Concord. The sandy upland soils occupy some 35 percent of the town, including the fairly droughty Windsor soils and the very droughty, coarse Hinckley soils. Hinckley soils are practically too poor to farm, but the

---

[1]Soil Conservation Service. *Soils and Their Interpretations for Various Land Uses: Town of Lincoln, Massachusetts* (No place, 1971), page [5].

Windsor soils are redeemable and easily worked if organic matter is built up to protect against drought. Finally, 25 percent of the town is the upland glacial till that gives gives New England its unsavory agricultural reputation.

Correlation between Geology and Vegetation

Walden Woods lies along the junction of the Fells Upland and Sudbury Valley geomorphic districts.[1] The base-rock is metamorphic, consisting of successive beds of biotite and granitic gneisses, schists, quartz, and gabbro-diorites, and contains a variety of mostly acid minerals. These beds were folded, base-levelled, and now are projected on the local U. S. geological map as bands of varying widths (1,000 to 5,000 feet) trending southwest to northeast. There are relatively few exposures, and those notably in the Conantum–Fairhaven Hill regions and in the northern part of Concord. Two of the bands, known as the Marlboro Formation and the Salem–Gabbro-diorite, contain enough calcite in paper-thin layers to "sweeten" the soil significantly where it is exposed from Martha's Point to Lee's Bridge and westward to the vicinity of Garfield Road.[2]

The bedrock of the Concord area belongs to the upper Precambrian Marlboro and Nashoba Formations, intruded by diorite and granite plutons of various ages. The Nashoba Formation, which is made up predominantly of interstratified, metamorphosed volcanoclastic and epiclastic materials, ranges from 52,000 to 62,000 feet in thickness in Concord. Its beds dip steeply, 50° to 75° northwest. Bedrock outcrop outcrops resemble glacier boulders and are therefore difficult to identify.[3]

In his book on the birds of Concord, Ludlow Griscom, an ornithologist who was affiliated with Harvard University's Museum of Comparative Zoology, states matter-of-factly (but correctly) that

> The geology and climate [of an area] come first. The underlying rocks and soils condition the flora. The climate also controls the length of the vegetative season, and therefore the composition of the flora.[4]

Professor John C. Kricher, an ecologist who teaches at Wheaton College in Norton, Massachusetts, states that "plants depend upon both climate and soil … for their survival. Unlike animals," he points out,

> a plant cannot escape an unsuitable area by merely running, hopping, or flying away. *Therefore, plant distribution is tightly linked to climate and soil type*, both of which vary considerably across North America. . . .[5]

Kricher points out that geology and soil—the substrate—have a very strong influence on biological communities. The *p*H, texture, and drainage of soils are ecologically important characteristics. "Geological characteristics and soil type vary throughout eastern North America," he notes,

> and combine with climate in affecting forests. . . . For example, some species . . . are common only on soils rich in limestone. Other species . . . prosper only on sandy soils too poor for many other species. A forest may be xeric . . . because it is located in a hot, dry climate or because it sits on sandy, highly drained soils that cannot retain moisture. Though not as important a determinant as climate, soil and geological characteristics cannot be neglected in interpreting forest types.[6]

Thoreau was acutely aware of the correlation between soils and vegetation. For example, in his *Journal* entry for October 17, 1860, he states

---

[1]James W. Skehan, S. J. *Puddingstone, Drumlins, and Ancient Volcanoes: A Geologic Field Guide along Historic Trails of Greater Boston*. Second, revised edition (Dedham, Massachusetts, 1979), page x (Figure 1).

[2]Richard J. Eaton. *A Flora of Concord* (Cambridge, Massachusetts, 1974), pages 1 and 2.

[3]James W. Skehan, S. J. *Puddingstone, Drumlins, and Ancient Volcanoes: A Geologic Field Guide along Historic Trails of Greater Boston*. Second, revised edition (Dedham, Massachusetts, 1979), page 44.

[4]Ludlow Griscom. *The Birds of Concord* (Cambridge, Massachusetts, 1949), page 33.

[5]John C. Kricher. *A Field Guide to Eastern Forests* [*of*] *North America* (Boston, 1988), page 11. See also pages 37 and 38.

[6]John C. Kricher. *A Field Guide to Eastern Forests* [*of*] *North America* (Boston, 1988), pages 38 and 39.

> It is an interesting inquiry what determines which species of these [trees—*viz.*, white pine, pitch pine, oaks, white birch, and red maple] grow on a given tract. It is evident that the soil determines this to some extent, as of the oaks only the swamp white stands in our meadows, and, so far as these seven trees are concerned, swamps will be composed only of red maples, swamp white oaks, white birch, and white pine. By removing to upland we get rid of the swamp white oak and red maples in *masses*, and are reduced to white and pitch pine, oaks, and white birches only, i.e., of those that are abundant and important.

Even as early as 1837, when he was only twenty, Thoreau was well aware of the correlation between plants and soils:

> Every part of nature teaches that the passing away of one life is the making room for another. The oak dies down to the ground, leaving within its rind a rich virgin mould, which will impart a vigorous life to an infant forest —— The pine leaves a sandy and sterile soil—the harder woods a stronger and fruitful mould ——
>
> So this constant abrasion and decay makes the soil of my future growth. As I live now so shall I reap. If I grow pines and birches, my virgin mould will not sustain the oak, but pines and birches, or, perchance, weeds and brambles, will constitute my second growth. ——[1]

Glacial Lake Sudbury

In a long passage in the "Spring" chapter of *Walden* Thoreau describes leaf-like patterns created by the oozing of "sand of every degree of fineness and of various rich colors, commonly mixed with a little clay," from the Deep Cut, a twenty- to forty-foot high bank created a year or two before Thoreau went to live in Walden Woods, when the Fitchburg Railroad was being built. This passage, probably the artistic and philosophical climax of the entire book, owes its existence to the water-laid deposits of Glacial Lake Sudbury.

The hydraulic gradient is the direction in which groundwater flows under the force of gravity.[2] It is determined by the amount of precipitation, the precipitation regime (or seasonality of precipitation), surficial geology, porosity of the substrate or mantle material, and depth to bedrock.

The Walden Ecosystem is unified by virtue of the fact that groundwater flows outward from the System on all sides except the eastern (because of the presence of Pine Hill, off of which groundwater flows in a westerly direction into Walden Pond) and southeastern (where groundwater flowing from Sandy Pond prevails). In most sectors of the Walden Ecosystem the water table lies deep below the surface (10 feet or more) during all seasons of the year, but where steep slopes fall off to watercourses, wetlands, or water bodies it lies nearer or even at or above the surface.

Eugene H. Walker's article, "Walden's Way Revealed,"[3] Anthony Maevsky's report on groundwater levels in Massachusetts from 1936 to 1974[4], and Henry Thoreau's comments in his *Journal* and *Walden*[5] all describe and discuss the hydrological relationships of Walden Pond and the other ponds on the Walden Woods kame delta complex, including the central role of the system's fluctuating water table.

Thoreau's comments in his *Journal* and in *Walden* reflect his awareness of the hydrological unity of the Walden Ecosystem. "I have said that Walden has no visible inlet or outlet," he writes in his *Journal*,

---

[1] Entry for October 24, 1837, in: Henry D. Thoreau. *Journal. Volume 1: 1837–1844.* Edited by E. H. Witherell, W. L. Howarth, R. Sattelmeyer, and T. Blanding (Princeton, New Jersey, 1981), page 5.

[2] In Robert L. Bates and Julia A. Jackson, editors. *Dictionary of Geological Terms*. Third edition (Garden City, New York, 1984), page 243, "hydraulic gradient is defined as "the rate of change of total *head* per unit of distance of flow at a given point and in a given direction."

[3] Eugene H. Walker. Walden's way revealed. *Man and Nature* [Massachusets Audubon Society], December 1971, pages 11 to 20.

[4] Henry D. Thoreau. *Journal* (Boston, 1906), Volume 4, pages 423 to 425 (5 December 1852); *Walden* (Princeton, New Jersey, 1971), pages 180 to 182, 194 and 195, 292.

[5] Anthony Maevsky. *Ground-Water Levels in Massachusetts, 1936–74*. Massachusetts Hydrologic-Data Report 17 (Boston, 1976), pages 42 and 93.

> but it is on the one hand distantly and indirectly related to Flint's [*i.e.*, Sandy] Pond, which is more elevated [for example, 70.5 meters above sea level in 1987, as opposed to Walden's 48.5 meters], by a chain of small ponds coming from that quarter [Goose Pond, Little Goose Pond, and the smaller nearby kettle ponds], and on the other hand directly and manifestly related to Concord [*i.e.*, Sudbury] River, which is lower [*circa* 35 meters above sea level], by a similar chain of ponds [the Andromeda Ponds], through which in some other geological period it may have flowed thither [into Fairhaven Bay, an embayment of the Sudbury River], and by a little digging, which God forbid, could probably be made to flow thither again.[1]

In *Walden*, Thoreau states:

> The pond [*i.e.*, Walden Pond] rises and falls, but whether regularly or not, and within what period, nobody knows, though, as usual, many pretend to know. It is commonly higher in the winter and lower in the summer, though not corresponding to the general wet and dryness. . . . It is remarkable that this fluctuation, whether periodical or not, appears to require many years for its accomplishment. I have observed one rise and a part of two falls, and I expect that a dozen or fifteen years hence the water will again be as low as I have ever known it. Flint's Pond, a mile eastward, allowing for the disturbance occasioned by its inlets and outlets, and the smaller intermediate ponds also, sympathize with Walden, and recently attained their greatest height at the same time with the latter. . . .
>
> As for the inlet or outlet of Walden, I have not discovered any but rain and snow and evaporation, though perhaps, with a thermometer and a line, such places may be found, for where the water flows into the pond it will probably be coldest in summer and warmest in winter. . . .[2]

A temporal ecocline, or a change in community composition in time, both by changes in the relative importance of component populations and by extinction of old species and invasion of new ones, is termed a *succession*. Primary succession . . . is the development of communities from bare rock; secondary successions are changes that take place after destruction of the natural vegetation of an area with soil. . . . The composition of the avifauna and bird species diversity also change drastically with these successional changes in the vegetation and are part of the community succession. Plants in each stage modify the environment, presumably making it more suitable for other species in following stages . Typically, shade tolerance increases as succession proceeds. The entire process of secondary succession may take many years. . . . Only the oak–hickory forest is a stable community in a dynamic equilibrium that replaces itself; such a final stage in succession is termed its climax. In deserts, where the open vegetation alters microclimate very little and soil formation is virtually nonexistent, the first plants to invade are usually the climax species, and the succession, if one calls it such, is short. Earth's biomes represent the climax communities that prevail at different localities. Disturbances, both man-made and natural (lightning, fires, droughts, hurricanes, floods), are often frequent enough that extensive areas have not had time enough to reach their own climax state. An equilibrium is reached whereby the proportion of a habitat supporting early successional stages is determined by the frequency of disturbance. Largely undisturbed areas may be primarily in the climax state. During the course of succession, annual production exceeds annual respiration, and organic materials accumulate to form soils and, generally, an increasingly larger biomass of plants and animals. At climax, production equals respiration, and organic materials cease to accumulate.

According to John C. Kricher,

> The pines appear 'scrubby' and often grow in dense single-species stands. Oaks may grow both upright or shrublike and often make a thick spreading shrub layer beneath the pines. Huckleberries are usually abundant, along with other heaths, and add to the dense shrub layer. Evidence of fire is usually apparent. In older, fire-protected tracts, Red, Black, and White oaks gradually replace the pines. Atlantic White-cedar Swamps . . . occur on mesic (moist) sites. . . .
>
> [Its range is] Coastal New England from Massachusetts (including all of Cape Cod, Nantucket, and Martha's Vineyard) south through Long Island, New Jersey, and eastern North Carolina. . . .
>
> . . . Sometimes called the 'Pine Barrens,' Pine–Oak Forests are far more interesting than they first appear. Among the birds present, Pine Warblers and Chipping Sparrows, sounding somewhat similar, sing from the upper branches, while Prairie Warblers sing their upscale *zee*, *zee*, *zee* from small oaks and other lower vegetation. The

---

[1]Henry D. Thoreau. *Journal* (Boston, 1906), Volume 4, page 425 (5 December 1852).

[2]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), pages 180, 181, 292.

> Rufous-sided Towhee, a large and colorful member of the sparrow tribe, scratches with both feet simultaneously in the dried litter, searching for insect food. A walk through a summer pineland forest can flush up a family of Northern Bobwhite or a sleepy Whip-poor-will. At night the repeated calls of the Whip-poor-wills and the deep hooting of a Great Horned Owl provide one of the finest choruses in nature.
>
> [T]he Northern Pine–Oak Forest [is] maintained largely by the effects of frequent fires. Were it not for fire, and the fact that pines, by virtue of their fire-resistant bark, withstand fire better than oaks, these forests would slowly change to become increasingly mesic, dominated by oaks, hickories, and Red Maple. The Northern Pine–Oak Forest is actually a unique part of the Oak–Hickory Forest that never quite become dominated by oaks and hickories because of the combination of dry sandy soil and frequent natural fires. The pine species that thrive have *serotinous* cones that open only when exposed to heat from fire. Fire also kills oak seedlings and releases minerals from the burned leaf litter to the soil, making a natural fertilizer for the seedling pines. Pines are not shade tolerant. With total protection from fire, slow-growing oaks gradually overtop, shade, and outcompete the pines. Research in New Jersey has shown that, on the average, any given tract of the Pine–Oak Forest now burns about every 65 years, compared with intervals of 20 years earlier in the century.
>
> Several 'scrubby' oak species are abundant in this forest type. Bear Oak [*Quercus ilicifolia*—Thoreau's shrub oak] rarely grows higher than 20 ft. and can develop into a very thick 'shrub' layer. Blackjack Oaks [not found in New England] have extremely thick leathery leaves, the undersurface of which is brown and hairy. These leathery leaves aid in reducing water loss during the heat of the day. Post Oak leaves, which have deep-rounded lobes, are also leathery [in Massachusetts, the Post Oak is found only in the southeastern part of the state]. Post Oak and Blackjack Oak grow to heights of 50 and 30 ft., respectively. The tallest of the scrubby sand-plain oaks is Chinkapin[1] Oak, which can reach 80 ft. in height. This species has elongate leaves with large notches. [2]

In *A Description of New England*, published in 1616, Captain John Smith said of the region's forests that "Oke [Oak] is the chief wood; of which there is great difference in regard of soyle [soil] where it groweth." He dismissed Cape Cod as "only a headland of high hills of sand ouergrowne [overgrown] with shrubbie pines, hurts [whorts, whortleberries, blueberries], and such trash."[3] Smith was describing (and disparaging) what is called the Sand Plain Community, or Northern Pine–Oak Forest, of the Cape. His words clearly reflect his realization that "soyle" and vegetation are closely related. Walden Woods contains a special type of this pine–oak sand-plain forest community, differing from most other examples primarily in its geological origins and relationships but also in its complement of animals and plants. Walden Woods resembles the forests of Cape Cod far more closely than it does most other woodlands in the Lincoln–Concord region. Few sand plain communities have developed on glacial-lake ice-contact deposits (because such deposits are uncommon); most (*e.g.*, those on Cape Cod) have developed on outwash plains.[4]

Pine barrens, or pinelands, occur not only on Cape Cod, but in Wisconsin; Kentucky; on the sand plains between Schenectady and Albany, New York; central and southern New Jersey; and, in the South, from Maryland south to Florida and west to Texas.[5] Walden Woods is minuscule in comparison to those pine barrens, some of which are millions of acres or thousands of square miles in extent, and it differs from them in other ways, primarily with respect to its flora and fauna; yet the following discussion of the New Jersey Pine Barrens (1.5 million acres) applies surprisingly well to Walden Woods (2,700 acres):

---

[1]Usually spelled "Chinquapin."

