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A postglacial paleoenvironmental dataset from New England

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ABSTRACT

This paleoenvironmental database features postglacial lake-sediment records from 31 study sites located across New England. The study sites span an environmental gradient from the cooler, northern and inland part of the region to the warmer, southern and coastal areas of New England. Sediment-core chronologies were determined using ^{14}C dating, ^{210}Pb analysis, and pollen evidence. Detailed analyses of sediment lithology, pollen, and charcoal were used to reconstruct changes in climate, vegetation, and fire at centennial temporal scales and subregional spatial scales for the last 14,000 years. Analyses of paleoenvironmental data provide insights into the rates, patterns, and drivers of ecosystem change, helping us anticipate future ecosystem dynamics and guiding present-day conservation strategies and land management.

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Specifications Table

Subject	Environmental Science
Specific subject area	Paleoecology and paleoclimate
Type of data	Table
How the data were acquired	Lake-sediment cores were collected with a modified square-rod piston sampler; sediments were dated using ^{14}C, ^{210}Pb, and pollen analyses; sediment lithology was characterized via loss-on-ignition; pollen grains were identified at 400X-1000X magnification; charcoal pieces were counted at 40X magnification.
Data format	Raw Analyzed
Description of data collection	Sediment core age models were created using Bchron; water-level reconstructions are based on analyses of paleo-shoreline deposits (e.g., sand layers) in multiple cores from different water depths; pollen percentages were calculated relative to the sum of pollen and spores from upland plant taxa; charcoal data are presented as charcoal accumulation rates (pieces cm^{-2} yr^{-1}).
Data source location	Region: New England Country: USA Locations of study sites listed in Table 1
Data accessibility	Repository name: Harvard Forest Data Archive Data identification numbers: HF376-HF405 Direct URL to data: https://harvardforest.fas.harvard.edu/harvard-forest-data-archive Repository name: NOAA NECI Data identification numbers: noaa-lake-16094; noaa-lake-16095; noaa-lakelevel-23074 Direct URL to data: https://www.ncei.noaa.gov/access/paleo-search/study/16094 https://www.ncei.noaa.gov/access/paleo-search/study/16095 https://www.ncei.noaa.gov/access/paleo-search/study/23074
Related research article	W.W. Oswald, D.R. Foster, B.N. Shuman, E.S. Chilton, D.L. Doucette, and D.L. Duranleau, Conservation implications of limited Native American impacts in pre-contact New England, *Nature Sustainability* 3 (2020) 241-246. https://doi.org/10.1038/s41893-019-0466-0

Value of the Data

- Analyses of paleoecological and paleoclimatic data provide insights into the rates, patterns, and drivers of ecosystem change.
- Understanding past changes in climate, vegetation, and fire helps us anticipate future ecosystem dynamics.
- Comparison of paleoenvironmental and archaeological data allows us to explore past human-environment interactions, informing present-day conservation strategies and land management.

1. Data Description

This postglacial paleoenvironmental dataset for New England [1,2,3] features lake-sediment records for 31 study sites distributed across New England (Table 1), spanning a regional-scale climatic gradient associated with elevation, latitude, and distance from the Atlantic Ocean (Fig. 1). The study sites represent a wide range of elevation (from <10 to >600 m), temperature (Growing Degree Days vary from 2500 to 3900), and precipitation (from 1000 to 1400 mm/year).

This climatic gradient has a strong influence on the present-day distribution and abundance of the major tree species. *Tsuga canadensis* (eastern hemlock), *Fagus grandifolia* (American beech), *Acer saccharum* (sugar maple), *Pinus strobus* (white pine), and *Betula* (birch) species are common in the cooler northern, inland, and higher elevation parts of New England, whereas *Quercus* (oak)

Table 1
Paleoenvironmental study sites from New England.

