How "Natural" Are Inland Wetlands? An Example from the Trail Wood Audubon Sanctuary in Connecticut, USA

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ABSTRACT / We examined the geology of a small inland wetland in Hampton, Connecticut to determine its postglacial history and to assess the severity of human impact at this remote wooded site. Using stratigraphic evidence, we demonstrate that the present wetland was created when sediment pollution from a 19th-century railroad filled a preexisting artificial reservoir, and that the prehistoric wetland was a narrow drainage swale along Hampton Brook. This same, severely impacted wetland was interpreted by the Pulitzer Prize-winning naturalist Edwin Way Teale as a beautiful wilderness area of particular interest. These conflicting perceptions indicate that artificial wetlands can be naturally mitigated in less than a century of healing, even in the absence of deliberate management. We also point out that the "wilderness" value of the Teale wetland was in the eye of the beholder and that unseen human impacts may have improved the aesthetic experience.

Beneath much of the controversy involving wetland regulation is the assumption that modern wetlands are ecologically sensitive natural systems that developed over millenia of postglacial time (Johnson 1985). Although this view is generally correct for large mires (Gore 1983, Walker 1970), is it equally true for small inland wetlands in the northeastern United States? Is the national zeal for wetland protection based on the public's appreciation of their biogeologic functions, or is our enthusiasm colored by an erroneous perception of wetland antiquity or naturalness? We especially want to protect our "best" wetlands, but what criteria are used to measure "quality" or "wilderness value?" We constantly hear about the sensitivity of inland wetlands, but over what time scale and at what resolution should "sensitivity" to anthropogenic changes measured?

The public assumes that such questions have been readily answered by today's scientist-managers and that wetland truths are self-evident. Those of us who read this journal, however, know better. Gone are the euphoric days of the early 1970s when wetlands protection rode the wave of unquestioned public support (Reilly 1979). Unfortunately, we now work in a climate of public opinion clouded by litigation and that increasingly demands maximum value for every management dollar. In order for us, as environmentalists, to protect wetlands in such a climate, we must be prepared to give the public technical and tactical answers to the questions posed above.

KEY WORDS: Wetland history; Human impact; Wilderness; Geology

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Since initial settlement in the early 17th century, the ecology and landscape of southern New England have been altered radically by agricultural and industrial land-use practices. Geomorphic theory alone would suggest that no part of New England's hydrologic system would have escaped human impact (Toy and Hadley 1987). Moving beyond theory, direct historic records of wetlands modification in Connecticut (Cronon 1983) parallel those in Europe, where "... few wetland ecosystems have escaped disturbance in one form or another." (Tallis 1983, p. 320). Modern studies confirm that historic impacts are common, if not ubiquitous (Barske 1988, Niering 1987), but seldom are these impacts quantified, measured, or evaluated relative to the presettlement character of the wetland (Brugam 1975, being a notable exception). Central questions involving the perceived antiquity, sanctity, and sensitivity of our inland wetlands can only be addressed when we have learned their aggregate life histories and ecologic trajectories.

In this article, we examine the history of a single small wetland in the woodlands of northeastern Connecticut, USA. Our objectives are to show how geological methods may be used to reconstruct the sequence of events, to document the postglacial stratigraphy at this site, and to illustrate how rapidly this wetland revegetated and "recovered" after an apparently unrecognized disturbance. We chose our study site because it was perceived as "natural" and "wild" by a highly regarded naturalist only a century after its inadvertent creation. Our site, hereafter referred to as the Hamp-

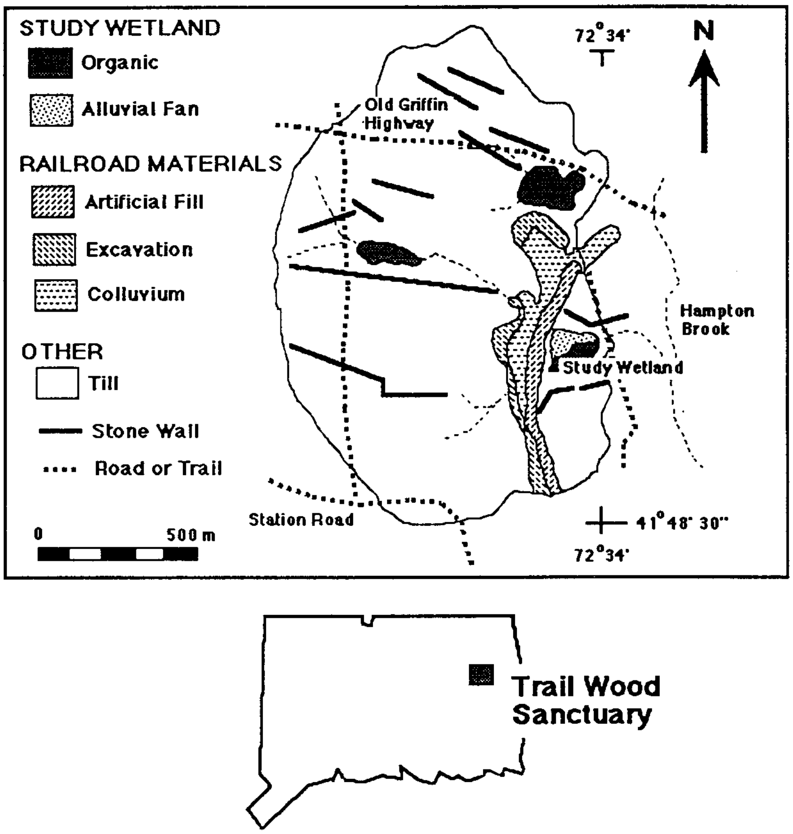

Figure 1. Photogeologic map showing location of Hampton-Teale wetland, which contains the western headwaters of Hampton Brook. Note that wetland is underlain by alluvial deposits to the north and organic deposits to the south. Three units associated with railroad construction lie along the western edge of the wetland.

ton-Teale wetland, is now part of Trail Wood, a wilderness preserve and memorial wildlife sanctuary in Hampton, Connecticut, now managed by the Connecticut Audubon Society (Egler 1987).