[2]John C. Kricher. *A Field Guide to Eastern Forests* [*of*] *North America*, (Boston, 1988), page 66.

[3]Quoted in Betty Flanders Thomson. *The Changing Face of New England* (New York, 1958), page 101.

[4]The Northern Pine–Oak Forest is described and discussed, under various names ("Sand Plain Community," "The Oak, Pine, Sand Country," *etc.*), in John C. Kricher. *A Field Guide to Eastern Forests* [*of*] *North America* (Boston, 1988), pages 65 to 67; Neil Jorgensen. *A Sierra Club Naturalist's Guide to Southern New England* (San Francisco, 1978), pages 192 (map), 238 to 248; and Betty Flanders Thomson. *The Changing Face of New England* (New York, 1958), pages 101 to 115. They are mentioned, in the context of a discussion of the broader category, "pine barrens," in Ann Sutton and Myron Sutton. *Eastern Forests* (New York, 1985), pages 95 to 104. Barbara Blau Chamberlain. *These Fragile Outposts—A Geological Look at Cape Cod, Marthas Vineyard, and Nantucket* (Garden City, New York, 1964) discusses Cape Cod's glacial geology. While kettles, kettle lakes, and kames are mentioned (kettles frequently), glacial lakes are not, nor are deltas. Arthur N. Strahler, in *A Geologist's View of Cape Cod* (Garden City, New York, 1966), also does not mention glacial lakes or deltas.

[5]Ann Sutton and Myron Sutton. *Eastern Forests* (New York, 1985), page 95.

> Despite their many assets, the New Jersey Pine Barrens [*read* "Walden Woods"] have not been densely settled and today are a comparative wilderness in the heavily populated stretch from New York to Washington [*read* "heavily populated metropolitan Boston area"]. Throughout recent history people have made some use of the area; for example, early Indians hunted deer here, setting the woods afire to claim their quarry as it fled. There was some farming and pasturing by European settlers, *but better soils existed elsewhere*. Lumbering and the commercial collection of fuel wood proved short-lived industries. . . .
>
> In more recent years, entrepreneurs subdivided parts of the land into homesites and small farms. Forest fires continued to be set for various purposes. . . . *But even though hundreds of thousands of acres* [for Walden Woods, *read* "hundreds of acres"] *were disturbed by human intervention, the forests have recovered, and much of the Pine Barrens* [*read* "Walden Woods"]*is relatively wild today*. . . .[1]

Ecologists have identified six major vegetation types in the Pine Barrens: pine–oak forest; Atlantic white cedar–red maple swamp; bog; marsh; stream–pond; and old [*i.e.*, abandoned] field.[2] The main body of Walden Woods is pine–oak forest; many of the other vegetation types occupy smaller areas of the overall ecosystem. It can be seen that Walden Woods is in some respects the New Jersey Pine Barrens Ecosystem in microcosm, differing from it because of differences in latitude, surficial geology, *etc*. The characteristics it shares with the Pine Barrens derive from two basic environmental factors: very porous, sandy soils and deep water table.

Sand Plains

Egler[3] discusses "a type of landscape, sufficiently distinctive for Vegetation[4] to become an entity in thinking and research, called sand-plains and sand-hills." "Because the Vegetation [of sand plains and sand hills] is often sparse or stunted, or dominated by pine in the northern hemisphere," he continues, "the terms *sand barrens* and *pine barrens* are frequent." Egler's discussion of sand plains has much that is applicable to Walden Woods:

> *Sand-plains* are extensive flat sandy areas. Physiographically, they may be old flood-plain terraces, *sometimes related to Pleistocene glaciation. They may develop on the sandy bottoms of drained lakes* [emphasis added]. . . .
>
> As a habitat for Vegetation, sand-plains form a distinctive Total Environment. The soil is loose, porous and well-leached. Nutrients are low in quantity, and the reaction is generally acid. *These conditions, from the viewpoint of agriculture and forestry, are considered relatively undesirable. Upper surfaces of the soil become exceedingly dry in a season of low precipitation* (when heavier soils would not become as dry [emphasis added]. The vegetation also becomes dry. Fires are started readily, and because of the flat land, sweep for vast distances. Since the entire ecosystem is related to geomorphic conditions, sand-plains may be very ancient. Endemic species are frequently found, tho[ugh] these are rarely of vegetational importance. The plant-communities tend to be open and scrubby, of slow growth. Sometimes growth may be so extremely slow as to give rise to a dwarf Vegetation of species which grow much taller on other sites. Developmental trends are toward a more closed and mesic Vegetation, but which may have remained as trends for millennia.

Neil Jorgensen describes and discusses the sand-plain communities of New England.[5] His map of their distribution (page 192) shows them to be widely distributed in southern New England; Walden Woods and other sand-plain communities adjacent or very close to it (*i.e.*, communities on ice-contact deposits of Glacial Lake Sudbury and Glacial Lake Concord) are easily seen on the map. (This isolated group of sand plain communities, located on the map on page 192 in Jorgensen's book, coincides with the northern tier of Glacial Lake Sudbury as shown on Goldthwait's location map[6] Another, larger such community, developed on ice-

---

[1]Ann Sutton and Myron Sutton. *Eastern Forests* (New York, 1985), pages 95 and 96.

[2]Ann Sutton and Myron Sutton. *Eastern Forests* (New York, 1985), page 96.

[3]Frank E. Egler. *The Nature of Vegetation, Its Management and Mismanagement: An Introduction to Vegetation Science*. Limited edition (Norfolk, Connecticut, 1977), page 251.

[4]Egler's idiosyncratic (though not inconsistent) capitalization, spelling, and hyphenation are retained in this and other quotations from his book, *The Nature of Vegetation*.

[5]Neil Jorgensen. *A Sierra Club Naturalist's Guide to Southern New England* (San Francisco, 1978), pages 192 (map), 238 to 248.

[6]James Walter Goldthwait. The sand plains of glacial Lake Sudbury. *Bulletin Museum of Comparative Zoölogy*, Volume 42 (1905), page 264.

contact deposits of Glacial Lake Nashua, appears northwest of Concord, in the Harvard–Lancaster area of northeastern Worcester County.) Jorgensen describes sand-plain communities as follows (page 239):

> The sand plain community is distinctive more for its soils and its botanical characteristics than for its topography. The hilly land on parts of Cape Cod, where some of the most striking examples of this woodland community may be seen, could hardly be considered a plain. But elsewhere on Cape Cod and in other parts of southern New England the community is commonly found on sandy outwash plains. *These may be elevated above the surrounding countryside and here and there pitted with kettleholes, but otherwise the surface of the land is fairly flat.*

By the 1890s geomorphologists had become interested in the so-called "sand plains" of Glacial Lake Sudbury. In 1891, for example, Warren Upham reported on the Walden Sand Plain before the Boston Society of Natural History[1]. In 1892 and 1898, George Hunt Barton, a geologist who taught at MIT and Boston University and who had worked on the State Topographic Survey, photographed and studied the Walden Sand Plain.[2] In 1905, James Walter Goldthwait, a Harvard doctoral candidate, reported on "The Sand Plains of Glacial Lake Sudbury" in the *Bulletin* of Harvard's Museum of Comparative Zoölogy.[3] Six decades after Goldthwait studied Glacial Lake Sudbury, Carl Koteff, a geologist working on the surficial geology of the *Concord* quadrangle for the United States Geological Survey, did further research on glacial lakes in the Concord area, refining some of Goldthwait's interpretations.[4]

Upham began his report by stating that

> The lakes and ponds here considered are bounded wholly or in large part by modified drift, that is, beds of gravel and sand, or rarely of fine silt or clay, which were supplied directly from the melting and receding ice-sheet, in which these materials had been held and from which they were brought and deposited in their present position by streams flowing down from the ice-surface.

Goldthwait describes Walden Pond as follows (page 231):

> The lake is wholly enclosed by beds of coarse gravel and sand, which in some places have an uneven contour of irregular knolls and hollows, but mostly are nearly level to distances varying from an eighth to three-quarters of a mile from the lake, with their surface approximately 200 feet above the sea. On the south and west these plains abut upon hills of rock; but northward, in which direction they extend farthest, their boundary is a sudden descent of about 60 feet to the *fertile farming land near* [*the village of*] *Concord* [emphasis added]. The modified drift enclosing Lake Walden is thus indented by a hollow [*i.e.*, a glacial kettle] a half mile long from east to west and a fourth of a mile wide, which now sinks about 150 feet and originally may have been considerably deeper. Obviously the strong currents bringing the gravel must have [*i.e.*, would have] filled the basin [the kettle] if it had been empty when the plain was deposited.

Goldthwait (pages 269 and 270) discusses the origins of Glacial Lake Sudbury's "sand deltas," or "sand plains," defines and describes them, and distinguishes them from ordinary deltas. It is worth presenting Goldthwait's discussion *in extenso*:

> Sand plains are delta-like deposits of sand and gravel, built out from the ice into standing water at its front. . . . In their broader features of form and structure, sand plains resemble deltas built under ordinary conditions, by

---

[1]Warren Upham. Walden, Cochituate, and other lakes enclosed by modified drift. *Proceedings of the Boston Society of Natural History*, Volume 25, Part 1, pages 228 to 242 (1891).

[2]Diaries of George Hunt Barton, Barton–Bradshaw Room, Goodnow Memorial Library, South Sudbury, Massachusetts. The entry for May 28, 1892 (Diary for May 1, 1890, to June 8, 1892, page 279) reads, in part: " A fine clear day. With Miss Jackson went to Baker's Bridge, Lincoln, on 9 A.M. train F[itchburg]. R[ail]. R[oad]. and photographed the glacial channel in the sand plain connecting Walden Pond and the Sudbury River, then climbed to top of Fairhaven Cliffs, and then back down to the rail road where we took photo's of the sand sections. . . ." That for May 6, 1898 (Diary for November 1, 1897, to October 31, 1900, page 48) reads, in part: ". . . . Studied the eskers thro' Sleepy Hollow, thence crossed the series to the Wayside and thence went to Walden Pond Sand plain, followed it to the river west of Fairhaven Bluffs then ascended the Bluff [sic], thence crossed to Walden and then took the 5.43 train at Baker's Bridge. . . ." Barton's remarks make it clear that the Walden Sand Plain extends to Fairhaven Bay.

[3]James Walter Goldthwait. The sand plains of glacial Lake Sudbury. *Bulletin Museum of Comparative Zoölogy*, Volume 42, pages 263 to 301 (1905).

[4]Carl Koteff. Glacial lakes near Concord, Massachusetts. Article 96 (pages C142—C144) *in:* Professional Paper 475-C (Washington, D.C., 1963).

streams entering a body of standing water. Like normal deltas, they have a nearly flat, gently sloping surface, the 'top slope,' and an outer or free border, the 'front slope,' which slants more decidedly and is lobate in form; in composition, the material becomes noticeably finer towards the free border; in structure, the sand plains show inclined beds below with horizontal beds of coarser material above. Yet while sand plains are delta-like in these respects, the peculiar conditions under which they are built give them certain very definite characteristics not common to ordinary deltas. Instead of being fan-shaped deposits built out from lake-shores by single streams, sand plains are more often semi-elliptical in outline, as if built out continuously from the ice for some distance along its front by many streams. In fact, they are most irregular in plan.

The headward border of a sand plain, moreover, is not the lake-shore border of a common delta, but an 'ice-contact' or 'back slope,' which marks the position of the ice-front against which the gravels were laid down. *Inasmuch as the back slope shows exactly where the ice-front was when the sand plain was built*, it is a great help in determining the ice boundary of the ice-front lake at that time [emphasis added]. In linear extent the back slope is straight or irregular, according as the ice-front was straight or irregular. In surface form it may be a simple straight slope of from 30 to 45 degrees,—the natural slope or 'angle of repose' assumed by the gravels when their ice support was removed by melting. It is frequently broken, however, by hollows or kettle-holes [***e.g.***, originally, near the summit of Brister's Hill], where isolated blocks of ice were enclosed in the gravel, and occasionally the ice margin of a plain is wholly a belt of knobs and kettles, indicating an irregular ice-front where deposition took place among ice-blocks or upon a thin irregular ice-margin [Thoreau, in *Walden*, writes of just such a "belt of knobs and kettles" when he mentions his having spent time reading "by a spring which was the source of a swamp and of a brook, oozing from under Brister's Hill {***i.e.***, groundwater oozing from the ice-contact, or back slope, of the Walden Sand Plain} half a mile from my field," and whose approach was "through a succession of descending grassy hollows {kettles}, full of young pitch pines, into a larger wood about the swamp."]. . . .

The top slope is often so flat as to appear like a level plain; but usually there is a perceptible slope, 3 to 5 degrees, from the ice-border towards the free border [***i.e.***, from north to south—in the case of the Walden Sand Plain, from, ***e.g.***, the Brister's Hill–Laurel Glen area to the Emerson's Cliff–Baker Bridge–Mount Misery area]. Near the back [***i.e.***, northern edge] of the plain, kettle-holes are common, forming depressions [Thoreau's "hollows"] in the top slope; near its front the plain is flattest, often unbroken save for shallow depressions which lead down to interlobate hollows, and which seem to indicate partial scouring, subsequent to the building of the plain. Cross-sections through the body of the plain [north to south in the case of the Walden Sand Plain] generally show a decrease in size of material towards the front, with also a decrease in thickness of the topset beds. . . . Associated with these ice-bound delta deposits are usually ridges of gravel, eskers, which mark the courses of streams that fed the deltas. . . .

Jorgensen[1] describes the differences between lake-bottom deposits and ice-contact or lake-shore deposits. "If the [extinct glacial] lakes lasted for any time," he notes,

the accumulation of fine sediments gradually smoothed out the irregularities on the lake bottoms, producing a very flat area [***e.g.***, much of Concord]. The lake sediments themselves are distinctive as well. In contrast to the coarse sand and gravel deposited by streams, these lake sediments are unusually fine—mostly silt and clay. Some of the extinct glacial lake bottoms are still marshy, never having completely drained. In others, the flat ground and rich, rock-free soil [as in parts of Concord] make good farmland.