Site	Latitude °N	Longitude °W	Elev. (m)	Area (ha)	Data type
Benson	42.3776	-73.0954	497	2.3	pollen
Berry-Andover	42.6201	-71.0873	42	1.6	pollen
Berry-Hancock	42.5054	-73.3189	630	3.7	pollen
Black	41.3281	-70.7923	13	1.4	pollen, charcoal
Blaney's	41.4717	-70.7652	5	1.0	pollen, charcoal
Blood	42.0800	-71.9615	211	8.5	pollen, charcoal
Davis	42.1355	-73.4077	213	2.1	paleoclimate
Deep-Falmouth	41.5641	-70.6358	19	1.0	pollen, charcoal, paleoclimate
Deep-Taunton	41.8824	-71.0115	7	1.5	pollen, charcoal
Doe	42.1754	-72.7024	79	1.4	pollen, charcoal
Duck	41.9328	-70.0006	3	5.1	pollen
Fresh-Block	41.1583	-71.5750	38	1.0	pollen
Fresh-Falmouth	41.5935	-70.5338	6	5.3	pollen, charcoal
Green	42.5668	-72.5111	82	5.0	pollen, charcoal
Guilder	42.1094	-73.4372	622	6.3	pollen
Knob Hill	44.3605	-72.3737	370	7.1	pollen
Little Willey	43.2918	-71.1778	254	11.4	pollen
Little-Royalston	42.6750	-72.1917	302	4.0	pollen
Mohawk	41.8167	-73.2833	351	6.6	pollen
New Long	41.8500	-70.6777	29	7.9	paleoclimate
No Bottom	41.2846	-70.1141	5	0.2	pollen
North	42.6510	-73.0531	585	7.8	pollen
Rogers	41.3635	-72.2994	11	107.0	pollen
Sears	40.8845	-72.5783	2	6.1	pollen, charcoal
Spruce	41.2369	-74.1833	273	1.9	pollen
Sutherland	41.3931	-74.0370	379	4.1	pollen
Umpawaug	41.3061	-73.4497	138	5.3	pollen, charcoal
Uncle Seth's	41.4331	-70.6647	13	4.6	pollen, charcoal
Ware	42.4825	-70.8825	4	1.1	pollen, charcoal
West Side	41.8556	-73.2566	390	15.7	pollen, charcoal
Winneconnet	41.9667	-71.1167	22	60.0	pollen

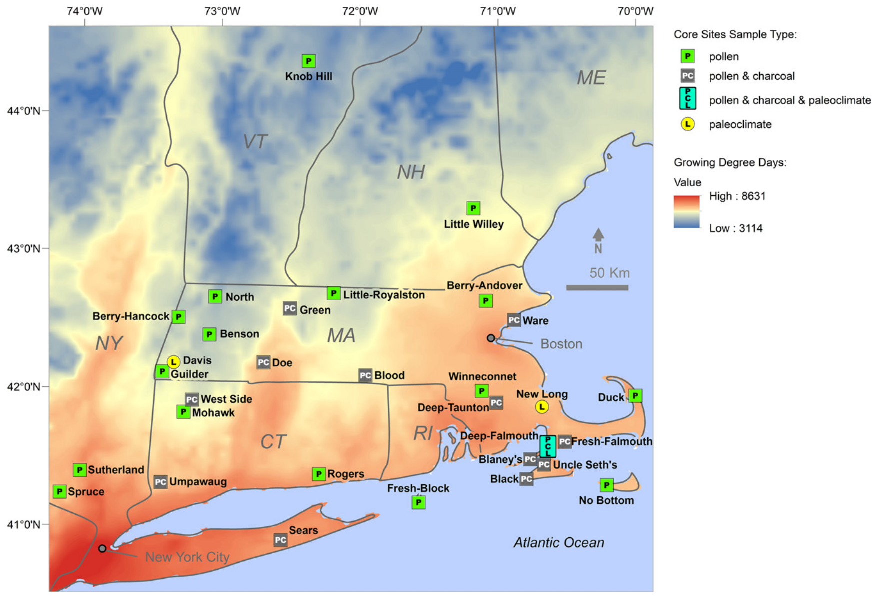

Fig. 1. Map of New England showing the location of study sites and the regional environmental gradient (growing degree days, 5°C base). Symbols indicate the types of paleoenvironmental data available for each study site.