Setting

The Hampton-Teale wetland is a small (0.89-ha) minerotrophic swamp located in the town of Hampton (41°48′58″N, 72°04′05″W) within the western headwaters of Hampton Brook (Figure 1). It lies within the Eastern Highlands of Connecticut, an area representative of much of the upland glaciated terrain of southern New England (Denny 1982). Watershed drainage patterns result primarily from differential erosion of high-grade crystalline metamorphic rocks during Cenozoic time (Rodgers 1985). Watershed soils are predominantly sandy loams and stony sandy loams classified as dystochrepts and udorthents (Cunningham and Ciolkosz 1984), reflecting moderate to weak horizonification under acidic postglacial conditions. The modern climate is temperate and highly variable, with mean July and January temperatures of 21°C and −2.3°C, respectively, and an annual precipitation (1233 mm) distributed evenly throughout the year (Ruffner 1985). Vegetation in the area is part of the Appalachian Oak Forest Section of the Eastern Deciduous Forest (Bailey 1978) and consists largely of areas reforested after abandonment of farms; dominant trees are oak, maple, hickory, ash, hemlock, and white pine.

The watershed of the Hampton-Teale wetland is large (0.9 km^2) relative to the size of the wetland, ellipsoidal in shape, 0.9 km in length, and has maximum and minimum elevations of 229 m and 170 m (Figure 1). Using a general hydrologic model (Miller and others 1986), we estimate its mean daily discharge as 1326 m^3/day. It is underlain principally by rusty-weathering schists (Dixon and Pessl 1966) with a strongly expressed east–northeast foliation subparallel to the path of Hampton Brook through the wetland. All of the watershed is mapped as till (Dixon and Pessl 1966), deposited by the Laurentide ice sheet sometime prior to deglaciation about 16,000–17,000 yr BP (Ridge and Larsen 1990). The till consists of a very stony loosely consolidated diamict adjacent to the wetland, but sandy coarse gravel forms the southern border of the wetland. Bedrock outcrops are restricted to the downstream channel of Hampton Brook. The thin stony soils and steep slopes in the watershed suggest that this part of Hampton Brook is characterized by heavy storm flow.

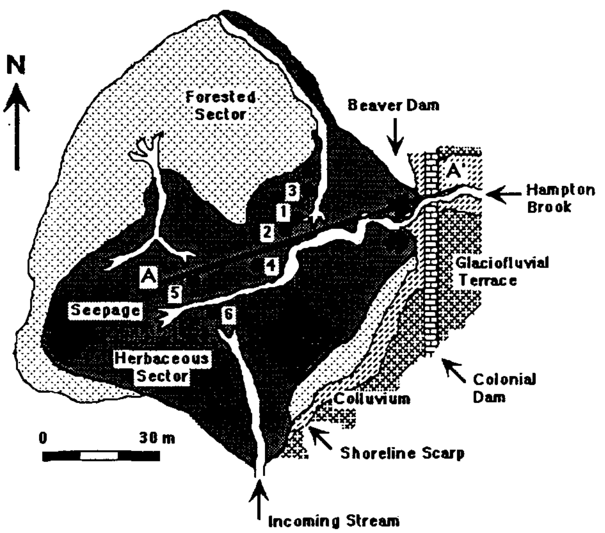

Figure 2. Generalized geologic map of the Hampton-Teale wetland showing location of cores along transect A–A'. Core stratigraphy shown in Figures 4 and 5. The alluvial and organic deposits shown in Figure 1 underlie the forested and herbaceous sectors, respectively. An abandoned road lies above the collapsed stone-faced dam.

The Hampton-Teale wetland consists of two principal sectors (Figure 2). To the north, red-maple shrubs cover a sandy substrate sloping gently towards the main stream. The southern sector contains a diverse herbaceous cover below a stand of large dead red maples (*Acer rubrum*), many of which recently have blown down. The southeastern edge of the wetland is bounded by a small (50 cm high) scarp cut into the gravelly colluvial slope. The western edge of the wetland lies 40–60 m east of an abandoned railroad embankment. Three small tributaries, which originally drained centripetally into the wetland, now drain through an abandoned culvert beneath the railroad embankment where they dissipate on the wetland surface. The main stream in the wetland originates as coalesced seepage lines and drains east–northeast through a collapsed spillway cut below an abandoned dam. Subsidiary channels enter the wetland but also dissipate before joining the main channel. A beaver dam, built against the upstream side of the failed spillway, was apparently responsible for killing the large trees, which remain largely undecomposed. The beaver dam was recently breached by storm flow and has since been abandoned.

The terrain surrounding the Hampton-Teale watershed was settled at or just before the middle of the 18th century, about 250 years ago. Many abandoned colonial roads and stone walls in the watershed, and a mosaic pattern to the vegetation, suggest that the typical pattern of agricultural use (pasture, woodlot, tilled fields) prevailed from initial settlement until the area was abandoned as a working farm about 1940 (Gradie 1990) (Figure 1). The present Trailwood property was assembled between 1840 and 1860 and worked intensively until 1940, but operating farms are still present along the western edge of the watershed. An abandoned colonial road, which forms the eastern border of the wetland, crosses Hampton Brook on a low earthen dam approximately 40 m long and 1.5 m high with a stone air face. A partially stone-lined spillway situated midway across the dam has been eroded out, and Hampton Brook drains over the rubble as a perennial cascade. The limited storage capacity of the pond and its location high in the drainage headwaters suggest that it was constructed as a watering place for cattle; heavy grazing in this area during the agricultural period, as indicated by the vegetation (Egler 1987, p. 13), supports this interpretation. A 20-m-high embankment, constructed for the bed of the Boston-New York-Erie Railroad between 1869 and 1871 parallels the western edge of the wetland about 200–250 m west of the outlet.