Some of these extinct lakes show a complex history. Many have existed at several different levels [***e.g.***, Glacial Lake Sudbury and Glacial Lake Concord], becoming progressively lower as first one spillway [***e.g.***, with respect to Glacial Lake Sudbury, the Cherry Brook spillway] and then another [the Hobbs Brook spillway] became ice free. These levels are often marked by elevated beaches and terraces that sometimes run for several miles along the valley sides.

Meltwater streams flowing into these glacial lakes formed deltas along their shores [that] often superficially resemble kame terraces; both are usually steep sided and often nearly flat on top. Where a gravel pit has been dug into the side of a delta, however, the difference is usually easy to see. The gravel layers in deltas are usually diagonal while these same layers in kame terraces are often jumbled where they collapsed as the ice melted from beside them. . . .

. . . In Massachusetts several of the major river valleys were the sites of glacial lakes. A large lake inundated most of what is now the town of Concord, and just to the south an even larger lake flooded the Sudbury River Valley for some 8 miles to Framingham.[1]

[1]Neil Jorgensen. *A Guide to New England's Landscape* (Barre, Massachusetts, 1971; Chester, Connecticut, 1977), pages 126 to 131.

John C. MacLean, in his recent history of Lincoln[2] (most of which town originally was part of Concord), summarizes the relationship of soils in the sand-plain area to geology as follows

> The local landscape acquired much of its character from the uplifting and faulting of its bedrock. . . .
>
> Later glacial action also had a major impact upon the landscape. Till from the advancing glaciers settled on the far side of outcroppings to create drumlins. As the glaciers retreated, water and till ran through cracks in the ice. Heavy till remained in the cracks and eventually settled to the ground as eskers. Finer till and silt washed out of the cracks and were deposited as delta-shaped outwash. (*The coarsest materials settled near the mouth of the crack and finer silt and sand near the outskirts of the delta. Much of South Lincoln, for example, was part of an outwash plain containing such a progression of soil conditions* [emphasis added].)

It is primarily this gradual north-to-south diminution of particle size that accounts for the greater water-holding capacity of soils in the southern sections of the Walden Sand Plain. Nonetheless, the kame and delta complex a single geological feature, Goldthwait's "sand plain."

Thomson discusses the sand plains of New England, concentrating on one particularly dry one (much drier than the Walden Sand Plain) in North Haven, Connecticut.[3] She makes some very telling comments on that particular sand plain, many (but not all) of which apply in some degree or other to Walden Woods. For example, she states (page 42) that "three kinds of evidence explain what a place used to be like and why it is what it is now. These are its present vegetation, its recorded history, and the structure of its soil." The sand plain in North Haven was laid down in Glacial Lake Hitchcock and has much in common with Walden Woods, as the following quotation from Thomson's book shows:

> [T]he soil [of the North Haven sand plain], like so much of New England, is the work of the glacier. Digging down into the earth, one finds that the sand is not homogeneous, but consists for many feet down of horizontal layers of varying textures, though all basically coarse and sandy. This is the sign of an old lake bottom, built up over the ages by sediments washed in from the country around. *Like so many in postglacial New England, the lake was long and narrow, caught between the surrounding hillsides and a remnant tongue of ice lying in the valley bottom* [emphasis added]. Currents flowing through the lake must have been fast enough at times to carry away all the fine mud and silt, leaving behind only the coarser, heavier sand.
>
> When at last the ice was entirely gone and plants could return to the valley, the old lake floor was left as a wide terrace standing high and dry above the little river. There was plenty of rain, but it trickled away so fast through the loose sand that the earth became dry again soon after every storm or shower. Only highly drought-resistant plants could grow in such a place; and for ages the sand plains were covered entirely with grass.

The Northern Pine–Oak Forest

Several systems are used to classify the vegetation of the United States. Küchler, for instance, bases his "physiognomic classification" system on the concept of "natural vegetation." The Walden Ecosystem lies, according to Küchler's map of the natural vegetation of the United States, on or very near the border between his categories DE-20 (Broadleaf deciduous trees/Needleleaf evergreen trees: Maple–yellow birch-hemlock-pine) and D-18 (Broadleaf deciduous trees: oak–tulip tree).[4] The Walden Ecosystem is situated in the Eastern

---

[1]Irving B. Crosby states (Groundwater in the pre-glacial buried valleys of Massachusetts. *Journal of the New England Water Works Association*, Volume 53, Number 3, pages 372 to 383 [September 1939]) that

> The valleys [of preglacial streams] in the central and western parts of Massachusetts are partially filled with glacial deposits, but the divides are seldom buried. In eastern Massachusetts, on the other hand, the valleys are sometimes completely filled with glacial outwash, and the divides [between watersheds] are partially buried. The present streams wander on the surface of these glacial deposits, often cross buried divides from one old [***i.e.***, preglacial] valley to another, and follow courses entirely different from the pre-glacial drainage. There are, therefore, many buried valleys in the bed rock beneath the present surface of eastern Massachusetts.

[2]John C. MacLean. *A Rich Harvest: The History, Buildings, and People of Lincoln, Massachusetts* (Lincoln, Massachusetts, 1987), page 5.

[3]Betty Flanders Thomson. *The Changing Face of New England* (New York, 1958), pages 42 to 46.

[4]A. W. Küchler. *Natural Vegetation [of the United States and southern Canada]*, *in:* J. Paul Goode, *Goode's World Atlas Physical, Political, and Economic* (New York, Chicago, and San Francisco, 1953), pages 52 and 53.

Deciduous Forest Province of North America, which extends from New England and the southern edge of the Great Lakes region southward into central Georgia and eastern Texas. As its name implies, this province consists mostly of deciduous forest; on continent-scale maps the scattered areas of coniferous forest that occur within the Eastern Deciduous Forest are not mapped separately. Nearby is the Coastal Plain Province, which includes the lowlands of the southeastern United States, from south-central Florida northward into southern New Jersey and westward into extreme eastern Texas. This Province embraces also the lowlands of the Mississippi Valley, as far north as southern Illinois. It has areas of deciduous forest, but stands of pine usually are more numerous. Swamps are numerous.[1]

Eaton states that

> The dominant forest element in Concord for at least the past three millennia has been the so-called oak–chestnut–hickory association[2] with a lingering and perhaps an increasing (since 1000 A.D.) of species characteristic of the cooler upland forests of western and northern New England: hemlock, yellow and white birch, beech, striped maple (rare), sugar-maple (rare). Before the land was cleared by the colonists for general farming, one may visualize a mature forest, broken only by river meadows, swamps, ponds and Indian clearings. Its understory must have been relatively free of shrubs and herbs, except in openings caused by blow-downs, fire, lightning and so on.[3]

The principal biotic component of the Walden Ecosystem, however, is Northern Pine–Oak Forest, a community of animals and plants that invariably develops on droughty, well drained, sandy soils in many parts of the northeastern United States. It is related to coastal pine-oak communities of the eastern part of the country and is, in fact, an outlier of the Coastal Plain Province. Jorgensen[4] calls this the "Sand Plain Community," as does Nichols,[5] while Bromley[6] refers to it informally as "[pitch] pine plain," but it is clear that they all are writing about the Northern Pine–Oak Forest. On maps, both Jorgensen (page 192) and Bromley (page 77) place a Sand Plain Community, or a pitch pine plain, respectively, on the site of Walden Woods.

Bromley states that

> Some of the higher over-drained gravelly plains were . . . destitute of large trees from the earliest times. The difficulties of the early settlers at Concord, Massachusetts, in 1635 were described in Johnson's "Wonder-working Providence" . . . . Much of the land was composed of "ragged plains," largely "shrub oak" and sweetfern, making traveling very difficult.[7]

According to Jorgensen,[8] "The sand plain community is distinctive more for its soils and its botanical characteristics than for its topography. . . . The hilly land on parts of Cape Cod, where some of the most striking examples of this woodland community may be seen," he continues, "could hardly be considered a plain. But

---

[1]Wilfred T. Neill. *The Geography of Life* (New York and London, 1969), page 306.

[2]Or Oak–Hickory Forest (see further on in the text).

[3]Richard Jefferson Eaton. *A Flora of Concord: An Account of the Flowering Plants, Ferns, and Fern-Allies Known To Have Occurred without Cultivation in Concord, Massachusetts, from Thoreau's Time to the Present Day* (Cambridge, Massachusetts, 1974), pages 7 and 8.

[4]Neil Jorgensen. *A Sierra Club Naturalist's Guide to Southern New England* (San Francisco, 1978), page 239.

[5]George E. Nichols. A working basis for the ecological classification of plant communities. Part II. *Ecology*, Volume 4, Number 2 (April 1923), page 177.

[6]Stanley W. Bromley. The original forest types of southern New England. *Ecological Monographs*, Volume 5, Number 1 (January 1935), pages 78 and 79.

[7]Stanley W. Bromley. The original forest types of southern New England. *Ecological Monographs*, Volume 5, Number 1 (January 1935), pages 78 and 79.

[8]Neil Jorgensen. *A Sierra Club Naturalist's Guide to Southern New England* (San Francisco, 1978), page 239.

elsewhere in southern New England the community is commonly found on sandy outwash plains. These may be elevated above the surrounding countryside and here and there pitted with kettleholes, but otherwise the surface of the land is fairly flat." The Walden Sand Plain is just such a plain "elsewhere in southern New England [*i.e.*, elsewhere than Cape Cod]." The Walden Sand Plain is "pitted with kettleholes," is higher than the surrounding terrain, and supports a distinctive sand plain community, Northern Pine–Oak Forest.

The Northern Pine–Oak Forest is a subclimax community; that is, it is a persistent biotic community that is prevented by some local influence from succeeding quite to the climatic climax stage.[1] As is the case with most stands of Northern Pine–Oak Forests, it is fire, due to either natural or human causes, that historically has prevented the Walden Woods Northern Pine–Oak Forest from succeeding to climatic climax. If protected from fire, it will gradually approach the regional, or climatic, climax, Oak–Hickory Forest. But sooner or later—because the Walden Sand Plain is exceedingly well drained and therefore prone to desiccation in midsummer, especially during periods of prolonged drought—the sand plain forest will catch fire and return to an earlier stage of ecological succession.

The rest of the Walden Ecosystem is divided among several other types of biotic community: wetland, stream, pond, and Transition Forest (also called Oak–Hickory Forest).[2] While these latter communities differ from the Northern Pine–Oak Forest, they are part of the Walden Ecosystem because (1) they occur on the same or geologically closely related landforms and (2) because they are regulated either by the same hydrologic regime as is the Forest, or by a closely linked hydrologic regime.

---

[1]"In ecology, ['climax' is] the final stage or equilibrium stage of development that a sere, community, species, flora, or fauna attains in a given environment. . ." (Robert L. Bates and Julia A. Jackson, editors. *Dictionary of Geological Terms*. Third edition [Garden City, New York, 1984], page 93). A "sere" is "A sequence of ecologic communities that succeed one another in development from pioneer stage to climax community" (*ibid.*, page 459). "Subclimax" is "a stage immediately preceding the climax [that] is long-persisting for any reason. . . . It may be the result simply of extremely slow development to climax, or of any disturbance, such as fire, that holds succession almost indefinitely in its subfinal stage. In the eastern United States, most pine forests are subclimax to hardwood climax because of the extremely slow elimination of pine in the progression toward hardwood dominance. In the coastal plain, subclimax pine forests are maintained indefinitely by the constantly recurring fires to which the pines are resistant and that keep down the hardwoods" (Henry J. Oosting. *The Study of Plant Communities*. Second edition [San Francisco and London, 1956], page 256).

"Succession" (called variously "biotic succession," "ecological succession," "ecosystem development," *etc.*) is "the developmental series of communities constituting a *sere* and leading up to a state of relative stability and permanence known as the *climax*" (Nicholas Polunin. *Introduction to Plant Geography* [London, 1960], page 323). It "involves changes in species structure and community processes with time. When not interrupted by outside forces, succession is reasonably directional and, therefore, predictable. . . ." (Eugene P. Odum. *Basic Ecology* [Philadelphia and elsewhere, 1983], page 444).

Thoreau's essay, "The Succession of Forest Trees," the result of studies he made largely in Walden Woods, is one of the earliest treatments of this apparently universal ecological phenomenon. Thoreau seems to have been the first person to attempt to explain how and why it occurs. (See, in this regard, *inter alii*, Leo Stoller. *After Walden: Thoreau's Changing Views on Economic Man* [Stanford, California, 1957; reprinted 1966], pages 77 to 89; William H. Drury and Ian C. T. Nisbet. Succession. *Journal of the Arnold Arboretum*, Volume 54, Number 3, pages 331 to 368 [July 1973], page 333; Henry S. Horn. Succession. Pages 187 to 204 *in:* Robert B. May, editor. *Theoretical Ecology: Principles and Applications* [Philadelphia, 19xx], page 187; Philip Whitford and Kathryn Whitford. Thoreau: Pioneer ecologist and conservationist. *Scientific Monthly*, Volume 73, Number 11, pages 291 to 296 [November 1951], pages 293 to 296; Kathryn Whitford. Thoreau and the woodlots of Concord. *The New England Quarterly*, Volume 23, Number 3, pages 291 to 306 [September 1950], pages 294 to 300; Stephen H. Spurr. Origin of the concept of forest succession. *Ecology*, Volume 33, Number 3, pages 426 and 427 [July 1952]; and Frank N. Egerton. Ecological studies and observations before 1900. Pages 311 to 351 *in: History of American Ecology* [New York, 1977], page 335.) Thoreau's *Journal* contains many references to the phenomenon of succession and to related phenomena, although he seldom used the word "succession" in the *Journal* in reference to them. (See especially the entries for September through early December 1860 [*Journal*, Volume 14, pages 69 to 291], which deal extensively with the ecology of Walden Woods and other woodlands in the Lincoln–Concord area.)

[2]The eastern part of the ecosystem, the so-called "Sandy Pond Unit" (for a definition of which see the text), while originally forested, apparently was not Northern Pine–Oak Forest, since it developed, not on a "sand plain" (glacial-lake ice-contact kame and delta deposits), but on till and coarse glaciofluvial (glacial-stream) deposits.

The presence of the Walden Ecosystem and its persistence as a landscape unit during the three and one-half centuries since European settlement are due directly to the area's distinctive surficial geology, which itself is a product of the Pleistocene glaciation. The surficial geology led to the development of an "island" of Northern Pine–Oak Forest within the surrounding "sea" of Oak–Hickory Forest. The environmental factors responsible for development of the original pine–oak forest on the site reflect the surficial geology and are the same factors that have made it a difficult site for the most part on which to raise crops. Since good agricultural land lay nearby, Walden Woods was farmed much less often and extensively than those nearby areas, and it has thus remained largely in woodland for centuries.

Even before the advent of the Europeans in Massachusetts, however, Walden Woods differed from the surrounding primeval forest. Walden Woods is a local, or edaphic, climax community (one strongly influenced by special, localized soil conditions), whereas most of the larger, surrounding forest was a regional, or climatic, climax community (one whose character and composition are determined primarily by the regional climate and not by any local peculiarities of the substrate, or soil).

