

**PALYNOLOGY IN HISTORICAL
RURAL LANDSCAPE STUDIES:
THE PRE-CLEARANCE FOREST BORDER
AT GREAT MEADOWS, PENNSYLVANIA**

Technical Report NPS/MARFONE/NRTR - 95/067

by Gerald K. Kelso, Ph.D.

**Cultural Ecology Laboratories
17214 W. 15th Place
Golden, Colorado 80401**

November 1994

Prepared for

**National Park Service
Resource Stewardship and Partnerships
U.S. Custom House
200 Chestnut Street
Philadelphia, PA 19106**

Table of Contents

List of Figures	iii
List of Tables	iv
Acknowledgments	v
Introduction	1
Feasibility Study	3
Methods	3
Background	3
Results	8
Pollen Record Formation Processes at Great Meadows	8
The Pre-Clearance Vegetation on Great Meadows	10
The Record of Euro-American Land Use	14
Summary and Recommendations	16
Full Analysis Stage	19
Methods	19
Theoretical Considerations	21
Results	22
Vegetation Community Distributions	22
Forest Composition	41
Summary	43
Recommendations	48
Literature Cited	50

List of Figures

Figure 1.	Location of Fort Necessity (after Harrington 1957)	2
Figure 2.	Feasibility study pollen core locations at Great Meadows (map courtesy of Roger Stone)	4
Figure 3.	Theoretical distribution of pollen in a soil profile	9
Figure 4.	Pollen percentages of dominant types in core 2 (hillside/former forest) of the feasibility study transect at Great Meadows	11
Figure 5.	Pollen percentages of pre-clearance pollen samples of the Great Meadows feasibility study cores presented in topographic order down the hill and onto the meadow	13
Figure 6.	Percentages of pollen types critical for edaphic and land-use interpretation in the Great Meadows feasibility study cores	15
Figure 7.	Stylized artist's conception of Great Meadows in 1754	18
Figure 8.	Full analysis core transect locations at Great Meadows	20
Figure 9.	The frequency of oak pollen deposited at increasing distance from the woodland edge (after Tinsley and Smith 1974 and Edwards 1982)	23
Figure 10.	Birch pollen dispersal at Bankshead Noss, Scotland (after Caseldine 1981 and Edwards 1982)	24
Figure 11.	Core Transect No. 1 pollen spectra	26
Figure 12.	Core Transect No. 2 pollen spectra	28
Figure 13.	Core Transect No. 3 pollen spectra	30
Figure 14.	Core Transect No. 4 pollen spectra	32
Figure 15.	Core Transect No. 5 pollen spectra	34
Figure 16.	Core Transect No. 6 pollen spectra	36
Figure 17.	Core Transect No. 7 pollen spectra	38
Figure 18.	Core Transect No. 8 pollen spectra	40

List of Tables

Table 1.	Scientific and Common Plant Names--Great Meadows Cores	5
Table 2.	Tree pollen percentages based on arboreal pollen only (no herbs) in the Transect No. 5 pre-clearance forest (no. 16-14) and ecotone (no. 13-10) cores	44

Acknowledgments

Many individuals have contributed to this research effort. I particularly wish to thank John Karish, Chief Scientist for the NPS Mid-Atlantic Region, who brought the research potential of the site to my notice and provided a major portion of the funding; Roger Stone, now at Hopewell Furnace National Historical Site, who graciously collected the first cores and provided archival materials; Charles Smith, Chief Ranger at Fort Necessity NB, who provided funding, material support, and equipment; Douglas Hutter, resource manager at Fort Necessity NB, and volunteer Ted Guzowski, who materially assisted in data collection; Stephen Strach, now at Rock Creek Park, who provided significant historical data on the meadow; and Linda Towle, now of Mesa Verde NHP, and Myra Harrison, Manager of the North Atlantic Cultural Resources Center, who arranged administrative support within the North Atlantic Region. Initial funding for the Fort Necessity pollen study was provided by Eastern National Parks and Monuments Association, and pollen laboratory equipment was provided by the National Science Foundation under Grant No. BNS-7924470 to Boston University.

Introduction

Lieutenant Colonel George Washington ordered the construction of an earthwork and stockade fortification in an opening in the forest called "Great Meadows" during his 1754 road building expedition to the forks of the Ohio (Figure 1). The fort was surrendered to the French and destroyed in July 1754 after a brief siege that is now considered to be the opening battle of the French and Indian War. The forest surrounding Great Meadows was a critical element in the battle because it provided cover within musket shot of the fort for the attacking French-led Indian force (de Villiers 1754; Dinwiddie 1754:I:239-241; Shaw 1754; Washington 1754; Harrington 1957:24). The forest around the meadow was cleared for agriculture between 1856 and 1880 (Torres-Reyes 1970).