Methods and Results

We determined the distribution, elevation, and character of surficial sediments in the wetland vicinity using aerial photography, shallow excavations, test cores, and a stainless-steel probe. Spatial coordinates for unit boundaries, specific features, and core locations were established with an alidade survey, using an arbitrary vertical datum of 10.00 m (Figures 2 and 3). The thickness of soft sediments was determined at all 48 survey control points, each of which was selected on the basis of spatial coverage and an unobstructed view. We walked all unit contacts in the field. We obtained six cores in 1-m increments along a transect parallel to Hampton Brook using a 5-cm-diameter modified Livingstone piston coring device. Core locations were selected as an optimum trade-off between known stratigraphic depth, the presence of an open brush-free clearing for work, and a lengthy transect; conditions were too brushy to the north and too shallow to the south. We selected core 3 as the reference core for detailed analyses; units from other cores were correlated to it on the basis of stratigraphic position and character (Figure 4). Sediment compaction was determined using penetration depth and pre- and postextrusion lengths. Refer to Thorson (1990) for details of the field methods used.

Laboratory analyses of cores included lithostratigraphic description, pollen analyses, loss-on-ignition, and macrofossil identification. Lithologic description included qualitative observations of sediment grain size, texture, shape, compaction, bulk density, organic con-

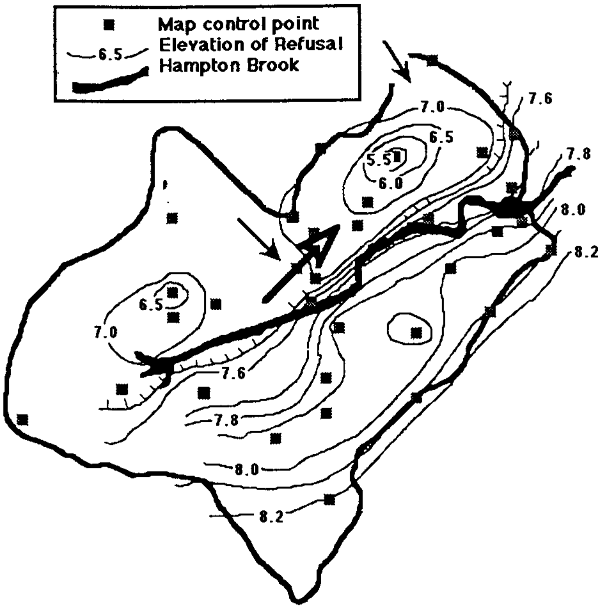

Figure 3. Contour map of the southern herbaceous sector of the Hampton-Teale wetland showing relative elevation of refusal. Points north of the 7.5-m contour line (hachured) are minimum limiting values for the depth to bedrock. Points south of the line indicate depth to bedrock or large boulders. Large open arrow shows direction of wetland slope prior to historic settlement based on top of unit 7. Smaller solid arrows show paleocurrent direction and slope of the alluvial fan (unit 10) caused by railroad construction. Scale shown on Figure 2.

tent, degree of decomposition, Munsell color, bed thickness, and sedimentary bedforms (Table 1, Figure 5). Loss-on-ignition testing followed the procedures of Aaby (1986). We prepared, counted, and plotted pollen grains using procedures outlined by Faegri and Iverson (1975) (Figures 6 and 7). We differentiated local pollen as those plants whose dominance is most likely to reflect wetland vegetation. We identified macrofossils and estimated their relative abundance from the washed fraction retained on a 1-mm seive (Table 2).

Chronology for our study was provided by radiocarbon, biostratigraphic, and historic-correlation dates (Table 3). Radiocarbon samples were washed, oven dried, and submitted to Beta-Analytic for pretreatment, counting, and stable-isotope corrections; dates are reported in ^{13}C-corrected ^{14}C yr BP (before 1950). We assigned biostratigraphic dates by comparison of the pollen diagram from core 3 to well-dated regional pollen chronologies (Davis 1983, Gaudreau and Webb 1985, Jacobson and others 1987); the error associated with these dates involves not only the vertical sampling resolution at Hampton-Teale, but the resolution of the radiocarbon chronology in the regional record. We adopt a chronological resolution of ±500 yr for biostratigraphic dates. Historic correlation dates are those for which a stratigraphic horizon in the cores can be unambiguously correlated to a documented historic event; we report them as calendar years before 1990.

Geological Interpretation

Mapping

Figures 2–4 show the spatial distribution of geologic units and other features. The present herbaceous wetland lies between 8.4 and 8.0 m above datum, sloping imperceptibly towards its outlet over the breached spillway. The crest of the dam and the road surface lie only 0.7 m above the lowest portion of the wetland, but 2.1 m above the bedrock channel of Hampton Brook on the eastern side of the dam (Figure 4). The presence of isolated large boulders, protruding through the herbaceous surface, and consistently shallow (<50 cm) sediment cover on the south side of the stream indicate that bedrock lies near the surface (Figure 3). Two deep basins in excess of 3 m depth lie north of the stream. Near the main channel, the depth to refusal increases dramatically in a south-to-north direction from 7.6 m to deeper than 6.5 m above datum, along a minimum reconstructed slope of 13°. The sharpness and continuity of this break, and its parallelism to the regional foliation, suggest that the slope break is a buried ledge of bedrock, which controls not only the depth of sediments, but the path of the stream as well.

Lithostratigraphy

The lowest six stratigraphic units represent a conformable sequence of interbedded strata interpreted to represent filling and shoaling of a small pond (Figure 5). All units contain less than 10% organic matter by dry weight. Unit 1 contains no disseminated organic material or pollen grains, includes schistose granules, and has well-preserved macrofossil fragments, suggesting that it was deposited postglacially from a nearby source without significant interruption; the presence of graded rhythmites is indicative of rapid deposition by intermittent sediment density underflows at water depths in excess of several meters. The absence of bedding, higher content of dissemenated organic matter, and the presence of pollen in unit 2 suggests slower accumulation as slightly organic pond silts; the presence of intraclasts suggests that the pond may have been shallow enough for root and(or) animal bioturbation. The sandy, more mineral-rich character of unit 3, which occurs above a basal detrital lag horizon composed of woody stems and twigs, represents an abrupt increase in allochthonous mineral input into at least a seasonally deeper pond.