Indicator Species of the Northern Pine–Oak Forest

The edaphic climax, or potential natural vegetation of the Walden Ecosystem (or, at the very least, of its sand-plain component—the so-called "Walden Pond Unit") is "Northern Pine–Oak Forest," "the predominant forest community on dry sandy soils along the northern Coastal Plain (Cape Cod and the southern New England coast, south through New Jersey to the Carolinas)." [1, 2]

Kricher lists what he calls "indicator species" for the Northern Pine–Oak Forest, many of which appear in *Walden*, Thoreau's *Journal*, and other of Thoreau's writings. "Indicator species," Kricher explains (page 10), "by their uniqueness or abundance, confer a distinct identity on the habitat." "In any habitat," he notes, "certain species will be very abundant and conspicuous In many parts of eastern North America, oaks and hickories comprise over 90% of the tree species in a forest. These are the *indicator species* of a community termed the Oak–Hickory Forest. . . . In addition to oaks and hickories, Blue Jays, Wild Turkeys, and Gray Squirrels are indicator species of the Oak–Hickory Forest. Both the birds and the squirrels eat acorns and hickory nuts."

He notes (page 11) that

> When we recognize a species as being an indicator of a certain habitat, what we are saying is that this species is biologically adapted to survive under the conditions imposed upon it in that area. Each species has certain tolerance limits beyond which it cannot persist. . . .
>
> Not all species serve as indicators of habitats. Red Maple occurs in virtually every forest type in the East and is therefore rarely a suitable indicator of any particular habitat (the exception being Red Maple Swamp Forests of the Northeast). White Oak is another species that is too widely distributed to be a good indicator, though it is a prominent member of the Oak–Hickory Forest. Only in combination with other oaks and several hickory species is it a useful indicator.

Kricher lists as indicator species of the Northern Pine–Oak Forest:[3]

---

[1]John C. Kricher. *A Field Guide to Eastern Forests* [*of*] *North America* (Boston, 1988), pages 65 to 67.

[2]Jorgensen distinguishes two related communities that closely resemble Kricher's Northern Pine–Oak Forest, namely, "The Hilltop Community" of the Oak Forest (pages 128 to 134) and "The Sand Plain Community" (pages 238 to 248). Both occur on dry, well drained, sandy or gravelly sites, and both are prone to fire. With minor exceptions, they are merely different aspects, or expressions, of Kricher's Northern Pine–Oak Forest, as an examination of the species listed as indicators of those communities shows. Jorgensen states (page 245), for example, that "All of the ericads [heaths] described under the hilltop community [huckleberry, lowbush blueberry, sheep laurel, *etc.*] also appear in the sand plain community. . . In addition, ericad subshrubs—wintergreen, *Gaultheria procumbens*, and trailing arbutus, *Epigea repens*—are common here. Other shrubs include . . .: Bearberry, . . . Sweet Fern, . . . Inkberry, . . . [and] Broom Crowberry. . . ." Jorgensen defines these communities according to their topographic position (hilltop, sand plain), and not the dominant species in the community (pine, oak) as does Kricher.

[3]In this list and in the text that follows the species listed by Kricher are correlated with references to the species in Thoreau's writings and in the writings of other authors (William Brewster, Ludlow Griscom, etc.). It becomes abundantly clear that Walden Woods—at least its sand plain component—is a mosaic of various successional stages of the Northern Pine–Oak Forest.

trees

pitch pine (*Pinus rigida*)***, [1]

Virginia pine (*Pinus virginiana*)§

bear (or shrub) oak (*Quercus ilicifolia*)***

blackjack oak (*Quercus marilandica*)§

chinkapin, yellow, or chestnut, oak (*Quercus muehlenbergii*)¶

scarlet oak (*Quercus coccinea*)**

post oak (*Quercus stellata*)†

black oak (*Quercus velutina*)***, [2]

eastern red cedar (*Juniperus virginiana*)*

shrubs

bearberry (*Arctostaphylos uva–ursi*)*, [3]

---

[1]**Boldface** type (including, in the case of Latin binomials, ***bold italic***) indicates species explicitly mentioned by Thoreau (in *Walden*, his *Journal*, etc.), William Brewster, Ludlow Griscom, or another author as occurring in Walden Woods as Walden Woods is defined in this Report.

The asterisks (*, **, ***) signify that the species is listed in the standard authorities on the biota of the Walden Woods area (Concord, the Concord area, or Middlesex County); Massachusetts; New England; or the eastern United States; *viz.*: M. L. Fernald, *Gray's Manual of Botany*, Eighth (Centennial) edition (New York and elsewhere,1950; reprinted Portland, Oregon,1988); F. C. Seymour, *The Flora of New England* (Rutland, Vermont, 1969); L. L. Dame and F. S. Collins, *Flora of Middlesex County, Massachusetts* (Malden, Massachusetts, 1888); R. J. Eaton, *A Flora of Concord* (Cambridge, Massachusetts, 1974); R. Angelo, *Concord Area Shrubs* (Cambridge, Massachusetts, 1978); R. L. Angelo, *Concord Area Trees* ([Cambridge, Massachusetts?], 1976); R. T. Peterson, *A Field Guide to the Birds . . . of Eastern and Central North America*, Fourth edition (Boston, 1980); E. H. Forbush, *Natural History of the Birds of Eastern and Central North America* (Boston, 1939); E. H. Forbush, *Birds of Massachusetts and Other New England States*, three volumes (Norwood, Massachusetts, 1929); L. Griscom, *Birds of Concord* (Cambridge, Massachusetts, 1949); and R. K. Walton, *Birds of the Sudbury River Valley—An Historical Perspective* (Lincoln, Massachusetts, 1984).

A single asterisk (*) indicates that a species is present but rare, infrequent, or uncommon in Concord or the Concord area, three (***) that it is common or abundant, and two (**) that it is neither rare nor abundant, but "frequent."

The symbol § indicates a southern species not found anywhere in New England, the symbol ¶ a species found only in extreme southern or western New England, and the symbol † a strictly coastal species or one found only in the southeastern part of the state—in each case, therefore, almost certainly absent from Walden Woods.

Note that the asterisks indicate only that published sources have a species occurring *in the vicinity of* Walden Woods, not that there is readily accessible documentation of its presence in the Walden Woods itself. (Boldface type indicates that there is such documentation, above and beyond the various authorities listed above.) Nonetheless, the likelihood is extremely high that a species recorded for the general vicinity of Walden Woods (*i.e.*, for the Concord area in most cases) *does* occur in Walden Woods because (1) Walden Woods provides suitable habitat for the species and (2) lies within the species' natural range. Given these considerations, one would reasonably expect to find the species within the bounds of Walden Woods as well as in the general vicinity. In fact, it would be highly unusual if the species did not occur there. Only a special, painstaking survey of the Walden Woods biota would provide physical proof that the species indeed did occur there.

[2]See, for example, *Journal*, Volume 6, page 244 (7 May 1854).

[3]Angelo (*Concord Area Shrubs*, page 120) "excludes" this species, but Eaton (page 156) cites a specimen of Edward S. Hoar collected in 1858 from The Cliffs in Walden Woods (Fairhaven Hill), "where it still persisted in 1972." Thoreau (*Journal*,Volume 11, page 238 [October 22, 1858]) writes of bearberry on Fairhaven Hill. It is rare in Concord, growing on "[e]xposed rocks, crests, and *sandy open woods* [emphasis added]." Eaton says it is abundant on Cranberry Hill in Lincoln. According to Dame and Collins (page 61), it was widely distributed in Middlesex County a century ago but was "not very common."

huckleberries (*Gaylussacia* spp.)*

inkberry (*Ilex glabra*)†

broom crowberry (*Corema conradii*)†

low-bush blueberry (*Vaccinium angustifolium*)** / ***

sheep laurel (or lambkill) (*Kalmia angustifolia*)***

wild raisin (*Viburnum cassinoides*)*, [1]

herbaceous species and vines

blazing star (*Chamælirium luteum*)

butterfly weed (*Asclepias tuberosa*)*

pinesap (*Monotropa hypopithys*)*, [2]

poverty grass (*Aristida dichotoma*)*

rough hawkweed (*Hieracium scabrum*)*

wild lupine (*Lupinus perennis*)*

"**wintergreen**"*, [3]

little bluestem (*Andropogon scoparius*, or *Schizachyrium scoparium*)*

birds[4]

pine warbler (*Dendroica pinus*)*

prairie warbler (*Dendroica discolor*)***, [5, ∞]

rufous-sided towhee (*Pipilo erythrophthalamus*)***, [∞]

---

[1]In Trillium Woods (a part of Walden Woods), Thoreau found *Viburnum cassinoides*, calling it by its synonym, *Viburnum nudum* var. *pyrifolium* (*Journal*, Volume 5, page 256 [15 June 1853]). In the vicinity of The Cliffs (part of Walden Woods) Thoreau saw the same species ("*Viburnum nudum*") on September 4, 1853 (*Journal*, Volume 5, page 419); he saw it again in Walden Woods, also near The Cliffs, on October 22, 1855 (*Journal*, Volume 7, page 511) and on November 5, 1855 (*Journal*, Volume 8, page 10). On August 13, 1856, he saw it at the other end of Walden Woods, near Saw Mill Brook (*Journal*, Volume 8, page 466).

[2]In Ebby Hubbard's Woods (a part of Walden Woods), Thoreau found great quantities of pinesap (*Journal*, Volume 10, page 69 [6 October 1858]). He named the path on which he was walking "Pine-Sap Path."

[3]Kricher gives only the common name (and a partial one, at that). Perhaps he means *Gaultheria procumbens* (the checkerberry, or aromatic wintergreen) or *Chimaphila* spp. (*C. umbellata* or *C. maculata*). Thoreau collected *Chimaphila maculata* near Goose Pond in Walden Woods (Eaton, page 153), and saw that species near Hubbard's Close in Walden Woods on July 9, 1854 (*Journal*, Volume 6, page 388).

[4]Bird populations fluctuate far more rapidly and widely than do those of plants, for example; thus, the notations of abundance (*, **, ***) are approximate and tentative. They are intended only to give a general indication of a species' abundance. Species that seem to have fluctuated most in numbers between Thoreau's time and the present are indicated by the symbol "∞."

[5]Reported by Ludlow Griscom, not Thoreau, for Walden Woods. Griscom, writing in 1948, says (pages 291 and 292) that the prairie warbler was "Formerly unknown; a colony in the Walden Woods, 1899 on; then very rare as a transient; a marked increase in recent years. . . . . Now a regular transient, scattered pairs nesting here and there for brief periods of time. Contemporaneous with a great increase over the whole northeast, the bird is now [1948] rapidly occupying wrecked and burned over areas throughout the interior of the state, north into New Hampshire and southwestern Maine.

chipping sparrow (*Spizella passerina*)***

common flicker (*Colaptes auratus*)***, [1]

brown thrasher (*Toxostoma rufum*)*, ∞

northern bobwhite (*Colinus virginianus*)*, [2], ∞

whip-poor-will (*Caprimulgus vociferus*)**, [3]

great horned owl (*Bubo virginianus*)*

mourning dove (*Zenaida macroura*)**, [4]

eastern bluebird (*Siala sialis*) (uncommon)*, [5]

mammals

---

[1]Thoreau reports seeing a flicker (which he calls "pigeon woodpecker"), as well as a towhee, on Shrub Oak Plain in Walden Woods on July 13, 1851 (*Journal*, Volume 2, page 304). The shrub oak (*Quercus ilicifolia*) is an indicator species of the Northern Pine–Oak Forest.

[2]Formerly a common resident in Concord, relatively common at the turn of the century, badly reduced by 1907 (Griscom [*The Birds of Concord*], page 207). On March 22, 1853, Thoreau mentions "quails" (an alternative name for this bird) at or near The Cliffs on "Fair Haven Hill-side" (*Journal* [Volume 5, page 37]). Two other references to quails in the *Journal* (Volume 13, page 5 [December 5, 1859] and Volume 13, page 77 [January 5, 1860]) apply to the Cambridge Turnpike and Smith's Hill area, on the opposite side of Walden Woods from The Cliffs. Earlier, on January 3, 1860, Thoreau had stated (*Journal*,Volume 13, page 72) that "Quails are very rare here [in Concord], but where they are is found the hunter of them, whether he be man or hawk."

Cruickshank (*Thoreau on Birds*) notes (page 89) that "Concord is very near the northern extremity of its range and the Bobwhite's hold is precarious there." Walton (*Birds of the Sudbury Valley—An Historical Perspective*) states (page 123) that the indigenous population of the northern bobwhite has been extirpated from the Sudbury River valley. "The original, indigenous population was strong at the end of the last century. . . . The ongoing loss of farmlands and the severe reduction of old-field and second growth habitat has deterred any possible re-establishment of a Northern Bobwhite population."

[3]Thoreau mentions hearing the whip-poor-will in Walden Woods several times in his *Journal* entry for June 11, 1851 (*Journal*, Volume 2, pages 234 to 237). He says, in part (pages 235 and 236): "The whip-poor-will suggests how wide asunder [are] the woods and the town. Its note is very rarely heard by those who live on the street, and then it is thought to be of ill omen. Only the dwellers on the outskirts of the village hear it occasionally. It sometimes comes into their yards. But go to the woods in a warm night at this season, and it is the prevailing sound. I hear now five or six at once. It is no more of ill omen therefore here than the night and the moonlight are. It is a bird not only of the woods, but of the night side of the woods. . . ."

In 1874, William Brewster reported that the whip-poor-will was abundant in the "great woods" around Sandy Pond, Lincoln (Ludlow Griscom. *The Birds of Concord* (Cambridge, Massachusetts, 1949), page 240). Brewster's "great woods" were, at least those along the Pond's western shore, the Sandy Pond Unit of the Walden Ecosystem.

[4]Griscom (*The Birds of Concord*, page 233) says that the mourning dove was "Well known to Thoreau." Thoreau mentions the mourning dove and several other indicator species [set in **boldface** type] of the Northern Pine–Oak Forest in the following passage from the "Brute Neighbors" chapter of *Walden*:

> . . . Commonly I rested an hour or two in the shade at noon, after planting, and ate my lunch, and read a little by a spring [Brister's Spring] which was the source of a swamp and of a brook, oozing from under Brister's Hill, half a mile from my field. The approach to this was through a succession of descending grassy hollows, full of young **pitch-pines**, into a larger wood about the swamp. There, in a very secluded and shaded spot, under a spreading white-pine, there was yet a clean sward to sit on. . . . There too the **turtle-doves** [*i. e.*, mourning doves] sat over the spring, or fluttered from bough to bough of the soft **white-pines** over my head; or the **red squirrel**, coursing down the nearest bough, was particularly familiar and inquisitive.