The current reconstruction of Fort Necessity is the result of careful excavations by J. C. Harrington (1957) and is generally considered to be accurate. The bare hillsides around the fort, however, conflict with the reported primeval forest of the 1754 scene (Fitzpatrick 1931/1944:I:73-90) and make it difficult for National Park Service interpreters to present realistically the events of the battle to visitors. The National Park Service plans to restore the forest around Fort Necessity to its pre-clearance boundary. The objective of this research is to locate the pre-clearance edge of the forest with the greatest possible accuracy. The objective was approached in two stages: a feasibility study and a full-analysis stage. The objectives of the feasibility study were to determine if pollen spectra predating clearance of the forest were preserved in the soil profile and to determine if pollen composition and location of the plant communities on and around the meadow were recorded among the pollen data.

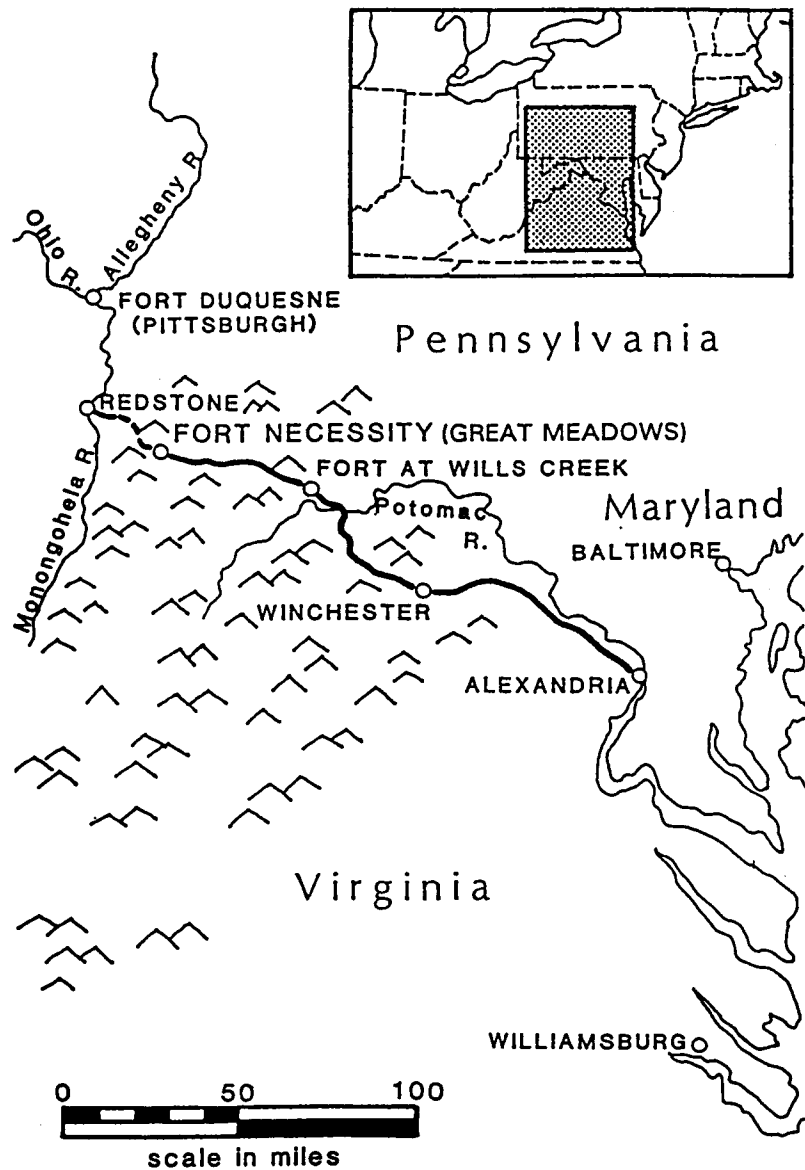


Figure 1. Location at Fort Necessity (after Harrington 1957).

Feasibility Study

Methods

Six soil cores were taken in a transect down the hillside on the west side of the meadow and across the meadow to the edge of the fort lawn (Figure 2) for the feasibility study. All cores were analyzed in 2-cm contiguous samples. The sediment in the cores was compressed about 20% by the coring process. This compression is not factored out in the diagrams and should be taken into account when comparing the Great Meadows data with profiles collected from exposed sediment faces.

Extraction generally followed Mehringer's (1967) mechanical/chemical procedure. His first two HCL washes and HNO₃ step were eliminated because they are unnecessary in acidic temperate zone soils where only weak colloids are formed in the HF step. The strength of the final NaOH wash was reduced to 0.05%. Sodium hydroxide is necessary to remove humic acids, but stronger concentrations of this chemical destroy the already weakened pollen in temperate zone terrestrial deposits. Residues were mounted in glycerol for viewing. The pollen was identified at 400x. Four hundred grains were counted for each sample, and problematical grains were examined under oil immersion at 1000x.