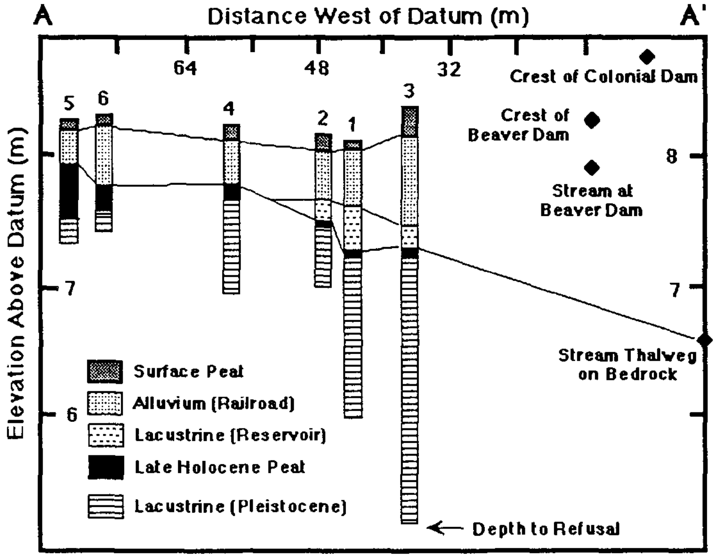

Figure 4. Diagram showing correlation and elevation of lithostratigraphic units and other features. Basal correlation line marks the top of the presettlement wetland.

Within unit 4, the gradual decrease in grain size and more evenly bedded character suggest that a reduced rate of background sedimentation was periodically interrupted by discrete sediment inputs, perhaps during storms. The higher amount of disseminated organics in unit 5, in conjunction with discrete sand interbeds, suggests that slow accumulation in an organic pond was periodically interrupted by minor erosional discontinuities, which we interpret to represent gradual shoaling and winnowing of the pond margin. Unit 6 is similar to the underlying organic-stained mineral silt but contains no bedding, suggesting bioturbation by rooted plants.

Unit 7, the lowest peat, lies in sharp contact with the underlying regressive sequence. Its fibrous and layered character and maximum organic content for the entire core (15%) indicate that it accumulated in situ as partially decomposed herbaceous litter and roots. Plant fragments consist almost entirely of monocot epidermis, suggesting a persistent cover of obligate hydrophytes such as sedge and grass (Cowardin and others 1979).

Unit 8 represents a radical change in sedimentation from the underlying peat. Its clayey texture and delicate bedding and the inclusion of multiple beds of undecomposed fragile plant rootlets and stems in growth position convincingly demonstrate that it was deposited by fallout of suspended mineral matter from a turbid pond which, on several occasions, drained long enough to be colonized by herbaceous plants. Its uppermost 2 cm is heavily organic stained, suggesting incipient soil development and peat accumulation after final drainage of the pond. Unit 9 marks an abrupt return to slackwater accumulation of evenly bedded inorganic sand and silt, which in turn abruptly coarsens upward into the coarse granule sand and fine gravel of unit 10. The coarse size of the largest clasts (>30 mm), the scour channels reflected in unconformable bed contacts, and the southeasterly imbrication of discoidal clasts indicate a fluvial origin in a braided channel carrying sandy gravel; the abundance of coal and cinder in the gravel indicates that the railroad embankment served as a dominant sediment source. The woody peat of unit 11 indicates that fluvial aggradation was interupted by organic deposition, possibly in an abandoned channel. The overlying unit 12 is interpreted as a return to lacustrine deposition in a shallow pond. Unit 13, a woody bioturbated peat, indicates drainage of the pond prior to emplacement of current-bedded (fluvial) sand (unit 14) and coal-bearing gravel (unit 15). The uppermost peat (unit 16), which rises to the surface of the present herbaceous cover, is woody near its base, becoming more hemic and fibrous at the top.

The uniqueness of the lowest peat (unit 7), its overlying lacustrine clay (unit 8), and the cinder- and coal-bearing coarse clastics (units 9 and 10 and units 14 and 15), facilitate unambiguous correlation of the upper meter of cores 1–6 (Figure 4). Although lacustrine (pond) strata similar to units 1–6 were present in all cores, correlation of specific units cannot be demonstrated.

Regional Pollen Stratigraphy and Chronology

Eight dates—two radiocarbon, four biostratigraphic, and two historic-correlation—provide chronological control for the sequence (Table 3). The basal lag of detrital organic matter in unit 3 dates 11,290 ± 170 yr

Table 1. Abbreviated description of stratigraphic units in core 3

Depth (cm)	Unit	Description
0–20	16	Woody peat. Matrix is very dark grayish brown (10YR 3/2) peaty silt mottled to reddish brown (5YR 4/4) along rootlets. Sharp contact.
20–28	15	Coarse sand. Light olive brown (2.5Y 5/4) massive coarse sand and granules including abundant cinder and coal fragments to 20 mm diameter. Top 1 cm is bedded sand. Sharp, conformable contact.
28–30	14	Silt. Dark olive gray (5Y 3/2) inorganic silt, laminated in places, and including coal. Sharp contact.
30–43	13	Woody peat. Black (10YR 2/1) degraded organic silt with abundant wood fragments. Minor washed sand horizons near base. Sharp erosional contact.
43–60	12	Bedded sandy silt. Very dark grayish brown (2.5Y 3/2) massive, slightly organic silt with carbonized twigs. Sharp contact.
60–63	11	Organic sandy silt. Very dark gray (10YR 3/1), with abundant large wood fragments. Sharp contact.
63–74	10	Coarse sand. Cleanly washed light olive brown (2.5Y 5/4) unit containing two graded sequences of coarse-to-medium sand with abundant coal and wood and rare cinder clasts. Erosional contact.
74–86	9	Sand. Upper 8 cm contains dark olive gray (5Y 3/2) massive silty sand with clayey silt partings. Lower 4 cm is a graded sequence of washed fine sand.
86–104	8	Silty clay. Bulk of unit is stiff, weakly bedded dark olive gray (2.5Y 3/2) inorganic silty clay with zones of well-preserved herbaceous rootlets. Basal 4 cm exhibit delicate laminae of clay, silt, and fine detrital organics. Very sharp contact (most distinct of all).
104–110	7	Fibrous layered peat. Massive zone of layered plant tissue in dark reddish brown (5YR 2/2) oxidized organic-stained sandy silt. Sharp contact.
110–122	6	Organic silt. Generally dark reddish brown (5YR 2/2) organic silt interbedded with dark olive gray (5Y 3/2) inorganic silt. Contains abundant detrital twigs. Mixed lower contact.
122–143	5	Interbedded silt. Dark grayish brown (10YR 4/2) sandy silt thinly interbedded with laminae of cleanly washed medium-to-fine sand. Organic staining more common at top. Sharp erosional contact.
143–180	4	Bedded sandy silt. Weakly bedded, slightly organic-stained stiff, micaceous, dark grayish brown (10YR 4/2) sandy silt. Increasing organic content upward with organic laminae at 172 cm. Mottled sand concretions near gradational contact.
180–217	3	Peaty sand and silt. Massive, stiff, inorganic very dark grayish brown (10YR 3/2) sand and silt matrix with abundant woody detrital plant fragments, intraclasts, and rhizomes/rootlets. Becomes more silty upwards. Lag of detrital wood fragments at erosional contact.
217–240	2	Organic silt. Massive, unlaminated very dark gray (5Y 3/1) organic silt with minor plant fragments. Sharp contact.
240–301	1	Bedded sandy silt. Weakly bedded very dark gray (5Y 3/1), slightly micaceous, stiff clayey and sandy silt with prominent organic-stained laminae and rhythmic bedding more common near top. Minor detrital fragments.