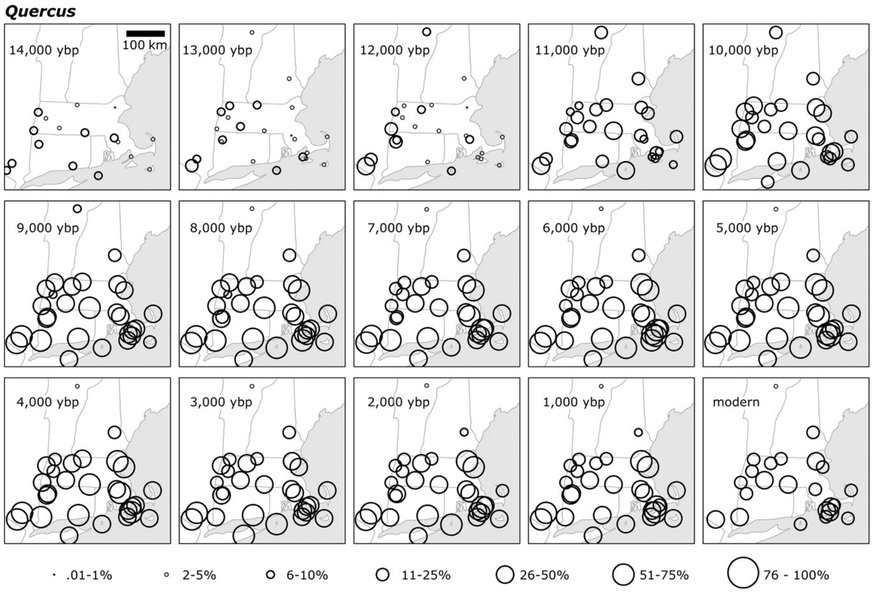

Fig. 2. Map of *Quercus* (oak) pollen percentage data from New England lake-sediment records. Geography of these maps does not reflect changes in sea level and isostatic rebound. *Quercus* expanded across the region as climate became warmer and wetter after ~11,000 ybp [1].

species and *Carya* (hickory) species dominate in the warmer southern part of the region [4]. *Acer rubrum* (red maple) is abundant across the region. At finer spatial scales, other tree species become locally important due to edaphic controls on moisture availability. In particular, *Pinus rigida* (pitch pine) is prevalent on sites with well-drained, sandy soils [5].

The lake-sediment records begin between 14,000 and 9600 calibrated ^{14}C years before present (cal ybp). The dataset includes pollen data from 29 study sites (Figs. 2-3), and the mean sampling interval for the pollen records is 219 years between samples [1]. Of the 29 lake-sediment records analyzed for pollen, 13 were also analyzed for charcoal (Fig. 3), with a mean sampling interval of 104 years between samples [3]. Lastly, we reconstructed water depth and inferred past effective moisture (Fig. 4) for three study sites [6], one of which was analyzed for pollen and charcoal (i.e. Deep-Falmouth).

The lakes and ponds are relatively small in size (mostly <10 ha) such that the pollen and charcoal data should reflect landscape-scale variations in vegetation composition [7] and fire activity [8]. Most of the study sites are located in areas of glacial till or moraines, although a few sites are located on either glacial outwash or glaciolacustrine kame-delta deposits and thus have sandier soils.

For the datasets in the Harvard Forest Data Archive, multiple data files are available for each study site: (1) chronological data, including ^{14}C and ^{210}Pb data and calibration results; (2) age-depth model, with an age assignment for each sample depth; (3) pollen-count data, including numbers of pollen grains or spores for each plant taxon at each sample depth; (4) pollen-percentage data, with percentage values for selected taxa at each sample depth; and in some cases (5) charcoal data, including concentration (pieces cm^{-3}) and charcoal accumulation rate (pieces cm^{-2} yr^{-1}) values at each sample depth. The datasets in the NOAA NECI repository feature two different formats. For New Long Pond there is a single data file with water-level values at 50-year intervals. For Davis and Deep Ponds there are multiple data files for each study site: (1) loss-on-ignition data, with values for each sample depth for each coring location; (2) water-level reconstructions, with values at 50-year intervals; (3) effective-moisture reconstruc-