Benninghoff's (1962) exotic pollen addition method was employed in computing pollen concentrations per gram of sample. Pollen concentration figures were not calculated for individual taxa. These would not be meaningful in the absence of chronological control over sedimentation rate and might be mistaken for pollen influx data. All pollen grains too degraded to be identified were tabulated to provide further control over corrosion factors. Unidentifiable pollen grains were not incorporated in any sum from which the frequencies of other types were computed, but the data for this pollen group, as a percentage of total identifiable and unidentifiable pollen, are presented for each profile. Corroded oak pollen, a prominent type that retains its identity while readily degrading (van Zeist 1967:49), was also tabulated. The terms "corroded" and "degraded" are used interchangeably and refer to any kind of pollen deterioration other than tearing. They are not intended as references to the specific classes of deterioration defined under these terms by Cushing (1964) and Havinga (1984).

Historical archaeologists most frequently encounter plants under common names in their documentary sources. For their convenience, the common names for plant taxa are employed in both the text and the diagrams. Equivalent scientific names are introduced at the first mention of each plant taxon, and a list of scientific/common names is presented in Table 1.

Background

Great Meadows was important to both early traders and the Washington expedition because it was one of the few tracts for grazing in the densely forested Allegheny Mountains (Toner 1893:127; Hulbert 1903:92, 135). The mixed mesophytic nature of the forest in

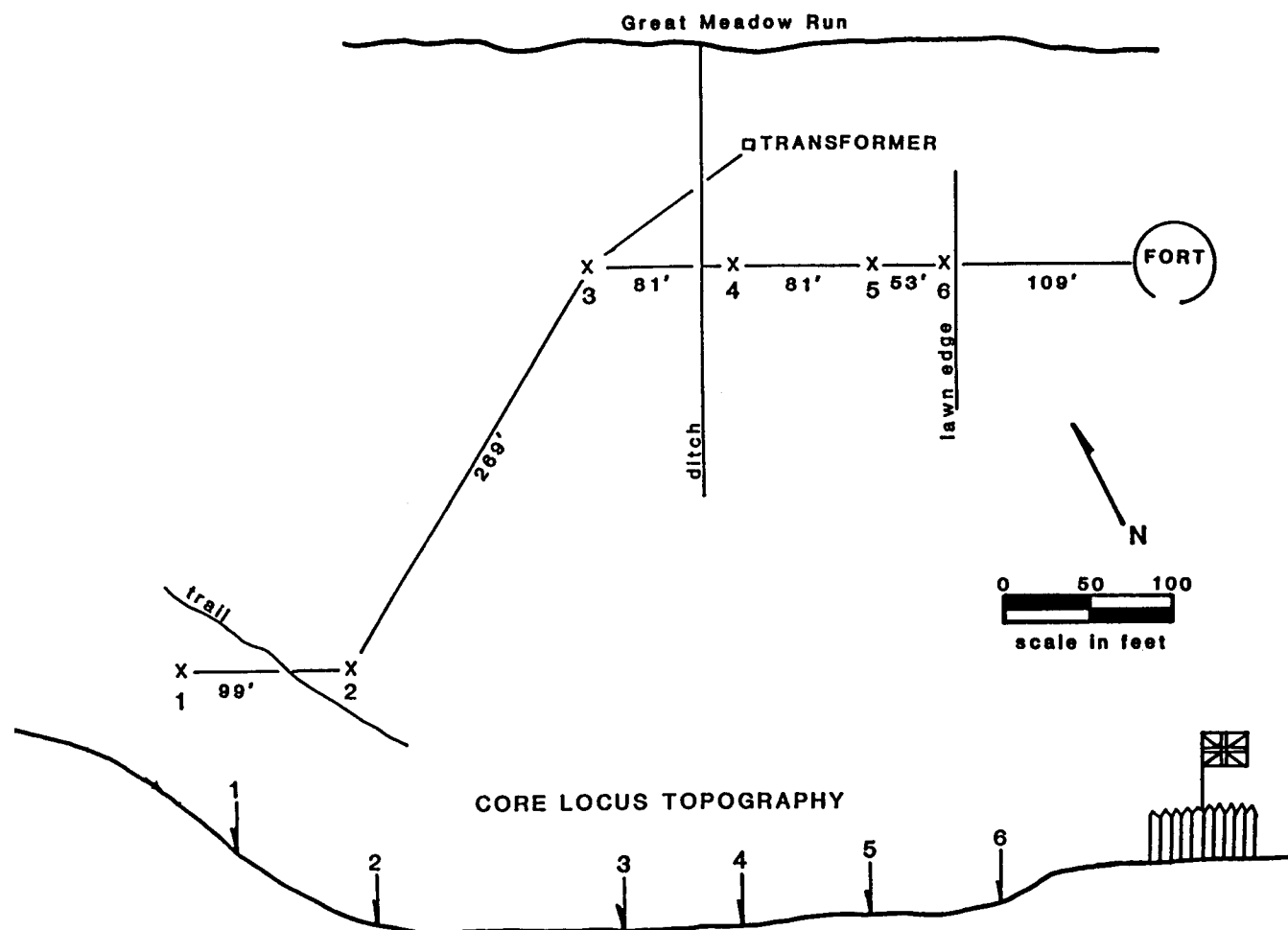


Figure 2. Feasibility study pollen core locations at Great Meadows (map courtesy of Roger Stone).