BP, confirming a Pleistocene age for the lower lacustrine sequence. The dominance of herbaceous pollen, and such species as *Alnus, Salix,* and *Betula,* together with *Pinus* in the basal pollen sample suggests that the base of the core is younger than 14,000 yr BP, probably 12,000–13,000 yr BP. The much younger radiocarbon date of 1120 ± 70 yr BP provides an average age for the lowest peat (unit 7), a date consistent with the abundance of chestnut (*Castanea*) pollen (<2000 yr BP). The uppermost pollen sample in the subjacent unit 6 contains a regional pollen spectrum dominated by pine pollen with subordinate spruce, sedge, and birch, indicating that it predates the pine/oak transition at 8500 ± 500 yr BP. The presence of coal and cinder in unit 10 indicate that it (and the gradationally underlying unit 9) were emplaced during or shortly after railroad construction between 1869 and 1871.

Based on the following evidence, we interpret unit 8 to indicate sedimentation into a shallow historic reservoir: (1) The late Holocene conversion from a herbaceous peaty wetland to an open pond requires the creation of a downstream impoundment sometime after about 1100 yr BP but before 1869 AD; the sharp increase in the abundance of ragweed (*Ambrosia*) pollen also suggests a postsettlement age. (2) The excellent preservation of the plant fibers between undisturbed beds of mineral sediment indicate that rapid sedimentation coincided with transient subaerial exposure, con-

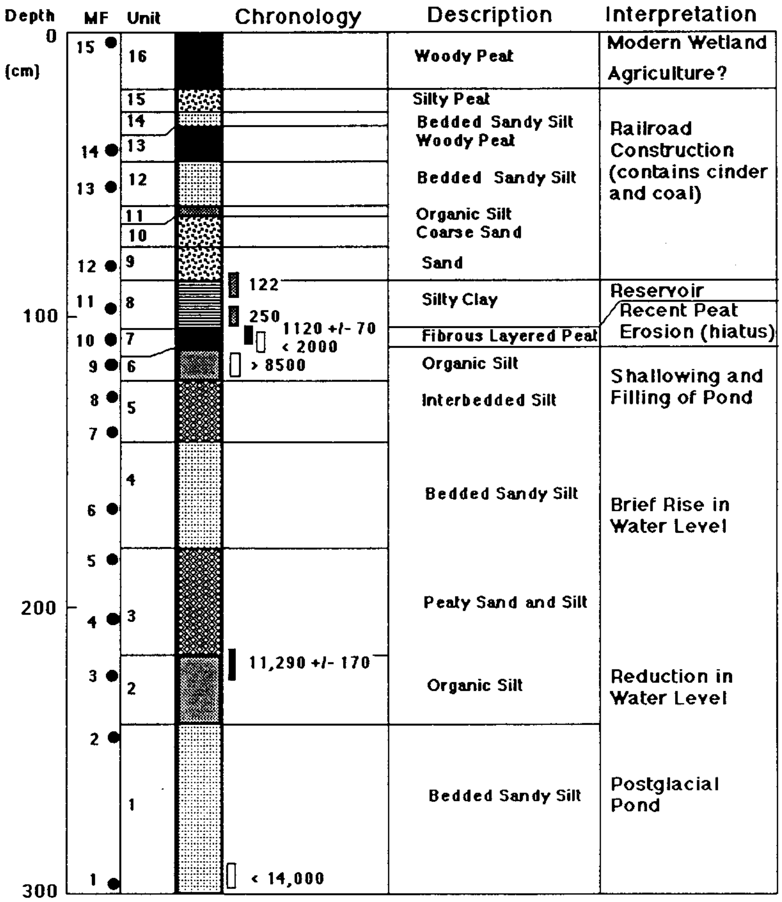

Figure 5. Generalized stratigraphic diagram and interpretations of the reference core (core 3). Filled, open, and shaded boxes show sampling interval and ages for radiocarbon, biostratigraphic, and historic-correlation dates, respectively, listed in Table 3. Stratigraphic units are described in Table 1. Macrofossil samples (MF) are described in Table 2.

ditions characteristic of shallow reservoirs beneath agricultural watersheds. (3) The presence of a historic dam and breached spillway at the downstream limit of the wetland would have impacted the basin sometime between about 1100 yr BP and 1869. We assign a general date of 250 ± 50 yr for the contact between units 7 and 8.

Local Pollen Stratigraphy and Macrofossils

The shallowing and reduction of sedimentation rate in the pond suggested by the lithostratigraphic transition of units 1 and 2 coincide with, and are supported by, a sharp rise in shrub pollen (particularly Ericaceous shrubs) and with an increase in abundance of monocot epidermis in this interval (Table 2). The replacement of shrub-dominated pollen in unit 2 with emergent and aquatic local pollen in units 3 and 4 support the return to deeper water and more rapid sedimentation after about 11,300 yr BP, as indicated by the lithostratigraphy. The upward increase in shrub pollen in units 5–7 and the abundance of rootlets support the sedimentological evidence for a final shallowing of the pond sometime prior to 8500 ± 500 yr BP. The fibrous peat of unit 7 consists almost entirely of monocot epidermis.