Brister's Spring is located in the present Hapgood Wright Town Forest, a part of Walden Woods. It originates as groundwater flowing from Walden Pond and intersecting the surface of the ground at the bottom of the ice-contact face of the Walden Sand Plain. The grassy hollows (kettles) conceivably could have been solid stands of **XXXXXX**

[5]Thoreau mentions hearing bluebirds on Fairhaven Hill in his *Journal* (Volume 10, page 73 [7 October 1857]).

gray squirrel (*Sciurus carolinensis*) (abundant)[1]

eastern chipmunk (*Tamias striatus*) (abundant)

The pitch pine (*Pinus rigida*) and the bear, or scrub, oak (*Quercus ilicifolia*) are primarily successional trees; that is, they occur during the early stages of ecological succession (*e.g.*, in old fields) in areas protected from fires.[2]

Quercus ilicifolia "is most abundant in rather barren, sandy regions along the Atlantic coast. It is characteristic of that part of Massachusetts where Thoreau's Walden was located, and appears to have been one of his favorite trees. . . ."[3] André Michaux writes that its presence "is considered as an infallible index of a barren soil, and it is usually found on dry sandy land mingled with gravel. . . ."[4] Michaux notes (*ibid.*) that, "It usually grows in compact masses, which are traversed with difficulty, though no higher than the waist. As the individuals which compose them are of an uniform height, they form so even a surface that at a distance the ground appears to be covered with grass instead of shrubs." It "occurs on sites which have a history of disturbances by heavy cutting, fire, or both. Soils are acid and low in available nutrients. Intolerant [of the shade of larger species of trees], bear [*i.e.*, scrub] oak may occur in pure stands of dwarf trees or shrubs. These sites are usually referred to as 'oak barrens' or 'shale barrens.'"[5]

In Thoreau's time, the area between Fairhaven Bay and Fairhaven Hill was called "Shrub Oak Plain"[6]—in reference both to the area's dominant vegetation, the scrub, shrub, or bear, oak (*Quercus ilicifolia*),[7] which, according to Kricher, is an indicator species of the Northern Pine–Oak Forest, and to its geomorphology, a sand plain, or "kame delta," as indicated at precisely this spot by the letters "kd" on Koteff's map (1964) of the surficial geology of the *Concord* quadrangle.[8]

Thoreau spent the afternoon of July 13, 1851, on Shrub Oak Plain. His account of the afternoon mentions several indicator species of the Northern Pine–Oak Forest:

> . . . . Looking across the [Sudbury] river to Conantum from the open plains [Shrub Oak Plain], I think how the history of the hills would read, since they have been pastured by cows, if every plowing and mowing and sowing and chopping were recorded. I hear, 4 P.M., a **pigeon woodpecker** [flicker] on a dead **pine near** by, uttering a harsh and scolding scream, spying me. The **chewink** [towhee] jingles on the tops of the bushes, and the rush sparrow, the vireo, and oven-bird at a distance. . . . These plains are covered with **shrub oaks**, birches, aspens,

---

[1]In the "Winter Animals" chapter of *Walden*, Thoreau mentions red squirrels (*Tamiasciurus hudsonicus*) "coursing over the roof and up and down the sides of the house" (*Walden* [Princeton, New Jersey, 1971], page 273). In a passage in his *Journal* on which this passage is based, he states that both red and gray engaged in such antics: "Often a red or grey squirrel awaked me in the dawn—coursing over my roof—and up and down the sides of my house. . ." (*Journal, Volume 2: 1842–1848* [Princeton, New Jersey, 1984], page 138 [Fall–Winter 1845–1846]).

[2]John C. Kricher. *A Field Guide to Eastern Forests* [*of*] *North America* (Boston, 1988), page 125.

[3]Arthur I. Emerson. *Our Trees: How To Know Them* (Philadelphia and London, 1908).

[4]F. Andrew Michaux. *The North American Sylva, or a Description of the Forest Trees of the United States, Canada, and Nova Scotia. . . .* Translated from the French (Paris, 1819), page 83.

[5]Howard A. Miller and Samuel H. Lamb. *Oaks of North America* (Happy Camp, California, 1985).

[6]Herbert W. Gleason. *Map of Concord, Mass., Showing Localities Mentioned by Thoreau in His Journals* (Boston, 1906), site 110 (coordinates J–7). This apparently is the "oak plain" Thoreau refers to in his *Journal* entry for March 22, 1853 (*Journal*, Volume 5, page 38).

[7]Angelo (in *Botanical Index to the Journal of Henry David Thoreau* [Salt Lake City, 1984], page 125) assigns the term "shrub oak" as used in Thoreau's *Journal* to *Quercus ilicifolia*, the SCRUB OAK of his (Angelo's) *Index*. Another vernacular name of this species is "bear oak."

[8]Carl Koteff. *Surficial Geology of the Concord Quadrangle, Massachusetts* (Washington, D. C., 1964), plate .

> hickories, mingled with **sweet-fern**[1] and brakes and **huckleberry** bushes and epilobium, now in bloom, and much fine grass. . . .[2]

William Brewster, the renowned ornithologist, describes a walk he made in Walden Woods in October 1892, from Staples' Camp on Fairhaven Bay through Shrub Oak Plain to Walden Pond:[3]

> At 2 P.M. we started through the woods for Walden [Pond]. It was a walk to be long remembered. I think I have never before seen oak woods so richly colored as these—*painted woods*—wine-red the dominant tint. The scarlet oaks[4] were steeped with this color and the undergrowth of huckleberry[5] bushes seemed to reflect it, as the scarlet of the maples along the river was reflected by the water a week or more ago. Of course these huckleberry bushes were really of the same color as the oaks. *In places they formed a rich unbroken carpet which covered the ground as far as the eye could reach under the trees*. . . [emphasis added].

In his *Wonder-working Providence* Edward Johnson writes (1653) with respect to the settling of Concord that scouts from the Massachusetts Bay Colony had encountered "unknown woods," "watery swamps," "thickets," and, significantly, "a scorching plaine" in their trek to the site of the new town:

> . . . [W]ith much difficulties travelling through unknowne woods, and watery swamps . . . they[6] at the end of this meete with a scorching plaine, yet not so plaine, but that the ragged bushes scratch their legs fouly . . . , [a]nd in time of summer, the sun casts such a reflecting heate from the sweet ferne [*Comptonia peregrina*—not actually a fern but a low shrub with fragrant foliage, a member of the Myricaceæ, or wax-myrtle family, found in "open sterile woodlands, clearings,"[7] "sterile soil, open oak scrub, gravel banks, etc."[8]—*i.e*, in terrain exactly like that of Walden Woods, especially during the early stages of secondary succession], whose scent is very strong, that some herewith have beene very nere fainting. . . .
>
> Thus this poore people populate this howling desert, marching manfully on (the Lord assisting) through the greatest difficulties, and sorest labors that any with such weak means have done.

Some modern authorities have dismissed this passage as erroneous or hyperbolic. For example, Townsend Scudder says, "Certainly the families of Concord's settlers, who suffered hardship enough, met with no such preliminary ordeal,"[9] not realizing that Johnson was referring to the advance scouting party. Ruth R. Wheeler, author of *Concord: Climate for Freedom*, says that parts of Johnson's account "are too confused to be taken literally,"[10] perhaps referring to this passage (among others). Yet Wheeler herself identifies "Hurtleberry Hill," where three Indian women suspected of spying during King Philip's War were captured and shot, along with three of their children, in 1676, as the present Mount Misery in Lincoln. Mount Misery is situated in the

---

[1]The sweet-fern, so-called, is "an aromatic deciduous shrub found in dry sandy soils as well as fertile pastures" (Kricher, page 122). It becomes abundant during succession but eventually is shaded out by larger shrubs and trees.

[2]Henry D. Thoreau. *Journal* (Boston, 1906), Volume 2, page 304 (13 July 1851).

[3]William Brewster. *October Farm: From the Journals and Diaries of William Brewster* (Cambridge, Massachusetts, 1936), page 69.

[4]*Quercus coccinea*, an indicator tree of the Northern Pine–Oak Forest.

[5]*Gaylussacia* spp., indicator shrubs of the Northern Pine–Oak Forest.

[6]Rather than the settlers themselves, these were *scouts* under the command of Major Simon Willard, who reconnoitered the Concord area in 1634–5. Ruth R. Wheeler says in *Concord: Climate for Freedom* (Concord, 1967), page 8, that "Simon Willard must have used the remaining months of 1634 [he had arrived in the Massachusetts Bay Colony in May of that year] and the first eight months of 1635 to explore the unsettled country beyond the Cambridge and Watertown settlements and to become acquainted with the few Indians left in the area. He then must have approached a few people with money to invest and with them petitioned the General Court for a new town."

[7]Merritt Lyndon Fernald. *Gray's Manual of Botany*, eighth edition (Portland, Oregon, [1987?]), page 525.

[8]Richard Jefferson Eaton. *A Flora of Concord* (Cambridge, Massachusetts,1974), page 103.

[9]Townsend Scudder. *Concord: American Town* (Boston, 1947), page 9.

[10]Ruth R. Wheeler *Concord: Climate for Freedom* (Concord, 1967), page 16.

southern part of Walden Woods, in "Ancient Concord."[1] John MacLean, in *A Rich Harvest*, concurs, placing "Hertleberry Hill," as he spells it, "near the future 'South Lincoln' section of Concord [*sic*]."[2] The Mount Misery area was part of Concord until 1754. Whether the "scorching plaine" plain was the Walden Sand Plain is difficult to say; it may have been the pitch pine plains in the southwestern part of the town that are mentioned in records from 1653 (Walden Woods is in the southeastern part of Concord).[3] A sand plain covered with sweet fern in 1635 could easily have become a pitch pine plain within eighteen years. In any event, west of the Sudbury River there are glacial-lake deposits identical to those east of the River—*i.e.*, identical to the Walden Sand Plain.

The "hurtleberry," or whortleberry, is the huckleberry—*Gaylussacia* spp.—an indicator species of the Northern Pine–Oak Forest.[4] Like the sweet fern (*Comptonia peregrina*), it is most abundant during the early stages of biotic succession. The grisly incident described in Wheeler's and MacLean's books occurred only forty years after Concord's settlement; the presence of sweet fern and huckleberries, both of which are indicators of early successional stages, suggests that, indeed, the sand plains in the Concord area were routinely being burned over by the Indians to provide habitat for game animals. Johnson's description of Concord as a "scorching plaine" and "howling desert" is consistent with that fact and should not be dismissed as hyperbole.

Huckleberries (*Gaylussacia* spp.) were important to Henry Thoreau. At his death he left the draft of an essay, "Huckleberries," which was not published until 1970.[5] It derives its character from the nature of huckleberries and therefore from the ecosystems and plant communities of which they were a part. The following quotation shows that Thoreau was aware of their role in ecological succession:

> If you look closely you will find blueberry and huckleberry bushes under your feet, though they may be feeble and barren, throughout all our woods, the most persevering Native Americans, ready to shoot up into place and power at the next election among plants, ready to reclothe the hills when man has laid them bare and feed all kinds of pensioners. What though the woods be cut down; it appears that this emergency was long ago anticipated and provided for by Nature, and the interregnum is not allowed to be a barren one. She not only begins instantly to heal that scar, but she compensates us for the loss and refreshes us with fruits such as the forest did not produce. As the sandal wood is said to diffuse a perfume around the woodman who cuts it—so in this case Nature rewards with unexpected fruits the hand that lays her waste.
>
> I have only to remember each year where the woods have been cut just long enough to know where to look for them. It is to refresh us thus once in a century that they bide their time on the forest floor. If the farmer mows and burns over his overgrown pasture for the benefit of the grass, or to keep the children out, the huckleberries spring up there more vigorous than ever. . . . All our hills are, or have been, huckleberry hills, the three hills of Boston and no doubt Bunker Hill among the rest. . . .
>
> In short all the whortleberry bushes in the Northern States and British America are a sort of miniature forest surviving under the great forest, and reappearing when the latter is cut.

Compare this passage with a statement from Kricher's discussion of the Northern Pine–Oak Forest:

> Huckleberries are usually abundant [in the Northern Pine–Oak Forest], along with other heaths [sheep laurel is a heath also], and add to the dense shrub layer. . . .[6]

---

[1]The present town of Lincoln had not yet been carved out of Concord, Lexington, and Weston. "Ancient Concord" means the town before parts of it were separated out into the towns of Acton, Lincoln, etc. MacLean, in *A Rich Harvest*, pages 1 to 3.

[2]John C. MacLean. *A Rich Harvest: The History, Buildings, and People of Lincoln, Massachusetts* (Lincoln, Massachusetts, 1987), page 8.

[3]*Early Massachusetts Records*, Town of Concord, Volumes 4 to 6 (cited in Brian Donahue. The forests and fields of Concord: An ecological history, 1750–1850. Pages 14 to 63 *in:* David Hackett Fischer, editor. *Concord: The Social History of a New England Town 1750—1850*. Waltham, Massachusetts, 1983), page 24).

[4]John C. Kricher. *A Field Guide to Eastern Forests* [*of*] *North America* (Boston, 1988), page 65.

[5]Henry D. Thoreau, "Huckleberries," edited by Leo Stoller ([Iowa City and New York?], 1970).

[6]John C. Kricher. *A Field Guide to Eastern Forests* [*of*] *North America* (Boston, 1988), page 66.

In terms that have an uncanny resemblance to Edward Johnson's "thickets," "ragged bushes," and "scorching plaine," Jorgensen describes the effects of forest fires:

> In the initial stages of regeneration following fire, the sprouting stumps[1] often produce impenetrable thickets. These sprout thickets are especially dense in areas where the previous forest itself was immature and thick following some earlier disturbance. . . .
>
> A number of shrubs are also favored by fire. Lowbush blueberry, *Vaccinium* spp., ***Gaylussacia baccata*** [a species of huckleberry], **sweet fern, *Comptonia peregrina***, and **sheep laurel, *Kalmia angustifolia*** [an indicator species of the Northern Pine–Oak Forest],[2] all quickly appear in burned-over areas, adding further competition in the regenerating forest. *In areas with a history of forest fires, these shrubs often form a continuous layer*.[3]

Jorgensen proceeds to discuss the pitch pine's ecological role in such fire-prone areas:

> Among the conifers of the region, only pitch pine, *Pinus rigida*, is thoroughly adapted to periodic burning. If all its foliage is burned away, needles will grow again on the branches. If the terminal shoot is killed, a new one will develop. If the trunk is killed, a new one will sprout from the base. On some trees the cones will remain closed for several years, in many cases until the heat of a fire opens them. Trees with this characteristic have evolved in areas with the worst forest fire history.[4]

In *Walden* Thoreau states that "There were scores of pitch-pines around my house, from one to four inches in diameter. . . ."[5] In his *Journal* he speculates on the place of the pitch pine in ecological succession:[6]

> . . . Though the pitch pines are the prevailing trees at the south end [of Hubbard's Wood, a part of Walden Woods], I see no young pitch pines under them.
>
> Perhaps this is the way that a natural succession takes place. Perhaps oak seedlings do not so readily spring up and thrive within a mixed white pine and oak woods as pines do,—in the more open parts,—and thus, as the oaks decay, they are replaced by pines rather than by oaks.
>
> But where did the pitch pines stand originally? Who cleared the land for its seedlings to spring up in? It is commonly referred to very poor and sandy soil, yet I find it growing on the best land also. The expression "a pitch pine plain" is but another name for a poor and sandy level. It grows on both the sand and [in] the swamp, and the fact that it grows on the sand chiefly is not so much evidence that it prefers it as that other trees have excluded it from better soil. If you cut down the pines on the pitch pine plain, oaks will come up there too. Who knows but the fires or clearings of the Indians may have to do with the presence of these trees there? They regularly cleared extensive tracts for cultivation, and these were always level tracts where the soil was light—such as they could turn over with their rude hoes. Such was the land which they are known to have cultivated extensively in this town, as the Great Fields and the rear of Mr. Dennis's,—sandy plains. It is in such places chiefly that you find their relics in any part of the county. They did not cultivate such soil as our maple swamps occupy, or such a succession of hills and dales as this oak wood covers. Other trees will grow where the pitch pine does, but the former will maintain its ground there the best. I know of no tree so likely to spread rapidly over such areas when abandoned by the aborigines as the pitch pine—and next birches and white pines.