Table 1. Scientific and Common Plant Names--Great Meadows Cores.

Arboreal

alder - *Alnus*
ash - *Fraxinus*
basswood - *Tilia*
beech - *Fagus*
birch - *Betula*
blue beech - *Carpinus*
buckthorn - *Rhamnus*
catalpa - *Catalpa*
cedar family - *Cupressaceae*
chestnut - *Castanea*
elm - *Ulmus*
fir - *Abies*
gum-type - *Nyssa*-type
hackberry - *Celtis*
hazel - *Corylus*
hemlock - *Tsuga*
hickory - *Carya*
holly - *Ilex*
honey locust-type - *Gleditsia*-type
locust-type - *Robinia*-type
oak - *Quercus*
pine - *Pinus*
poplar (cottonwood)-type - *Populus*
red maple-type - *Acer rubrum*-type
silver maple-type - *Acer saccharinum*-type
spruce - *Picea*
sugar maple-type - *Acer saccharum*-type
sycamore - *Platanus*
walnut - *Juglans*
willow - *Salix*

Non-Arboreal

corn - *Zea mays*
goldenrod-type - *Solidago* and other insect-pollinated Compositae
ironweed-type - *Liguliflorae*
mugwort - *Artemisia*
ragweed-type - *Ambrosia* and other wind-pollinated Compositae
thistle-type - *Centaurea*-type

Table 1. (continued)

Non-Arboreal

bluebell family - *Campanulaceae*
broad-leaved plantain-type - *Plantago major*-type
buttercup family - *Ranunculaceae*
cattail family - *Typhaceae*
currant - *Ribes*
dock-type - *Rumex mexicanus*-type
European cereals - wheat (*Triticum*), barley (*Hordeum*), oats (*Avena*), and rye (*Secale*)
flax - *Linum*
geranium family - *Geraniaceae*
goosefoot family - *Chenopodiaceae*
grass family - *Gramineae*
groundcherry-type - *Physalis*-type *Solanaceae*
heath family - *Ericaceae*
honeysuckle family - *Caprifoliaceae*
Indian hemp family - *Apocynaceae*
lance-leaved plantain-type - *Plantago lanceolata*-type
lily family - *Liliaceae*
mallow family - *Malvaceae*
meadow rue - *Thalictrum*
mint family - *Labiatae*
morning glory family - *Convolvulaceae*
mustard family - *Cruciferae*
nightshade-type - *Solanum*-type *Solanaceae*
parsley family - *Umbelliferae*
pea family - *Leguminosae*
phlox family - *Polemoniaceae*
pink family - *Caryophyllaceae*
primrose family - *Primulaceae*
rose family - *Rosaceae*
rue family - *Rutaceae*
saxifrage family - *Saxifragaceae*
sedge family - *Cyperaceae*
smartweed-type - *Polygonum*-type
sorrel-type - *Rumex acetosella*-type
vervain family - *Verbenaceae*
vine family - *Vitaceae*
violet - *Viola*

southwestern Pennsylvania has been described (Braun 1950). A traveler writing in the Daily National Intelligencer newspaper of Washington, D.C. indicated that the primeval forest was essentially intact in 1822. At that time the woods on Laurel Hill on the east flank of the meadow consisted of chestnut, locust, maple, elm, ash, several varieties of oak, and stands of tall, mature pines (Torres-Reyes 1970:10).

There is also some information about the meadow. A British private described the meadow in his 1755 journal as " . . . being a mile long and two hundred yards wide," while a contemporary British officer recorded it as " . . . about 150 acres of meadow-land entirely clear" (Hamilton 1959:45, 23). Washington reported bushes, which he cleared to improve his field of fire, in the meadow (Fitzpatrick 1931/1944:I:54), and he was forced to capitulate by fire from a point of woods about 60 yards from the fort (Sparks 1834:463; Washington 1754). In 1759 Colonel James Burd reported, without providing distances or directions, that three points of wood commanded the fort (Day 1843:336), but neither Washington's (1754) statement nor Shaw's (1754) supporting affidavit indicate the direction from which the decisive fire came. An unscaled 1755 British map of the Braddock road does show forest closest to the fort on the southeast (Torres-Reyes 1970:Exhibit I).