The uppermost macrofossil sample in the surface peat consists almost entirely of undecomposed herbaceous nodule-bearing rootlets unique to the core. Although the source plant has not yet been identified (leaves and stems are absent), it is most likely a nitrogen-fixing legume (M. W. Lefor, written communication 1989). Its restriction to historic strata elsewhere in the region (Thorson 1990), its nearly exclusive dominance in the sample, and historic documentation of frequent wetland-to-pasture conversion (Cronon 1983) suggest that the sample represents an artificially introduced agricultural hay. Alternatively, it may represent a formerly rare endemic plant that responded dramatically to anthropogenic disturbance.

Contrasts in Perception

A Geologist's View

The physical, chronologic, and biologic evidence

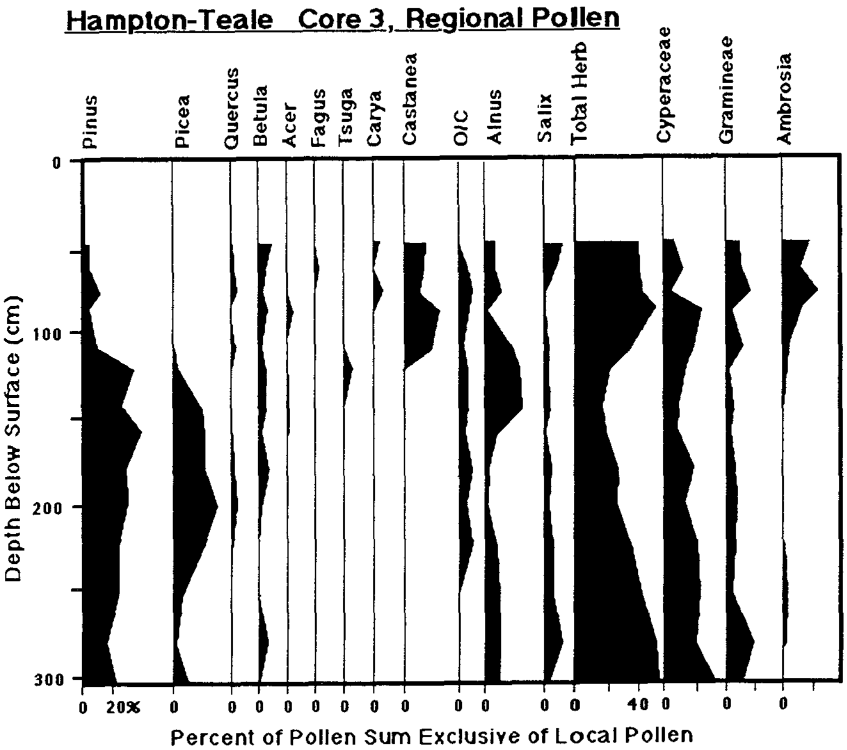

Figure 6. Diagram showing relative percent of regional pollen types excluding taxa interpreted to have been locally produced in the wetland. Identified and counted by Sandra Harris in 1989.

permits a stratigraphic reconstruction of the Hampton-Teale wetland. The relict shoreline bordering the southern sector, and the identical elevation of a paired glaciofluvial terrace along the outlet stream indicate that the bedrock-floored postglacial depression was originally occupied by a small 3 to 4-mm-deep postglacial pond bordered to the south by a bedrock ledge. Filling of the pond with sediment from the watershed, accompanied by downcutting of the outlet, caused it to shallow substantially between about 13,000 and 8500 yr BP. This in turn led to the gradual spread of shrubs around its perimeter and growth of obligate hydrophytes on its surface.

The oldest peat could not have begun accumulating more than a few centuries prior to 1120 yr BP, yet it lies directly on sediments predating 8500 yr BP. This hiatus in sediment deposition strongly suggests that, once the pond filled, additional sediment fed from the watershed bypassed the site via a stream, and that at no time was the water table high enough to permit net peat accumulation. Using a three-point geometrical projection on the basal peat, the reconstructed former surface of the presettlement wetland slopes gradually to the northeast and subparallel to the present stream from 7.55 m above datum at core 5 to 7.30 m at core 3 (Figure 3). This gradient projects directly on line with the bedrock thalweg of Hampton Brook east of the dam, lies below refusal depth for all control points in the southern sector, and slopes much more steeply than the present stream (Figure 4). These relationships demonstrate that the Hampton-Teale wetland was a vegetated swale along Hampton Brook prior to construction of the reservoir.

The uniform slope of the presettlement surface, in comparison to the horizontal contacts above and below it, and the prolonged hiatus indicated by the dates, indicates that the basal contact of the peat is an erosional unconformity. The former floor of the pond must have been incised under conditions of free drainage and flushed of sediment for at least part, if not most of the hiatus. The absence of bedding, high mineral content, slight oxidation, and decomposed character of macrofossils in the subadjacent unit 6 may represent a relict paleosol from the hiatus. These relations indicate that the former wetland probably drained completely some time during the middle Holocene. The uniformity in thickness of unit 7 suggests that its accretion resulted from a local rise in the water table.