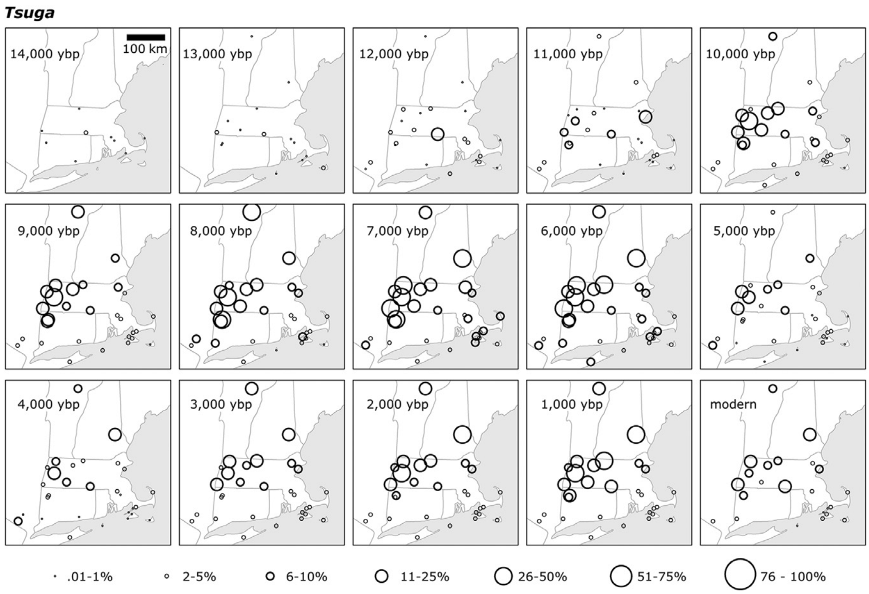

Fig. 3. Map of *Tsuga* (hemlock) pollen percentage data from New England lake-sediment records. Geography of these maps does not reflect changes in sea level and isostatic rebound. The decline in *Tsuga* abundance at 5000-4000 ybp has been attributed to abrupt cooling ~5500 ybp [1,6].

tions, with values at 50-year intervals; and (4) a set of R Script files and CSV data files for reconstructing water levels and effective moisture.

2. Experimental Design, Materials and Methods

Pollen and chronological data for 10 of the study sites were obtained from the Neotoma Paleoecology Database [9]. We collected and analyzed sediment cores from the 21 other study sites, using a similar approach in all cases. Upper sediments (100-150 cm), including an undisturbed sediment-water interface, were collected with a 10-cm-diameter plastic tube fitted with a piston. These surface cores were transported to the laboratory and extruded vertically in 1-cm segments. Lower sediments were collected in 1-m drive lengths using a 5-cm-diameter modified Livingstone piston sediment sampler [10]. Those core segments were extruded horizontally in the field, wrapped in plastic and aluminum foil, and subsampled at 1-2 cm intervals in the laboratory. All samples were subsequently refrigerated and archived.

The chronologies of the sediment cores are derived from accelerator mass spectrometry ^{14}C analysis of plant macrofossils and bulk-sediment samples, pollen evidence for European forest clearance, and ^{210}Pb analysis of recent sediments. For ^{210}Pb dating [11], 1-cm^3 sediment samples were analyzed with an alpha spectrometer and ages were determined using the constant rate of supply model [12]. ^{14}C dates were calibrated with the IntCal13 calibration curve [13] and age models were constructed using Bchron [14].

Sediment samples of 1-2 cm^3 were prepared for pollen analysis following standard procedures [15]. Pollen residues were mounted in silicone oil and analyzed at 400X-1000X magnification using a regional key [16]. Percentage values were calculated relative to the sum of pollen and spores from upland plant taxa.

For charcoal analysis, 1-cm^3 sediment samples were soaked in KOH and washed through a 200-μm sieve; all charcoal fragments >200 μm were counted at 40X magnification. Charcoal