The remaining known references to vegetation on the meadow postdate the battle by well over half a century. By that time the property had passed through the hands of a series of owners and had, undoubtedly, been modified. George Washington was the first Euro-American private owner of the property. He laid claim to 234.5 acres around the fort in 1767, and he still owned the tract at the time of his death in 1799 (Torres-Reyes 1970:8; Fitzpatrick 1931/1944:XVIII:379). By 1784, he had a tenant on the property with a house and " . . . arable land in culture and meadow enclosed . . .," but in 1794 he wrote that the meadow was "unimproved" (Torres-Reyes 1970:8, 9). By 1825 a party of canal surveyors reported that the area adjacent to the fort had been under cultivation for some time (Torres-Reyes 1970:10). This probably indicates drained mowing meadow, rather than plowland, because a historian researching the battle reported that the glade was covered with tall grass and small bushes in 1830 (Sparks 1834:58). Utilization of the meadow was apparently continuous because it was again reported " . . . highly cultivated and improved . . ." in 1854 (Torres-Reyes 1970:12).

Notes on an 1816 map by a professional surveyor indicated that the tree line to the south was 30-40 rods (165-220 yds) from the fort, that the tree line on the north was 50 rods (275 yds) or more from the fort and that there was a point of trees 12-15 rods (66-82.5 yds) southeast of the fort (Lewis 1816). In 1830 the east-to-west width of the meadow was estimated at 250 yds, while the tree line was 100 yds from the fort on the south and 150 yds from the fort on the north (Sparks 1854:51). The same tree line was reported in 1854 (Torres-Reyes 1970:12), but this changed rapidly when Great Meadows was purchased by a family of farmers and stock raisers named Fazenbaker in 1856 (Harrington 1957:19). By 1880 the Fazenbakers had cleared the adjacent hillsides, ditched the meadow, and straightened the creek near the fort to improve drainage (Ellis 1882, 2:830, in Strach 1987; Thwaites 1896:299-308, in Strach 1987). The hillsides were called "fields" by the patriarch of the Fazenbaker family in 1882 and were apparently under cultivation. Fazenbaker tradition, however, holds that the meadow in the

vicinity of the fort was used only for grazing and that the fort site was never plowed (Harrington 1957:19). Cultivation ceased when the property became a state park in the 1920s (Strach 1987) and the property was last grazed in 1977 (Frank Marhefka, pers. commun. 1994).

Today the forest is still closest to the site on the southeast. The hill west of the meadow, cleared to the crest, has been allowed to go to grass (*Poaceoideae*) and goldenrod (*Solidago* spp.), while black cherry (*Prunus serotina*), arrowwood (*Viburnum recognitum*) and hawthorn (*Crataegus* spp.) have colonized the lower slopes. Goldenrod and ironweed (*Vernonia noveboracensis*) have come to dominate the late summer and fall flora of the hillside and dry meadow since the National Park Service stopped mowing in 1985. There is also evidence that the meadow itself has been modified. Buried drains located with remote-sensing techniques were excavated in 1990, and artifacts thought to have been deposited during the battle period were recovered several feet below present ground surface during a recent trenching episode in the meadow. This indicates that there has been considerable alluviation in the meadow during the last 350 years. Most of the sediment must have come down the watercourse, but there has undoubtedly been some sheet erosion off the immediately adjacent, now rocky, hillsides.