The construction of the colonial road or dam is the next event recorded in the wetland strata. The maximum depth of the reservoir (1.3 m) indicates a limited storage capacity. Consequently, the recurrent episodes of vegetation growth on its floor probably occurred during dry intervals. Because hydrologic modeling of

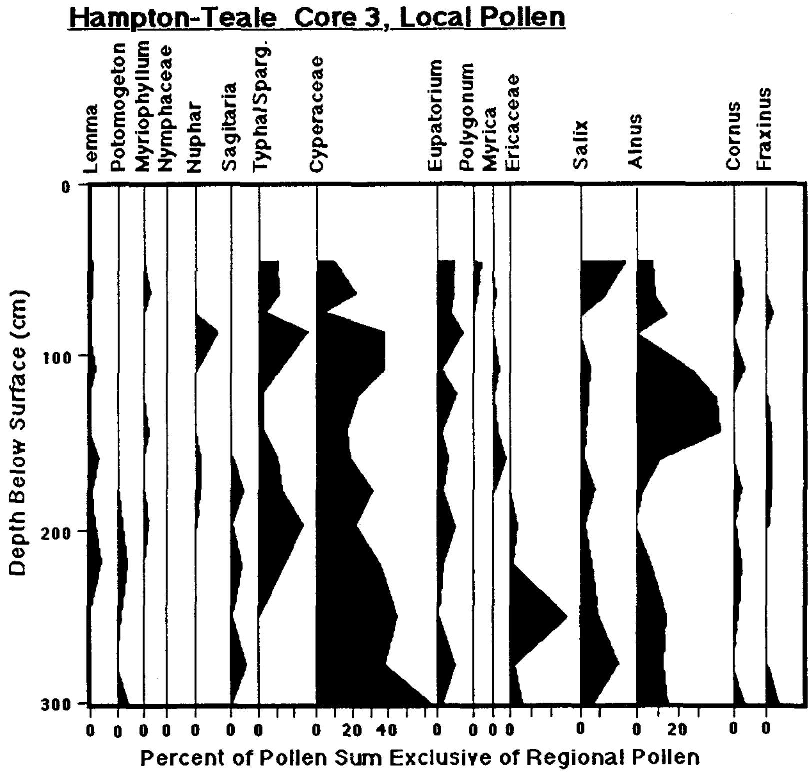

Figure 7. Diagram showing relative percent of pollen types interpreted to have been locally produced in the wetland. Identified and counted by Sandra Harris in 1989.

Table 2. Description of plant macrofossils in core 3—Hampton-Teale Wetland[a]

Sample	Unit	Moss fragments	Monocot epidermis	Dicot leaves	Herbaceous rootlets	Woood/twigs stems (etc.)	Seeds present
15	16				Dominant		
14	13		Abundant	Present	Dominant		
13	12	Present	Dominant		Frequent		Grass
12	9		Dominant		Abundant		Birch
11	8		Dominant	Present			
10	7		Codominant		Codominant		
9	6		Dominant				
8	5		Dominant	Present	Rare		
7	5		Dominant		Abundant		
6	4		Dominant				
5	3		Dominant			Present	Conifer
4	3		Dominant				Sedge
3	2	Present	Dominant			Abundant	Sedge
2	1	Rare		Present	Dominant		
1	1	Codominant		Present	Codominant		

[a]Relative abundance is qualitatively estimated. Rootlets in sample 15 are well preserved, nodular, and morphologically similar to herbaceous legumes. Samples located on Figure 5.

Hampton Brook indicates a minimum dry-year daily flow exceeding 300 m^3/day, desiccation of the reservoir suggests either more pronounced variability in streamflow (possibly resulting from deforestation) or leakage around the dam. Woody peat above the reservoir sediments indicates that the spillway was subsequently destroyed or washed out below a depth of 90 cm.

The return to lacustrine strata above the peat indicates that the reservoir was reestablished prior to the influx of sediment associated with railroad construction. Two pulses of construction-related sediment separated by an undecomposed woody peat are recognized. The initial pulse entered into standing water of the reservoir, causing a southward progradation of the

Table 3. Chronology for core 3 at the Hampton-Teale Wetland

Radiocarbon dates Depth (cm)	Unit	BETA-Lab no.	^{14}C yr BP	$^{13}C/^{12}C$ (%)	^{13}C corrected
105–110	7	30698	1170 ± 70	28.4	1120 ± 70
216–220	2	29818	11,350 ± 170	28.7	11,290 ± 170
Biostratigraphic dates Depth (cm)	Unit	yr BP	Explanation		
75	10	<250	Postsettlement; *Ambrosia* maximum.		
107–108	7	<2000	Abrupt rise in chestnut (*Castanea*).		
108–122	6	>8500±	Predates pine/oak transition.		
303	1	<14,000	Basal pollen spectra of 50% herb, 35% Cyperaceae, 15% *Pinus*, and 5% *Picea* postdates 14,000 yr BP.		
Historic-correlation dates Depth (cm)	Unit	yr BP	Explanation		
86	9	≤122	Coal and cinder in sand postdates construction of railroad in 1869–1871.		
108	8	<250	Sharp return to muddy lacustrine strata indicates postsettlement impoundment.		

shoreline beyond a fan-delta. Reconstruction of the slope of the uppermost clastic strata associated with railroad debris indicates that the second pulse occurred as part of a coalesced alluvial fan that prograded southeast from both streams entering the northern edge of the wetland (Figure 3). Woody vegetation then invaded the abandoned fan surface prior to the appearance of what we interpret as an agricultural hay. The presence of large standing dead trees in the coring vicinity indicates that a woody swamp reestablished itself after agricultural activities, only to be killed by submergence associated with the recent beaver dam.

The top of the presettlement peat everywhere lies below the firm substrate on the southern sector of the wetland, indicating that this part was mantled with a thin freely drained soil prior to the arrival of European settlers. Thus, the southern sector was artificially created by construction of the road or dam and by progradation of railroad debris from the north. Using the present mapped boundary of the wetland, and conservatively estimating that the 7.6-m contour marks its presettlement upper limit, the wetland boundary has been displaced as much as 45 m southward by human activities. Furthermore, 46% of the present wetland area was added during this interval.

A Naturalist's View

The naturalist Edwin Way Teale (1974) described this same wetland in two separate sections of his book, *A Naturalist Buys an Old Farm*. We are certain that he described the wetland of our study because he explicitly locates it at the junction of Hampton Brook and Old Colonial Road in what he termed the "North Woods," and because he correctly describes the bordering slopes.

On page 174, Teale describes this location as the "... center of interest for us in this northern part of our land." He then goes on to say:

> Everywhere along the paths of Trail Wood wildness seems near at hand. But nowhere else do we feel so remote from the world as here beside this woodland brook as it traces its serpentine course among the mosses and ferns and trees. We might be in the midst of a scene in the Adirondacks or far back in the woods of northern Maine. ... So wild does this setting seem that one August day I even brought along an aluminum pie tin and at the little gravel bar above the ford panned for gold.