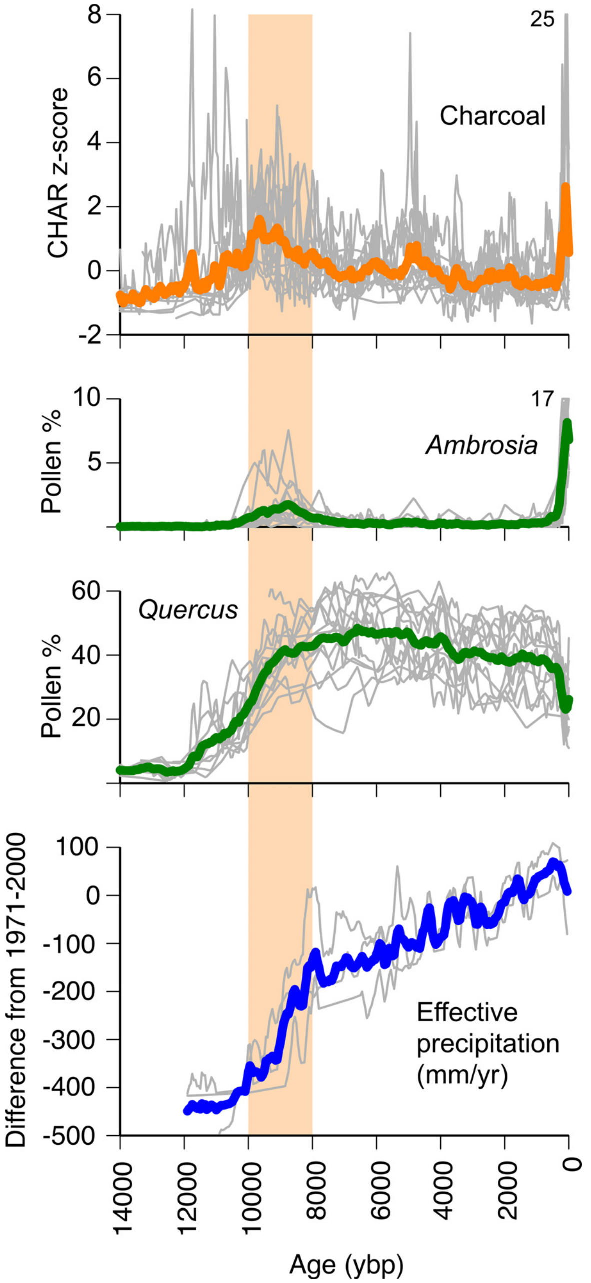

Fig. 4. Selected paleoenvironmental data from New England [3]. Top panel: Lake-sediment charcoal data spanning the past 9600-14,000 yr from 13 study sites located across southern New England. Values are z scores of charcoal accumulation rates (pieces cm^{-2} yr^{-1}; CHAR-z) interpolated at 50-yr intervals and based on the means and standard deviations for the period >500 ybp. Grey lines are records from individual sites; the orange line is the mean. Two sites have CHAR-z scores of 10-25 at 50-100 ybp. Middle panels: Pollen percentage data for selected taxa from the same 13 study sites as in top panel. Grey lines are records from individual sites; green lines are means. For *Ambrosia*, values reach 10-17% at four sites during 50-200 ybp. Bottom panel: Reconstruction of effective precipitation (mm/yr) for southern New England. Grey lines are the moisture reconstructions for Davis, New Long and Deep-Falmouth; the blue line is the average of the three records. In all graphs, orange shading marks a period of high fire severity and open *Quercus* woodlands at 10,000-8000 ybp [3].

concentration values (pieces cm^{-3}) were converted to charcoal accumulation rates (pieces cm^{-2} yr^{-1}).

To reconstruct the water-level history of Davis, New Long, and Deep-Falmouth Ponds, multiple sediment cores were collected along transects across the ponds. Loss-on-ignition (LOI) and grain-size analysis was conducted following standard methods [17,18] at contiguous 1-cm intervals. The LOI and sand content data were used to quantitatively constrain past positions of sandy littoral (high sand, low LOI) and deep-water (low sand, high LOI) sediments in each sediment core along a transect. Combining the sedimentary environment classifications with the ages and elevations of the samples within each core provides the basis for estimating past shoreline positions and associated changes in water-surface elevation, ΔWSE [18]. Changes in the water-surface elevation are assumed to parallel changes in the minimum elevation of sandy littoral sediments across all cores.

Effective moisture ($\Delta_{P\text{-}ET}$) reconstructions represent past departures from the modern balance of precipitation and evapotranspiration across a lake's watershed and are represented as changes in mm of effective annual precipitation. The reconstructions derive from the quantified water-level (ΔWSE) reconstruction represented as meters below the modern lake surface, where positive values represent lower than modern levels. Effective moisture change is calculated from the inferred change in water level using the following equation [18]:

$$\Delta_{P-ET} = [-\Delta WSE * A_L]/[A_W * \Delta T]$$

The equation includes the area of the lake, A_L, and watershed, A_W, in square meters, and the lake equilibration time, ΔT, which reflects the time required for precipitation across the watershed to flow into the lake. Confidence intervals of the $\Delta_{P\text{-}ET}$ reconstructions account for both uncertainty in ΔWSE and a range of likely values of ΔT [18].

Ethics Statement

This study did not involve human or animal subjects.

CRediT Author Statement

W. Wyatt Oswald: Conceptualization, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization, Funding acquisition; **David R. Foster:** Conceptualization, Writing – review & editing, Funding acquisition; **Bryan N. Shuman:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – review & editing, Funding acquisition; **Brian R. Hall:** Visualization, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Paleoecological data (Original data) (Harvard Forest Data Archive).

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