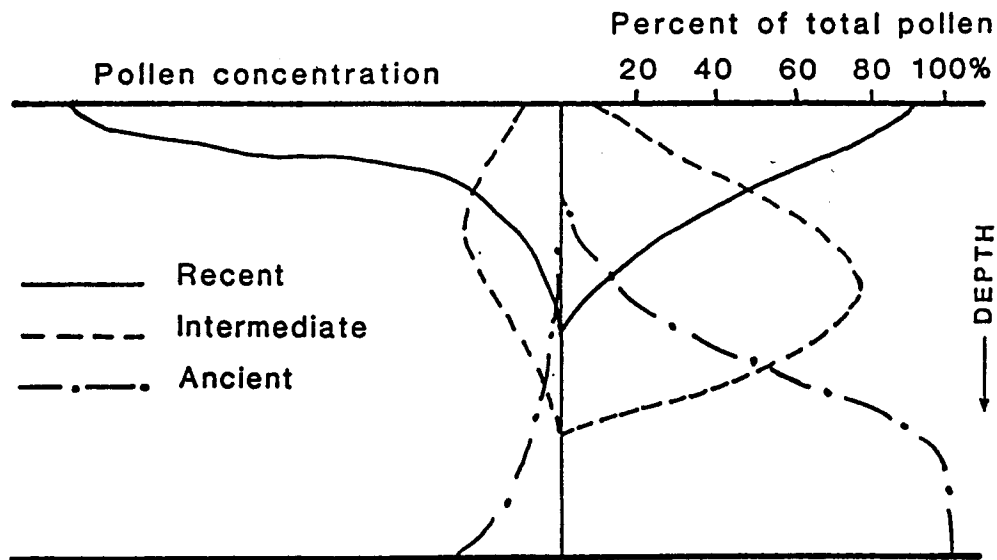
Results

There are three facets to the Great Meadows pollen spectra recovered during the feasibility study. The nature of pollen record formation processes is one facet, while the reconstruction of a pre-clearance vegetation transect across the meadow is a second facet. The third facet is a record of Euro-American era land use.

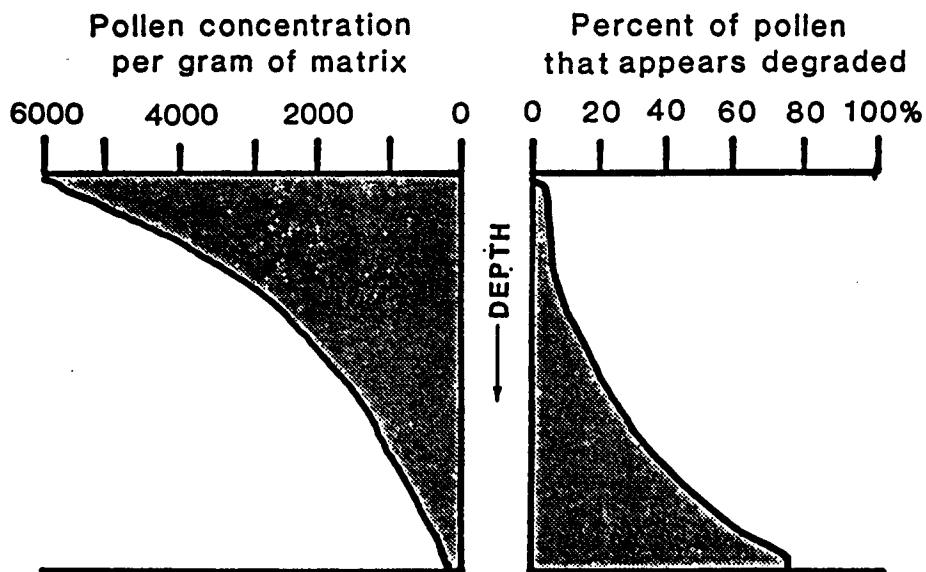
Pollen Record Formation Processes at Great Meadows

The pollen spectra of temperate zone terrestrial deposits are subject to post-depositional distortion. Two kinds of post-depositional changes are recognized: pollen movement and pollen destruction. In normal exposed terrestrial deposits, pollen is carried downward by percolating groundwater (Dimbleby 1985:5), while earthworms move it both up and down (Walch et al. 1970:40). The product of these processes is a stratigraphic pollen distribution in which most of the oldest pollen lies at the bottom of the profile, but some may be found at the top. The majority of the youngest pollen grains are found near the surface, but some have been moved deep into the sediment. Pollen of intermediate age is concentrated in the middle of the sequence, but a few grains of this age are recovered from the top and bottom of the sequence (Dimbleby 1985:5). Dimbleby's (1985:Figure 3) model of this theoretical distribution is presented in Figure 3A.

When pollen is moved downward in the profile, it is also progressively destroyed by oxygen in percolating rainwater (Tschudy 1969:95) and by aerobic fungi (Goldstein 1960:544). This produces pollen concentration and preservation patterns in which there are more pollen grains



A. THEORETICAL DISTRIBUTION IN SOIL OF
POLLENS OF DIFFERENT AGES
(after Dimbleby 1985)



B. THEORETICAL POLLEN CONCENTRATION
AND DEGRADATION IN A SOIL PROFILE

Figure 3. Theoretical distribution of pollen in a soil profile.

per gram of matrix and fewer pollen grains displaying evidence of corrosion at the top of profiles than at the bottom. An idealized model of this distribution may be seen in Figure 3B.

The pollen concentration and pollen degradation (too corroded to identify and percent corroded oak) patterns characteristic of percolated pollen spectra were observed in all of the Great Meadows cores. They were particularly clear in the cores from the dry hillside. The example from core 2 is presented in Figure 4. The pollen counts of the groundcover plants themselves also suggest pollen percolation in these cores. In hillside core 2 (Figure 4), for instance, the pre-clearance forest is registered in the prominent oak (*Quercus*) pollen counts near the bottom of the profile. The ragweed (*Ambrosia*-type) frequencies dominating the center of the profile reflect the disturbed, bare soil of the clearance period, while the grass (*Gramineae*) pollen dominating the upper third of the sample series records the maturing of the grass cover of the park period. The similarity between this oak/ragweed/grass sequence and Dimbleby's (1985:Figure 3) old, intermediate, and recent pollen model illustrated in Figure 3A is striking. The core 2 pollen concentration, "too corroded to recognize," and "percent corroded oak" data (Figure 4) also conform to the normal pollen concentration and degradation model presented in Figure 3B.