The next relevant passage (p. 288) describes the northern sector of the study area, the only forested part of the wetland that slopes gradually inward: "... where the oaks and maples gradually descend to the edge of a swamp, the slope provides our greatest concentration of pink lady's slippers. There we sometimes stand with more than thirty of these largest orchids around us."

Discussion

What is now part of an Audubon sanctuary, what Teale describes as his "... center of interest ..." and the place where "... wilderness seems near at hand ..." is an artificial wetland. It was intentionally created as a shallow impoundment behind a small colonial dam, was later unintentionally filled by excavation spoil associated with railroad construction, and may have been used as a hayfield. Teale must have panned for gold in the cinder- and coal-bearing alluvium because no other gravel is present. His description of the orchids is almost certainly from the surface of the fan-delta composed of railroad-related sediment. His "... cascade where the water tumbles down among moss-covered rocks ..." is the collapsed remnant of an old stone-faced dam.

Teale, a highly regarded and widely published naturalist, died in 1980 after more than 40 yr of scientific and nature writing between 1937 and 1978. Described as "scientifically learned in botany, zoology, geology ...", he was a Fellow of the American Association for the Advancement of Science and the New York Academy of Sciences (Moritz 1961, p. 448). He won the John Burroughs Medal in 1943 and the Pulitzer Prize for general nonfiction in 1966 (Cook 1980). He is to be "... ranked in American annals with Henry David Thoreau, John Burroughs, John Muir, Joseph Wood Krutch and Rachel Carson" (Egler 1987). In every sense of the word, he was a great American naturalist.

Although widely exposed to all aspects of science, Teale was not a field ecologist or geologist and was not unbiased in his appreciation of his own property. Nor was Teale attempting to describe the history of his wetland or its origin. He appears to be describing the rapture he felt while enjoying his personal wilderness so "... remote from the world."

The disclaimers above notwithstanding, Teale did mistakenly report the wetland as "natural" and "wild" less than a century after the dramatic impact associated with railroad construction. Furthermore, we suspect that Teale would not have taken such an interest in the presettlement "natural" state of the wetland—a narrow swale along the path of Hampton Brook. From this single example, we conclude that Teale's appreciation was based on his perception of its wilderness value (rather than on his knowledge of its history) and that the anthropogenic impacts may have unknowingly enhanced his enjoyment of the site. Would Teale have enjoyed this wetland as much had he known what we know now? Probably not, because it is more difficult to be poetic about a sediment-filled livestock pond than a "pristine" wetland. Regardless of the origin and history of the wetland, however, we agree with Teale that it is a beautiful, almost spiritual place, and that the historic impacts are well hidden.

Our purpose here is not to judge the accuracy of Teale's observations or to question his motives. We know only that he valued the wetland and that the rationale for his appreciation need not be debated. We do wish, however, to point out the contrasts in perception between two views: one with unambiguous stratigraphic knowledge and one without it. Teale apparently was not able to recognize the severe anthropogenic impacts that lay preserved beneath his feet. Alternatively, he may have been aware of the impacts, but chose to overlook his knowledge, consciously or otherwise, if it detracted from his aesthetic pleasure. Finally, he may have known of the impacts, but especially enjoyed this spot where he could celebrate the healing process of revegetation, the victory over human harm. From his written words, however, we know only of his perception of wilderness and the enjoyment derived from it.

In closing, we return to the questions raised in our introduction. Is this lovely little sanctuary in the New England woods a "high-quality" wetland? Apparently, its quality was sufficiently high to repeatedly attract and inspire not only a variety of wildlife but a venerated naturalist and his followers as well. We must ask whether this wetland would pass our modern standard of "quality" used to measure the success of restored or artificial wetlands. If the answer is yes, we must then acknowledge that natural processes alone have "mitigated" against the deleterious effects of railroad construction in less than a century. If the answer is no, meaning that this is not a high-quality wetland, then we must account for Teale's repeated presence and enjoyment. This paradox highlights our confusion over the "quality" of wetlands. Which is more important? Our intangible aesthetic perceptions, or the quantitative (but reductionist) measures we attempt to legislate and use?

From another perspective, is our Hampton-Teale wetland "sensitive" to environmental "disruption?" The answer is an unequivocal yes and no. During the last 250 yr of the historic period, the wetland has moved southward at least 20 m, has doubled in present area, and its surface character has changed spasmodically every quarter century, alternating among an herbaceous marsh, a shrub–scrub swamp, an open pond, and a gravelly streambed. Clearly, these frequent changes indicate its sensitivity. Alternatively, we can argue that this wetland is almost insensitive to human impact because it has maintained a lush cover of hydrophytic vegetation above wet soils regardless of purposeful or inadvertent impacts. Every environmental condition interpreted from the postsettlement stratigraphic record at Hampton Teale could be classified as wetland, based on legal, hydrologic, soil, and vegetational definitions (Cowardin and others 1979). With the retrospective advantage offered by geologic data, the wetland's sensitivity to human impact can be assessed only if the magnitude of change and the time scale of interest are first specified. Yes, it is sensitive because we influence its appearance very 25 yr. No, it is not sensitive because our purposeful or inadvertent impacts have not filled or drained it out of the domain of legal wetlands.

Are we, as citizens, regulators, and environmentalists, reluctant to accept restored or mitigated wetlands on par with "natural" ones because their "naturalness" values cannot, by definition, be artificially produced? If so, we must learn the lesson of the Teale sanctuary. Here is the story of an artificial wetland, mitigated so completely by natural processes that it gave the illusion of wilderness in less than a century. Such a story can be retold many times throughout our region. As managers and scientists, we must begin to acknowledge that wilderness is an entirely human construct and we must begin to publicly admit that few, if any, small inland wetlands in our region are truly "wild." Their wilderness value derives from the observations that any wetland out there is "wilder" than our everyday experience and that organisms coadapted to a human world do seek refuge in locales that few of us care to visit.

In conclusion, we must base our strategies for management of these small inland wetlands not on what we would like to think about their naturalness, but rather on what we can learn of their ecological values. They must be preserved for the right reasons.

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