In his *Birds of Concord* Ludlow Griscom discusses the role of fire on natural ecosystems and gives as a telling example the history of Walden Woods that corroborates Kricher's statements about the Northern Pine–Oak Forest. Griscom first assesses the impact of fires in general:

> Whether or not fires are regarded as destructive is largely a matter of human interest, and popularly they are so considered; but biologically they are neutral, as the destruction of one type of habitat and the local decrease of one set of birds are followed by the creation of a new habitat and the arrival of a new set of birds previously locally unknown or rare. Under *absolutely natural* conditions the area affected reverts to the primeval forest, but under

---

[1]Jorgensen states (page 105) that "Oaks, hickories, and red maple, all common southern New England trees, sprout vigorously from burned stumps following fire. . . ."

[2]*Kalmia angustifolia* is an "indicator shrub" of the Northern Oak–Pine Forest (Kricher, page 65), as are species of the genus *Gaylussacia*.

[3]Neil Jorgensen. *A Sierra Club Naturalist's Guide to Southern New England* (San Francisco, 1978), page 105.

[4]Neil Jorgensen. *A Sierra Club Naturalist's Guide to Southern New England* (San Francisco, 1978), pages 105 and 106.

[5]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), page 280.

[6]*Journal*, Volume 14, pages 271 and 272 (26 November 1860).

> modern civilized conditions this never happens and becomes theoretical. In certain cases where an area has been constantly (and unnaturally) fire-swept, the humus and the top soil have been completely destroyed and leached out, and foresters debate as to how long, if ever, it will take for original conditions to return.[1]

As a case in point, he describes the effects of fire on Walden Woods:

> An excellent example [of fire's effect on bird populations] is furnished by the Walden Woods between Concord and Lincoln. Thoreau accidentally set part of them on fire [the part near Fairhaven Bay], and was sharply criticized for letting the fire burn and not summoning aid.[2] But shortly after the lumbering of the old oak and chestnut woods of Brewster's youth with scattered stands of pine, a bad fire raged over 1000 acres in 1896 [in the vicinity of Brister's Hill],[3] followed by another in 1900. The area was reduced to a sandy scrub oak barrens, and largely remains so today [1948]. *The first colony of Prairie Warblers*[4] *in the whole region was found here by Walter Faxon in 1899; today it is abundant locally along with chewinks* [*i.e.*, towhees[5]], *field sparrows,*[6] *and thrashers.*[7]

As noted above, *all three* of the birds that Griscom mentions in his discussion of the role of fire in the history of Walden Woods—*viz.*, the chewink (*i.e.*, the rufous-sided towhee), the field sparrow, and the brown thrasher—as well as the prairie warbler, are "indicator birds" of the Northern Pine–Oak Forest of Kricher's system. Thoreau mentions three of them in *Walden*.

Brewster, in his book *Concord River*, reports seeing two of the indicator birds of the Northern Pine–Oak Forest—the brown thrasher and the rufous-sided towhee—in large numbers on Fairhaven Hill, a part of Walden Woods: "Brown Thrashers and Towhees numerous on Fairhaven Hill and in full song."[8]

Richard Walton[9] and Sandy Mallett[10] report that the prairie warbler is still found in the Concord area. It is a "markedly uncommon migrant and summer resident [there usually being "between five and ten pairs of summer residents"]. . . . The typical nesting habitat for this species in s.e. Massachusetts [primarily Cape Cod] is Pitch Pine and Scrub Oak. Locally [*i.e.*, in the Sudbury River valley], disturbed areas with second growth near sandy soil are the preferred nesting habitat," according to Walton. Forbush and May state that it breeds on "dry, open, brushy plains, with scattering trees, not far from water, also rocky bushy pastures," nesting in bushes or low trees.[11]

---

[1]Ludlow Griscom. *The Birds of Concord* (Cambridge, Massachusetts, 1949), page 60 and 61.

[2]Henry D. Thoreau. *Journal* (Boston, 1906), Volume , page ( ).

[3]Described in F. B. Sanborn's account, "Thoreau and the Walden Woods: The Damage by the Recent Fire Not As Great As Was Reported," Concord *Herald*, May 26, 1896, where it is said to have affected "less than half a square mile."

[4]An indicator bird of the Northern Pine–Oak Forest.

[5]An indicator bird of the Northern Pine–Oak Forest.

[6]An indicator bird of the Northern Pine–Oak Forest.

[7]An indicator bird of the Northern Pine–Oak Forest.

[8]Smith O. Dexter, editor. *Concord River: Selections from the Journals of William Brewster* (Cambridge, Massachusetts, 1937), page 29.

[9]Richard K. Walton. *Birds of the Sudbury River Valley—An Historical Perspective* (Lincoln, Massachusetts, 1984), page 167.

[10]Sandy Mallett. *A Year with New England's Birds* (Somersworth, New Hampshire, 1978), page 67. The reference here is to a prairie warbler seen along the Concord River in July, an indication that the bird was breeding in or near Concord. Mallett mentions prairie warblers on only two other pages of her 120-page book (pages 29 and 42). In both cases the reference is to *migrating*, as opposed to breeding, birds seen in May.

[11]Edward Howe Forbush and John Bichard May. *Natural History of the Birds of Eastern and Central North America* (Boston, 1939), page 439.

Thoreau mentioned a number of the other indicator species of the Northern Pine–Oak Forest, some of them in the book *Walden* itself. For example, he several times mentions the pine warbler (which Walton, page 166, describes as "An uncommon spring migrant and summer resident" in the Sudbury River valley) in his *Journal* (quoted in Francis H. Allen's *Notes on New England Birds*[1] and in Helen Cruickshank's *Thoreau on Birds*[2]), though none of these appear to refer to Walden Woods, but to other sandy plains in Concord, in these cases formed in Glacial Lake Concord. In *Walden*, he mentions the brown thrasher and the bluebird twice each,[3] the chipmunk and towhee once each.[4]

He mentions the whip-poor-will, another indicator bird of the Northern Pine–Oak Forest, several times. For example:

> Regularly at half-past seven, in one part of the summer, after the evening train had gone by, the whip-poor-wills chanted their vespers for half an hour, sitting on a stump by my door, or upon the ridge-pole of the house. They would begin to sing almost with as much precision as a clock, within five minutes of a particular time, referred to the setting of the sun, every evening. I had a rare opportunity to become acquainted with their habits. Sometimes I heard four or five at once in different parts of the wood, by accident one a bar behind the other, and so near that I distinguished not only the cluck after each note, but often that singular buzzing sound like a fly in a spider's web, only proportionally louder. Sometimes one would circle round and round me in the woods a few feet distant as if tethered by a string, when probably I was near its eggs. They sang at intervals throughout the night, and were again as musical as ever just before and about dawn.[5]

The great horned owl[6], another indicator species of the Northern Pine–Oak Forest, makes at least two long appearances in *Walden*—evidence that it indeed is an indicator species for Walden Woods (and, therefore, that Walden Woods can be characterized as a Northern Pine–Oak Forest). "I was also serenaded by a hooting owl," he says in the chapter "Sounds."[7] ". . . It reminded me of ghouls and idiots and insane howlings. But now one answers from far woods in a strain made really melancholy by distance.—*Hoo hoo hoo, hoorer hoo*; and indeed for the most part it suggested only pleasing associations, whether by day or night, summer or winter.

"I rejoice that there are owls," he writes. "Let them do the idiotic and maniacal hooting for me. . . ."

"For sounds in winter nights," Thoreau writes later, in the "Winter Animals" chapter of *Walden*,[8]

---

[1]Francis H. Allen, editor. *Notes on New England Birds by Henry D. Thoreau* (Boston and New York, 1910).

[2]Helen Cruickshank, compiler. *Thoreau on Birds* (New York, Toronto, and London, 1964).

[3]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), pages 158 and 319 and pages 302 and 310, respectively.

[4]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), page 302 (as "striped squirrel") and page 319 (as "chewink"), respectively.

[5]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), pages 127 and 128. Thoreau also mentions whip-poor-wills on pages 86, 128, 129, and 319.

[6]According to Walton (page 140), the great horned owl is "An uncommon permanent resident" of the Sudbury River valley. Its "hooting is noted at dawn or dusk often on the edge of extensive woodlands," he says; the bird is "more often heard than seen." It was encountered every year but two during the annual Concord Christmas Count from 1960 to 1983 (*ibid.*, page 195).

[7]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), page 125. Francis H. Allen (page 183) and Helen Cruickshank (page 111) both identify Thoreau's "hooting owl" as the great horned owl [*Bubo virginianus*], as did Thoreau himself in his *Journal* on November 18, 1851 (where he used the alternative name for that species, "cat owl"). Forbush and May (*Natural History of the Birds of Eastern and Central North America* [Boston, 1939]), page 265) give "cat owl" and "hoot owl" as alternative names for this species. They describe its calls as "a deep-toned hoot, a blood-curdling shriek, and many others."

[8]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), pages 171 to 172. Edward Howe Forbush and John Bichard May (*Natural History of the Birds of Eastern and Central North America* [Boston, 1939], page 265) say that great horned owls "become vocal" in January and February. They are less vocal later in the year, "but now and then, especially in autumn, their hooting may be heard" (page 266). They are nocturnal birds (page 266), "most active in the dark of the evening and on moonlit nights, but . . . may be hooting at times at midnight in the 'dark of the moon.'"

I heard the forlorn but melodious note of the hooting owl indefinitely far; such a sound as the frozen earth would yield if struck with a suitable plectrum, the very *lingua vernacula* of Walden Wood, and quite familiar to me at last, though I never saw the bird while it was making it. I seldom opened my door in a winter evening without hearing it; *Hoo hoo hoo, hoorer hoo*,[1] sounded sonorously, and the first three syllables accented somewhat like *how der do*; or sometimes *hoo hoo* only[2]. One night in the beginning of winter, before the pond froze over, about nine o'clock, I was startled by the loud honking of a goose, and, stepping to the door, heard the sound of their wings like a tempest in the woods as they flew over my house. They passed over the pond toward Fair Haven, seemingly deterred from settling by my light, their commodore honking all the while with a regular beat. Suddenly an unmistakable cat owl[3] from very near me, with the most harsh and tremendous voice I ever heard from any inhabitant of the woods, responded at regular intervals to the goose, as if determined to expose and disgrace this intruder from Hudson's Bay by exhibiting a greater compass and volume of voice in a native, and *boo-hoo* him out of Concord horizon. What do you mean by alarming the citadel at this time of night consecrated to me? Do you think I am ever caught napping at such an hour, and that I have not got lungs and a larynx as well as yourself? *Boo-hoo, boo-hoo, boo-hoo!* It was one of the most thrilling discords I ever heard. And yet, if you had a discriminating ear, there were in it the elements of a concord such as these plains never saw or heard.

In *October Farm*, William Brewster, who often encountered great horned owls near his farm in the northeastern part of Concord, describes an encounter with one on the Fairhaven Bay side of Walden Woods some forty-five years after Thoreau lived in the Woods.[4] Brewster and the naturalist Frank Bolles were paddling down the Sudbury River in April 1891:

It was very dark when we reached Fairhaven Cliff and Bolles began hooting like a Barred Owl. I followed with a feeble imitation of the Great-horned Owl which, after a few minutes and to my infinite surprise, was answered by Bubo himself from the tall pines on the west bank of the river. We stopped paddling, of course, and I continued the conversation in the best Owl language that I could command. Bubo was prompt in his responses and presently appeared directly over our heads—a great shadowy bird with broad wings and big head, flapping at first, then sailing as majestically as an Eagle, finally descending in a series of undulations to the low trees on the shore of

---

Thoreau heard the great horned owl "at sundown" on November 18 and 25, 1851; July 5, 1852; and December 9, 1856 (*Journal*; quoted in Allen, pages 183 to 188). In his *Journal* (December 19, 1856), Thoreau asks with respect to his "old acquaintance the owl" in Walden Woods, "Do I not oftenest hear it just before sundown?" On January 7, 1854, he noted that he heard it "Oftenest at twilight." On a moonlit winter evening (February 3, 1852), he heard "[his] owl" at The Cliffs of Fairhaven Hill (quoted in Allen, page 184).

Virtually every detail of Thoreau's accounts in *Walden* and his *Journal* of hearing the "cat owl" or "hooting owl" in Walden Woods or in the Ministerial Swamp–Dugan Desert area is consistent with Allen's and Cruickshank's conclusion that Thoreau heard the great horned owl, which is an indicator species of the Northern Pine–Oak Forest as defined by Kricher.

[1]Peterson (Roger Tory Peterson. *A Field Guide to the Birds* [Boston, 1980], page 172) describes the great horned owl's call as "A resonant hooting of 3 to 8 hoots. Male usually 4 or 5, in this rhythm: *Hoo, hoo-oo, hoo, hoo*. Female lower in pitch, 6 to 8: *Hoo, hoo-hoo-hoo, hoo-oo, hoo-oo*." Thoreau's bird was probably a male. William Brewster applies the adjective "sonorous" to the hooting of a great horned owl he heard on November 8, 1902 (Brewster, *Birds of Concord*, page 183). "Sonorous" (Brewster and Thoreau) and "resonant" are synonyms. Dictionaries (*e.g.*, *Webster's Third New International Dictionary of the English Language Unabridged* [Springfield, Massachusetts: G. & C. Merriam Company, 1976], pages 1933 and 2173) and thesauruses (*e.g.*, *Roget's II: The New Thesaurus* [Boston, 1980]; pages 778 and 873; *Webster's New Dictionary of Synonyms* [Springfield, Massachusetts, 1984)] pages 689 and 756; and *Roget's International Thesaurus*, fourth edition [New York, London, and Sydney, 1979], pages 340 and 1220) give "resonant" (Peterson's word) and "sonorous" (the adjectival root of Thoreau's adverb, "sonorously") as synonyms. There can be no doubt that the owl Thoreau heard during his stay in Walden Woods was the great horned owl.