Dimbleby (1985:3, 59) used tree pollen horizon markers to calculate a pollen percolation rate of about 10 cm per 300 years under forest planted on plowsoil and pasture in Great Britain. The forest clearance horizon of core 1, where pollen movement has not been modified by alluviation, should serve a similar purpose at Great Meadows. No pollen was recovered deeper than 34 cm below present ground surface in core 1 (Figure 6). Calculating pollen percolation rates will permit us to estimate the length of pollen record that we can expect to recover from similar dry, rural pollen matrices.

The cores were collected in 1987. In core 1, clearance is recorded at about 20 cm below present ground surface. If clearance took place circa 1880, the pollen percolation rate was about 1 cm in 5.35 years (4.46 years allowing for 20% soil compression). Using this percolation rate, the oldest pollen recovered in this core dates to about 1805. If clearance took place in 1856, the pollen percolation rate was 1 cm in 6.55 years (5.46 years allowing for 20% soil compression), and the pollen at 34 cm depth dates to about 1764. The hillside pollen record apparently does not reach 1754, but late 18th-century pollen data, predating significant commercial exploitation of the meadow, were recovered. The pre-clearance pollen spectra in the Great Meadows cores can be considered representative of the pollen rain of the French and Indian War period.

The Pre-Clearance Vegetation on Great Meadows

A distinct series of vegetation changes correlated with local topography is evident among the pre-agricultural period spectra in the Great Meadows core transect. To make it easier to visualize this edaphic sequence, all samples below the oak decline (indicating clearance) and all samples below the sedge (*Cyperaceae*) decline (indicating drainage) in the pollen spectra

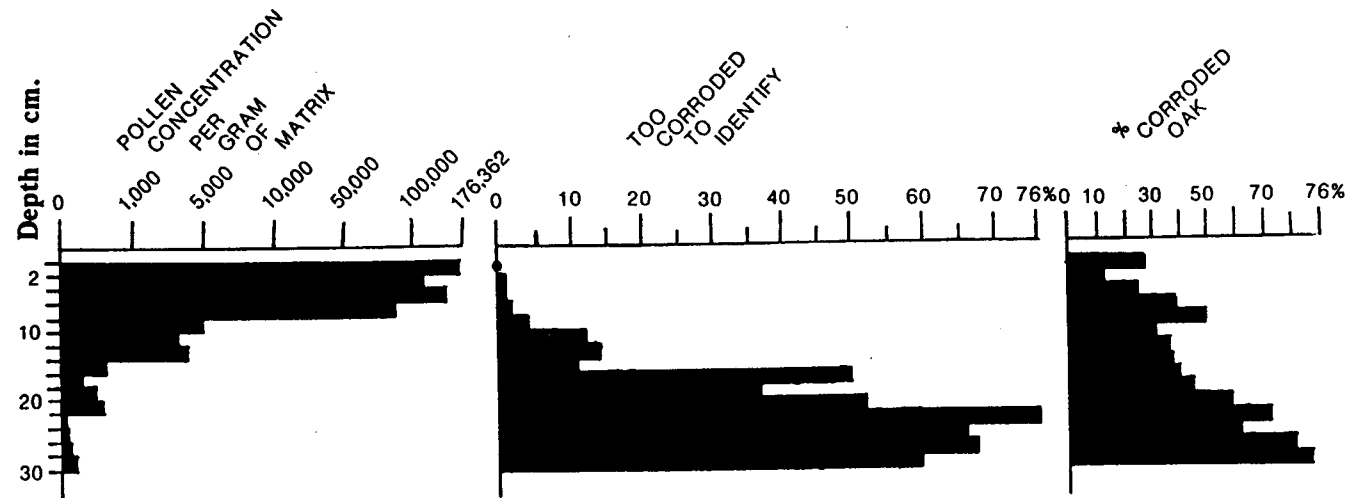
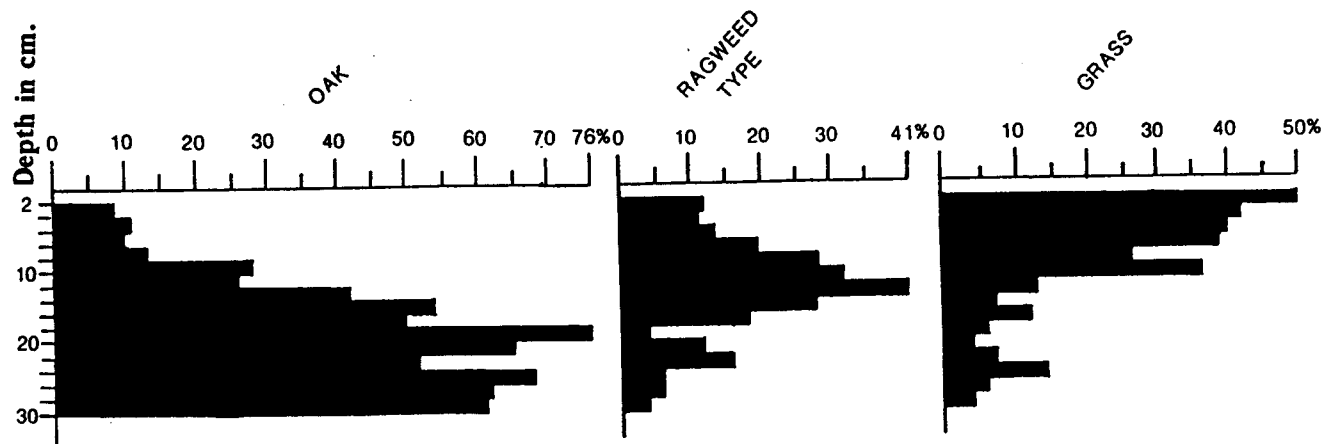