[2] In "The Allegash and East Branch" Thoreau records "Ugh, ugh, ugh,—ugh, ugh" as his guide Joseph Polis' rendering of the call of the great horned owl:

Just below this, a cat-owl flew heavily against the stream, and he [Joseph Polis], asking if I knew what it was, imitated very well the common *hoo*, *hoo*, *hoo*, *hoorer*, *hoo*, of our woods; making a hard, gutteral sound, "Ugh, ugh, ugh,—ugh, ugh."

[3] "Cat owl" is an alternative vernacular name for the great horned owl (Roger Tory Peterson. *A Field Guide to the Birds* [Boston, 1980], page 172).

[4]William Brewster. *October Farm* (Cambridge, Massachusetts, 1936), page 23. The same episode is described by Bolles in "A Voyage to Heard's Island," pages 130 to 148 *in:* Frank Bolles. *Land of the Lingering Snow: Chronicles of a Stroller in New England from January to June* (Boston and New York, 1891), pages 134 to 140.

> the Cliff landing. More Owl talk and Bubo soon on his way back to the pines, evidently sorely puzzled and speedily impelled to repeat the flight which he made three times each way, in all, passing over us each time.

Later that evening, at eight o'clock, after the rising moon had flooded Fairhaven with light, they returned to the pine grove where the owl resided and heard the bird "hooting again in the middle of the woods." This encounter occurred, not within Walden Woods, but on its western boundary; the owl apparently lived on the opposite (western) side of the Sudbury River, on late deposits of Glacial Lake Sudbury[1], in woods identical to, but by definition not part of, Walden Woods.

Francis Allen states (page 183, note), with reference to the great horned owl, that "There appear to have been two pairs of these birds regularly in Concord in Thoreau's time,—one in the Walden woods and one in the Ministerial Swamp[2] in the southwestern part of town." His observation is consistent with Walton's statement that "The Great Horned Owl's relatively large territorial requirements . . . limit the number of pairs in [the Sudbury River valley]" and with the fact that both the Walden Woods and Ministerial Swamp–Dugan Desert owls occupied virtually identical, "sibling" geological features formed in Glacial Lake Sudbury.

Edward Howe Forbush, State Ornithologist, describes hearing a great horned owl just after dark one evening when he was staying at one of Brewster's cabins on the Concord River (about two miles north of Walden Woods) in September 1904.[3]

Allen (pages 183 to 189) quotes *Journal* entries on the great horned owls in Walden Woods for February 3, 1852; May 1, 1852; December 9, 1856; December 15, 1856; December 19, 1856; May 20, 1856; and June 18, 1858. The other quotations on those pages refer to the owls near Ministerial Swamp.

In the passage for May 20, 1858, Thoreau records seeing

> in the street a young cat owl, one of two which Skinner killed in Walden Woods yesterday. . . . I visited the nest. It was in a large white pine close on the north side of the path, some ten rods west of the old Stratton cellar in the woods. . . . There were many white droppings about and large rejected pellets containing the vertebræ and hair of a skunk. As I stood there, I heard the crows making a great noise some thirty or forty rods off, and immediately suspected that they were pestering one of the old owls, which Skinner had not seen. It proved so. . . .

In his *Journal* entry for June 18, 1858, Thoreau writes

> A boy climbs to the cat owl's nest and casts down what is left of it,—a few short sticks and some earthy almost turfy foundation, as if it were the accumulation of years. *Beside much black and white skunk-hair, there are many fishes' scales (!) intimately mixed with its substance, and some skunk's bones* [emphasis added].

According to Forbush and May (pages 266 and 267) "Great Horned Owls kill and eat many skunks, and seem to care little for the disagreeable consequences of attacking these pungent animals. Many of the owls that I [*i.e.*, E. H. Forbush] have handled give olfactory evidence of this habit." They report that the owl also eats fish, as well as many other animals, and that great horned owls are continually harassed by crows, as does William Brewster, who also reported "an unmistakable but not very strong smell of Skunk mingled with the more offensive odors" emanating from the pellets and excrement of great horned owls he found in Lawrence's Woods in Concord, but he "failed to find any skunk hair or other remains."[4]

In the last paragraph of "Sounds" Thoreau recapitulates, mentioning again several of the indicator species (as well as non-indicator species) of the Northern Pine–Oak Forest:

---

[1]See Koteff's map of the surficial geology of the *Concord* quadrangle.

[2]The Ministerial Swamp lies near what in Thoreau's time was called "Dugan Desert" (which was located near the southwestern corner of the modern-day Concord Country Club, near the present intersection of the Old Marlborough Road and Williams Road). It was an eroded or denuded sandy portion of the same kind of glacial-lake deposits on which Walden Woods occurs, but it lay west of the Sudbury River and thus would not be considered part of Walden Woods. The existence of the Dugan Desert demonstrates the unsuitability for agriculture of such fragile terrain. Forbush and May (*Natural History of the Birds of Eastern and Central North America* [Boston, 1939], page 265) state that the great horned owl nests in "dense forests [*e.g.*, Walden Woods] and swamps [*e.g.*, Ministerial Swamp]" [bracketed material added].

[3]Forbush and May. *Natural History of the Birds of Eastern and Central North America* (Boston, 1939), page 266.

[4]Smith O. Dexter, editor. *Concord River: Selections from the Journals of William Brewster* (Cambridge, Massachusetts, 1937), page 133.

> . . . . I kept neither dog, cat, cow, pig, nor hens, so that you would have said there was a deficiency of domestic sounds; . . . An old-fashioned man would have lost his senses or died of ennui before this. Not even rats in the wall, for they were starved out, or rather were never baited in,—only squirrels on the roof and under the floor, a **whip-poor-will** on the ridge-pole, a blue jay screaming beneath the window, a hare or woodchuck under the house, a screech owl or a **cat owl** behind it, a flock of wild geese or a laughing loon on the pond, and a fox to bark in the night. Not even a lark or an oriole, those mild plantation birds, ever visited my clearing. . . . A young forest growing up under your windows, and wild sumachs and blackberry vines breaking through into your cellar; sturdy **pitch pines** rubbing and creaking against the shingles for want of room, their roots reaching quite under the house. Instead of a scuttle or a blind blown off in the gale,—a pine tree snapped off or torn up by the roots behind your house for fuel. . .[1]

At the end of the "Spring" chapter of *Walden* is a paragraph remarkable for the wealth of ecological insights it supplies about the composition of Walden Woods, its plants and animals. In light of modern ecological knowledge of biotic communities, Thoreau's words, while those of a consummate artist and not designed to fit the constraints of scientific nomenclature, reflect accurately the natural world he saw around his house in Walden Woods. In this paragraph, Thoreau mentions no fewer than *five* indicator species of the Northern Pine–Oak Forest. Including the passages on the great horned owl, these five species, plus Griscom's mention of the prairie warbler, bring to seven the number of indicator species of the Northern Pine–Oak Forest recorded for Walden Woods. Others no doubt occur in Walden Woods. With this kind of evidence there can be little doubt that Walden Woods is a Northern Pine–Oak Forest community that is distinct from the surrounding Transition Forest.

In the next to the last paragraph of "Spring" Thoreau says:[2]

> Early in May, the **oaks**, hickories, maples, and other trees, just putting out amidst the **pine** woods around the pond, imparted a brightness like sunshine to the landscape, especially in cloudy days, as if the sun were breaking through mists and shining faintly on the hillside here and there. On the third or fourth of May I saw a loon in the pond, and during the first week of the month I heard the **whip-poor-will**, the **brown thrasher**, the veery, the wood pewee, the **chewink**, and other birds. I had heard the wood thrush long before. The phœbe had already come once more and looked in at my door and window, to see if my house was cavern-like enough for her, sustaining herself on humming wings with clinched talons, as if she held by the air, while she surveyed the premises. The sulphur-like pollen of the **pitch pine** soon covered the pond and the stones and rotten wood along the shore, so that you could have collected a barrelful. . . .

In this single paragraph of *Walden* Thoreau explicitly mentions four indicator species of the Northern Pine–Oak Forest and by implication a fifth. Together with the bluebird, chipmunk, and great horned owl and other species mentioned elsewhere in *Walden*, more than seven indicator species of the Northern Pine–Oak Forest are mentioned in this single volume. Thoreau does give short shrift to the indicator herbaceous species and vines, however, mentioning none of them in *Walden*. Even so, it is remarkable that a literary work should contain such an ecologically meaningful catalogue of species for one site. The fact that *Walden* does contain such a catalogue demonstrates the intimate link between *Walden* the book and Walden Woods. *Walden*'s ecological veracity answers, perhaps, to the book's artistic and spiritual veracity.

This analysis shows beyond any reasonable doubt that virtually all of the indicator species of the Northern Pine–Oak Forest whose ranges extend far enough east, north, or inland to encompass the Concord area occur in Walden Woods—or, to be more exact, on the Walden Sand Plain (*i.e.*, the Walden Pond Unit of the Walden Ecosystem). At the very least one can say that Walden Woods is an inland northeastern variant of the type. Individually, none of these species would warrant special attention. Individually, no one of them makes Walden Woods a recognizable Northern Pine–Oak Forest community. Collectively, however, they demonstrate forcefully that Walden Woods is such a community. After three and one half centuries of European influence, Walden Woods has become a mosaic—a crazy-quilt mosaic—of successional stages, for, once it was set off into many individual woodlots, smaller parts of Walden Woods (the individual woodlots) became subject to the random depredations of their owners. Before the Europeans arrived, the successional mosaic consisted of larger elements, since the fires had affected much larger areas than individual woodlots. Thus, Walden Woods became a patchwork of disparate successional stages, and appeared to lose its ecological identity and integrity. But only the regional climax, or an edaphically controlled or fire-maintained subclimax, community is stable and self-perpetuating; earlier successional stages are constantly being replaced by later successional stages. In short, the

---

[1]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), pages 127 and 128.

[2]Henry D. Thoreau. *Walden* (Princeton, New Jersey, 1971), pages 318 and 319.

entire patchwork of successional stages are moving toward and converging in the subclimactic Northern Pine–Oak Forest. If fires are suppressed for any length of time (several decades), Walden Woods may progress to the climatic, or regional, climax forest community.

Because this "island" of Northern Pine–Oak Forest is an identifiable biotic community that differs from surrounding communities it can be be dealt with as an ecological unit.

History of the Walden Ecosystem

By applying modern ecological knowledge to the fragmentary and disparate accounts of Concord's earliest history, one can develop a meaningful and coherent picture of the area as it was when the first Europeans arrived. There can be no doubt that the Indians regularly set fire to the woods there so as to create open space in which to cultivate crops, and to provide open woodlands for game animals, such as deer, which foraged on the tender grasses that came in after the fires. Nor can there can be any doubt that pine and oak were abundant, that the uplands were sandy and poorly suited for farming, or that the forests on the uplands had been burned by the Indians for millennia. Among those upland pine and oak forests, if not principal among them, must have been what came to be called Walden Woods.

Woodlands were plentiful in Concord at the time of settlement, consisting primarily of pine.[1] The Indians had cut and burned over "sandy fertile locations" for farming on the upland plains along the Musketaquid River (their name for the Sudbury–Concord River system); to attract game, they had cleared paths by burning the underbrush.[2, 3, 4]

The first European settlers of Concord had tried to cultivate the uplands, but found them to be of poor quality and unsuitable for sustained agriculture.[5] They must soon have concluded to leave the uplands in woodland, as a source of fuel and timber, raising their annual crops on the less arid and more fertile lowlands. The forest they encountered on the infertile, sandy uplands (dubbed "sand plains" by geomorphologists about a century ago) would have been Northern Pine–Oak Forest, whether in its earlier or later successional stages of development. Because of the continual burning to which it was subjected, whether the burning was caused by Indians or by lightning, Walden Woods and similar tracts of woodland growing on sand plains seldom if ever attained full maturity as biotic communities—*i.e.*, they never developed into the "climatic climax"[6] forest of the

---

[1]Charles H. Walcott. *Concord in the Colonial Period* (Boston, 1884), page 17.

[2]Charles H. Walcott. *Concord in the Colonial Period* (Boston, 1884), page 17.

[3]Barbara Robinson. From Musketaquid to Concord: Trading places. Pages 17 to 24 in Shirley Blancke and Barbara Robinson. *From Musketaquid to Concord: The Native and European Experience*. (Concord, Massachusetts, 1985), page 20.

[4]Howard S. Russell. *Indian New England before the Mayflower* (Hanover, New Hampshire, and London, 1980), page 121.

[5]Lemuel Shattuck. *A History of the Town of Concord* (Boston and Concord, 1835), page 15. Jorgensen (*A Sierra Club Naturalist's Guide to Southern New England* [San Francisco, 1978], page 107, says that, "Following the custom of aboriginal people in many parts of the world, the Indians regularly set fire to the woods both to clear it for agriculture and for primitive game management. . . ."

[6]Ecologists have distinguished two types of "climax" community, the "climatic climax" (also called "regional climax") and the "local climax" (also called "edaphic climax," from the Greek word for soil). The climatic climax community "is in equilibrium with the general climate of a region," while more localized, soil-influenced communities "are modified steady states in equilibrium with special local conditions of the substrate [*e.g.*, with the dry, sandy, fire-prone conditions of the Walden sand plain]" (Eugene P. Odum *Basic Ecology* [Philadelphia, New York, and elsewhere, 1983], page 469).

The concept of successional climax derives from the so-called "American plant-succession school" of plant synecology (the study of relationships between biotic communities and their environments), which originated with the Harvard geomorphologist, William Morris Davis. Davis hypothesized that, if climate could be held constant, erosion gradually would wear down all topographic eminences and fill up all depressions, creating a "peneplain"—a low, gently undulating, nearly featureless land surface of considerable extent that has been reduced by erosion almost to base level.

The American ecologist Frederick E. Clements applied this line of reasoning to vegetation, theorizing that such a peneplain eventually would be occupied by a climatic climax, a community of organisms best suited to the particular climate that was being held constant. Ecologists eventually realized that climate is not fixed, however. It changes, and its region, the Transition Forest. Since the Pleistocene glacier receded the Walden Sand Plain forest must nearly always have been a fire-dominated subclimax community—the Northern Pine–Oak Forest. After the Europeans arrived fire remained an important influence on Walden Woods. Yet, while subclimactic because of the fires, most of Walden Woods was seldom if ever—and then only temporarily—cultivated for crops.

Some of Walden Woods' soils theoretically were suitable for agriculture (that is, were not stony, shallow, steep, water-logged, *etc.*), but they were excessively drained and "droughty" and could have been farmed profitably only with the aid of irrigation. Given, first, the presence of much better agricultural soils nearby in Concord, second, the expense of irrigation, third, the primitiveness or even absence of irrigation technology during the first two or three centuries of European occupation, and, fourth, the general exodus of farmers from New England to the Midwest beginning in the mid-nineteenth century, it would have been unnecessary, exorbitantly expensive, foolhardy, or even impossible to squander one's meagre resources irrigating the dry soils of the Walden Sand Plain. Those soils were best left in woodland that could be tapped for fuel wood and timber as needed. The evidence presented graphically on maps dating from before 1820 to the present day—namely, the presence of virtually continuous woodland on the Walden Sand Plain—reflects these ecological and economic realities. Any exceptions to the general rule (and there have been a few exceptions) have been sporadic and short-lived.

As early as the 1830s, Lemuel Shattuck, the historian of Concord, distinguished the soils of Walden Woods and similar formations from those of other parts of Concord as follows:

> The uneven soil at the north and northeastern, and the south and southwestern parts of the town [*i.e.*, kames, deltas, *etc.,* laid down in glacial lakes Concord and Sudbury], appears to be of a primary formation, and is composed chiefly of a thin, gravelly loam, mixed with various combinations of sand, clay, decayed vegetable matter, and rocks. *Though not uniformly well calculated for agricultural purposes*, it contains some highly productive farms [emphasis added].[1]

Socioeconomic Pressures on the Walden Ecosystem

The woodlands of Concord and Lincoln have always been important sources of fuel for the inhabitants of those towns. Shattuck, the historian of Concord, states[2] (page 199) that "Wood grows here with great rapidity; and it is supposed there is as much now [1835] as there was twenty years ago.[3] Walden woods at the south, and other lots towards the southwest parts of the town, are the most extensive, covering several hundred acres of light-soil land. Much of the fuel, which is consumed, is, however, brought from the neighboring towns. The most common trees are the oak, pine, maple, elm, white birch, chestnut, walnut, &c., &c."

New England's forests were shaped by the revegetation of a glaciated landscape over the past 12,000 years. The glacier left behind a wet, poorly drained landscape over much of northern New England; it left thin,

---

changes affect the animals and plants of an area much more profoundly than does erosion. They came to realize also that fire, browsing, and windthrow are natural phenomena that are to be expected in most parts of the world.

Despite its purely theoretical nature the concept of climatic climax (and of the related term, local climax) reflects ecological realities. It is of great value to the science of ecology, providing a framework within which to understand and study ecological succession and the development, nature, and functioning of ecosystems, including the Walden Ecosystem (Stephen H. Spurr. The natural resource ecosystem. Pages 3 to 7 *in:* George M. Van Dyne, editor. *The Ecosystem Concept in Natural Resource Management* [New York and London, 1969], page 6; Robert L. Bates and Julia A. Jackson, editors. *Dictionary of Geological Terms*. Third edition [Garden City, New York, 1984], page 375).

[1] Lemuel Shattuck. *A History of the Town of Concord* (Boston and Concord, 1835), page 197.

[2] Lemuel Shattuck. *A History of the Town of Concord* (Boston and Concord, 1835), page 199.

[3] However, Shattuck presents statistics showing a significant reduction (approximately 33 percent) in the area of woodland in Concord between 1821 and 1831, from 3,262 acres to 2,048 acres. Shattuck gives the following statistics for the area of Concord in woodland at ten-year intervals from 1781 to 1831: 1781—3,878 acres; 1791—4,436 acres; 1801—3,635 acres; 1811—3,386 acres; 1821—3,262 acres; 1831—2,048 acres.

'ledgy' soils and wide areas of sand plain in southeastern Massachusetts, Rhode Island, and Cape Cod. Walden Pond, surrounded by oaks and pines, is an example of the sandy landscapes[1]

In an historical survey of New England's forests, Harper[2] (1918) enumerates several waves of new economic demands on the region's forests. With respect to Massachusetts, he notes (page 449) that

> The use of wood for fuel has been one of the greatest drains upon the forests [of New England]. Up to 100 years ago [circa 1820] it was practically the only fuel used in the United States . . . . In the *American Journal of Science* (vol. 20, pp. 133–136), in 1831, which was just at the dawn of the railroad era, the editor viewed with alarm the vast consumption of wood by steamboats, and urged a more general use of coal, which was then a novelty. Fifteen years later, in 1846, G. B. Emerson, in his classic report on the trees and shrubs of Massachusetts, published by the state, estimated that the railroads in that state (560 miles) were using for fuel 53,710 cords of wood annually, and that the consumption was not likely to decrease.

By means of a graph, Harper chronicles (page 447) a precipitous decline in the percentage of forest cover in Massachusetts between 1620 and 1910, the low point coming during the 1850s and 1860s. The fluctuating borders of Walden Woods as shown on the several maps (Hales, Walling, Wood, Appalachian Mountain Club, etc., to the present day) reflect the socioeconomic forces at work on Walden Woods.

During the 1830s much of Walden Woods between Walden Pond and Sandy Pond in Lincoln was cut to meet Boston's growing demands. MacLean[3] quotes part of the advertisement of a Concord farmer published in the early 1830s in the *Yeoman's Gazette, Mechanic's Journal*:

> . . . about thirty acres of WOOD standing on a lot in Lincoln, near Flint's [Sandy] Pond . . . sold by the cord or by the lot.

Cyrus Stow of Concord had for sale

> ALL the WOOD and TIMBER standing on eighteen acres of land—near to Flint's Pond in Lincoln.

MacLean notes that

> Joel Britton of Concord was also harvesting extensive woodlands in the west part of Lincoln [*i.e.*, in Walden Woods]. In October 1843, he listed for sale in Lincoln, along the road from Concord: ". . . from 700 to 1000 cords of Oak, Chestnut, Pine and maple Wood, separated and corded" and "50 to 100 cords of Hewing Chips, and a lot of Lumber." Five-and-a-half years later, Britton was still cutting and dealing, for he then included in a description of his Lincoln holdings:
>
>> . . . all the wood and timber cut by me during the past Winter together with all the wood standing on several lots of Land in said Lincoln being the same wood and timber purchased by me of Major Weston and Cyrus Stow also all the wood and timber owned by me and now lying near Bakers Bridge in said Lincoln ready for transportation on the Fitchburg Rail Road.[4]

The cutting of firewood had always been an essential part of the farmer's life in Lincoln and Concord, but with the growth of Boston the demand for wood increased considerably. In December 1831, for example, the following information appeared in the *Yeoman's Gazette, Mechanic's Journal* in December 1831:

> The present fine sleighing and the continued high price of fuel in Boston, keeps our farmers quite busy—so much so, that it is with difficulty that we can get a stick of wood into our market, notwithstanding it goes quick at $4.00 a cord. We learn that one of our driving farmers, with no other assistance than his usual farm help, took $83 last

---

[1]Lloyd C. Irland. *Wildlands and Woodlots: The Story of New England's Forests* (Hanover, New Hampshire, and London, 1982), page 19.

[2]Roland M. Harper. Changes in the forest area of New England in three centuries. *Journal of Forestry*, Volume 16, Number 4, pages 442 to 452 (1918), page 449.

[3]John C. MacLean. *A Rich Harvest: The History, Buildings, and People of Lincoln, Massachusetts* (Lincoln, Massachusetts, 1987), page 441.

[4]John C. MacLean. *A Rich Harvest: The History, Buildings, and People of Lincoln, Massachusetts* (Lincoln, Massachusetts, 1987), page 442.

> week in Boston for wood; he kept three teams on the road all the time. Let all our farmers imitate this one, and Boston folks will not freeze this winter.[1]

In 1841, four years before the Fitchburg Railroad was built, George B. Emerson, author of several works on the trees and forests of Massachusetts, spoke at the Legislature's Tenth Agricultural Meeting, held at the State House, on "The Forest Trees of Massachusetts."[2] Discussing the economic uses of the state's forests, he mentions, among other uses, fuel and timber (for shipbuilding, etc,); but as the railroads were very new at the time and apparently had scarcely yet affected the state's forests, he makes no mention of them. A mere five years later, even as Thoreau was living in Walden Woods, Emerson reported to the Legislature again, mentioning this time the large quantities of wood being consumed to fuel railroad locomotives throughout the state.[3] He does not mention the Fitchburg Railroad, however, perhaps because it was so new, having been built only two years before.

After 1844, the Fitchburg Railroad would transport many cords of wood from Walden Woods and elsewhere to Boston. During the 1850s the railroads of the United States used some 4 million to 5 million cords of wood per year to generate steam in locomotive engines, and after the switch to coal, which itself had powerful environmental effects, the railroads still needed wood for ties. In 1910, one-fourth of the nation's total wood consumption was accounted for by this use.[4]

During the early 1850s Thoreau witnessed with anxiety and sadness the accelerating destruction of Walden Woods, mourning their destruction. He describes in *Walden* "timber like long battering-rams going twenty miles an hour against the city's walls." In 1853, he complained, "You can walk in the woods in no direction but you hear the sound of the axe."[5]

Expressing alienation at the loss, he records in his *Journal* (entry for January 24, 1852):

> I see in the woods [in Walden Woods] the woodman's embers, which have melted a circular hole in the snow, where he warms his coffee at noon. . . .
>
> These woods! Why do I not feel their being cut more sorely? Does it not affect me nearly? The axe can deprive me of much. Concord is sheared of its pride. I am certainly the less attached to my native town in consequence. One, and main, link is broken. I shall go to Walden less frequently.[6]

Although the virgin forests of New England have been reduced from 95 percent of the landscape to 5 percent, enough time has elapsed since widespread lumbering operations took place that the forests have begun to regain a semblance of their original primeval character, especially in protected areas. The recovering species are primarily birch, a few white pines, red pines, and red oaks.[7]

Significance of the Walden Ecosystem

Had Walden Woods not existed, or had its character been different from what it is, the book *Walden* would have been a very different book—had it been written at all. The Walden Sand Plain provided habitat for a distinct biotic community, the Northern Pine–Oak Forest, as well as a place of resort for Thoreau. Both the

---

[1]Quoted in John C. MacLean. *A Rich Harvest: The History, Buildings, and People of Lincoln, Massachusetts* (Lincoln, Massachusetts, 1987), page 441.

[2]"Forest Trees of Massachusetts," *Boston Semi-Weekly Advertiser*, March 27, 1841.

[3][George B. Emerson.] *Report on the Trees and Shrubs Growing Naturally in the Forests of Massachusetts* (Boston, 1846), pages 15 and 16.

[4]John H. White, Jr., "Railroads: Wood To Burn," pages 199 to 201, 215 *in:* Brooke Hindle, editor, *Material Culture in the Wooden Age* (Tarrytown, New York, 1981). Quoted in Thomas J. Lyon, editor, *This Incomperable Lande: A Book of American Nature Writing* (Boston, 1989), page 56.

[5]Henry D. Thoreau. *The Journal of Henry D. Thoreau* (New York, 1962), Volume 1, page 521 (28 January 1853).

[6]Henry D. Thoreau. *The Journal of Henry D. Thoreau* (New York, 1962), Volume 1, page 330.

[7]Ann Sutton and Myron Sutton. *Eastern Forests* (New York, 1985), pages 43 and 45.

existence and character of Walden Woods were crucial prerequisites for the creation of *Walden*. Had the Walden Ecosystem been significantly different from what it is, then *Walden* would have been significantly different, or nonexistent. If, for example, the Walden Ecosystem had not been the Walden Ecosystem we know, then the following features of the landscape would have been absent from the book *Walden*: Walden Woods, Walden Pond, Brister's Hill, Brister's Spring, the Deep Cut, the Boiling Spring, Baker Farm, Pleasant Meadow. The former human inhabitants of Walden Woods, many of them freed slaves or social outcasts, and Alek Therien, the woodchopper, would not have lived or worked in Walden Woods. Were the hydrological regime of the sand plain (which is a kame and delta complex) not what it is, Thoreau would have had been unable to develop the psychologically powerful symbolism he did around the "sympathic" subterranean relationship of Walden, Goose, and Sandy ponds to each other, their simultaneous rising and falling, and so on.

To be sure, as a master artist he might have used other features of landscape to achieve the same or a similar end, but *Walden* would have been quite a different book had he been forced to do so. And, of course, had Walden Woods not been a Northern Pine–Oak Forest, many of the animals (whip-poor-will, towhee, great horned owl, thrasher) and plants (pines, shrub oak, huckleberry) would likely not have been found there. Had there been no dry, sandy soil at Walden, but a richer soil, the beanfield might never have existed. Had Walden Pond not been oligotrophic, but eutrophic, its waters would not have been so pure as they are, and Thoreau would have had to resort to other strategies and devices in his art. Were there no sand plain, or kame delta, there would have been no Brister's Spring beside which Thoreau could refresh himself after a hard morning's work in the beanfield, no Deep Cut whose oozing sands and clays provided Thoreau with the perfect symbol of renewal and rebirth.

From both the literary and the scientific perspective Walden Woods occupies a strategically important position in the development of American culture, particularly in those aspects of American culture dealing with man's attitudes toward and relationship to the natural world. Because of the Walden Sand Plain's distinctive characteristics, Henry Thoreau had a pond and a surrounding forest to which he could resort for his literary and scientific pursuits. The pond and the forest have become symbols of wildness in American culture.

Were the preglacial geology, the Pleistocene geology, and the land-use history of the Concord–Lincoln area not what they are, Thoreau would never have been able to write a book like *Walden* or discover the principles of ecological succession, because the Walden Woods area would not have remained largely in woodland but would have been cleared and exploited for annual crops like those raised in the surrounding parts of Lincoln and (especially) Concord. There is a direct cause-and-effect link between the surficial geology of the Walden Woods area and both the substance and character of Thoreau's writings—his *Journal*, *Walden*, and "The Succession of Forest Trees," in particular. There is a similar cause-and-effect link between surficial geology and the character of the Walden Northern Pine–Oak Forest ecosystem. Absent Glacial Lake Concord and its bottom deposits and there would have been no prosperous intellectual center like the village of Concord to draw Emerson and the other Transcendentalists. Absent the ice-contact glacial-stream and glacial-lake features of Glacial Lake Sudbury and there would have been no accessible Walden Woods back country for Thoreau and thus neither the book *Walden* nor the essay "Succession of Forest Trees," nor beautiful landscape to inspire him and the other Concord authors.

The history of Concord—economic, social, literary, and spiritual—is inextricably linked to the glaciation-created surficial geology of the surrounding countryside. The juxtaposition of rich farmland (bottom deposits of Glacial Lake Concord) and wooded back country (ice-contact deposits of Glacial Lake Sudbury) created a dynamic interplay between the ongoing development of American culture as manifested in Concord's lively political, social, and intellectual life in pre-Civil War America on the one hand, and the nearby still-wild tracts of land on the other. Concord was America in microcosm: it reflected a burgeoning social and economic force on the one hand and the country's wilderness and frontier heritage on the other. Concord's history and geography, related like hand to glove, reflected and influenced development of the larger culture.

Clearly, the very substance and character of *Walden* are linked inextricably, in a cause-and-effect manner, to the characteristics of the Walden Ecosystem. To the humble scenery and unremarkable denizens of this living ecosystem we owe, in large measure, one of the masterpieces of American literature.