Figure 4. Pollen percentages of dominant types in core 2 (hillside/former forest) of the feasibility study transect at Great Meadows.

of each core are combined as single samples, and presented in order down the hillside and across the meadow in Figure 5.

Oak pollen is the most common type in all cores in Figure 5. It is most prominent in cores 1 and 2, and these counts reflect oak-dominated forest covering the western hillside above the meadow. Oak percentages are lower and relatively uniform in cores 3-6 because they record the background oak pollen contribution that was homogenized while being wind-transported onto the treeless meadow (Janssen 1973:40). The relatively high hickory (*Carya*) and red maple (*Acer rubrum*-type) counts of cores 1 and 2 indicate that these trees were present among the oaks on the western slopes (Figure 5). The slightly higher beech (*Fagus*) and birch (*Betula*) percentages of cores 1-4 suggest a local, rather than an extra-local or regional, pollen source (Figure 5). They probably reflect the presence of a few trees of this kind on the west side of the meadow near or just outside the tree line of the oak-dominated forest.

Alder (*Alnus*) pollen percentages rise and fall in a bell-shaped curve from core 1 to core 6 (Figure 5). They peak where the oak contribution falls off in core 3, suggesting that most of this pollen came from an alder population situated between the tall forest and the grass-dominated portion of the meadow. The largest percentages of black locust-type (*Robinia*-type) and holly (*Ilex*) pollen were also found in this segment of the core transect (cores 3-5) and a few of these trees must have been scattered about the meadow between the forest proper and the marshy area near the fort.

The pollen contributions of pine (*Pinus*), hazel (*Corylus*), hemlock (*Tsuga*), spruce (*Picea*), walnut (*Juglans*), blue beech/hornbeam (*Ostrya/Carpinus*), sugar maple (*Acer saccharum*), ash (*Fraxinus*), willow (*Salix*), and poplar/cottonwood (*Populus*) all increase in cores 5 and 6, nearest the fort. Mesic taxa, such as cottonwood or willow, may have been growing at the lowest part of the meadow, but it is unlikely that many of the other trees were rooted here. Most of this pollen was probably water transported down the stream and deposited on the meadow during periods of bank overflow. It is also possible that some of this pollen was blown from trees growing on the slopes to the east of the meadow.

Among the non-arboreal pollen types, only that of the pink family (Caryophyllaceae) was more common among the oaks (cores 1 and 2) on the western slope than on the meadow. The presence of more grass (Gramineae) among the alders at the forest edge is indicated by the increase in this pollen type in core 3, and the extent of the meadow proper is recorded by the high, uniform grass pollen percentages of cores 4, 5, and 6. The remaining non-arboreal pollen types, sedges excepted, were clustered in cores 3, 4, and 5. Some of these, such as elderberry family (Caprifoliaceae), hawthorn, and other members of the rose family (Rosaceae), are from woody shrubs and probably record the sort of "bushes" that Washington ordered removed to deny cover to potential attackers (Fitzpatrick 1931/1944:I:54). Other non-arboreal types, such as meadow rue (*Thalictrum*), goldenrod-type (*Solidago*-type), ironweed-type (*Liguliflorae*), goosefoot family (*Chenopodiaceae*), and dock-type (*Rumex mexicanus*-type), record the presence of relatively tall non-woody herbs. Lower growth is indicated by mugwort (*Artemisia*), ground cherry-type (*Physalis*-type), buttercup family

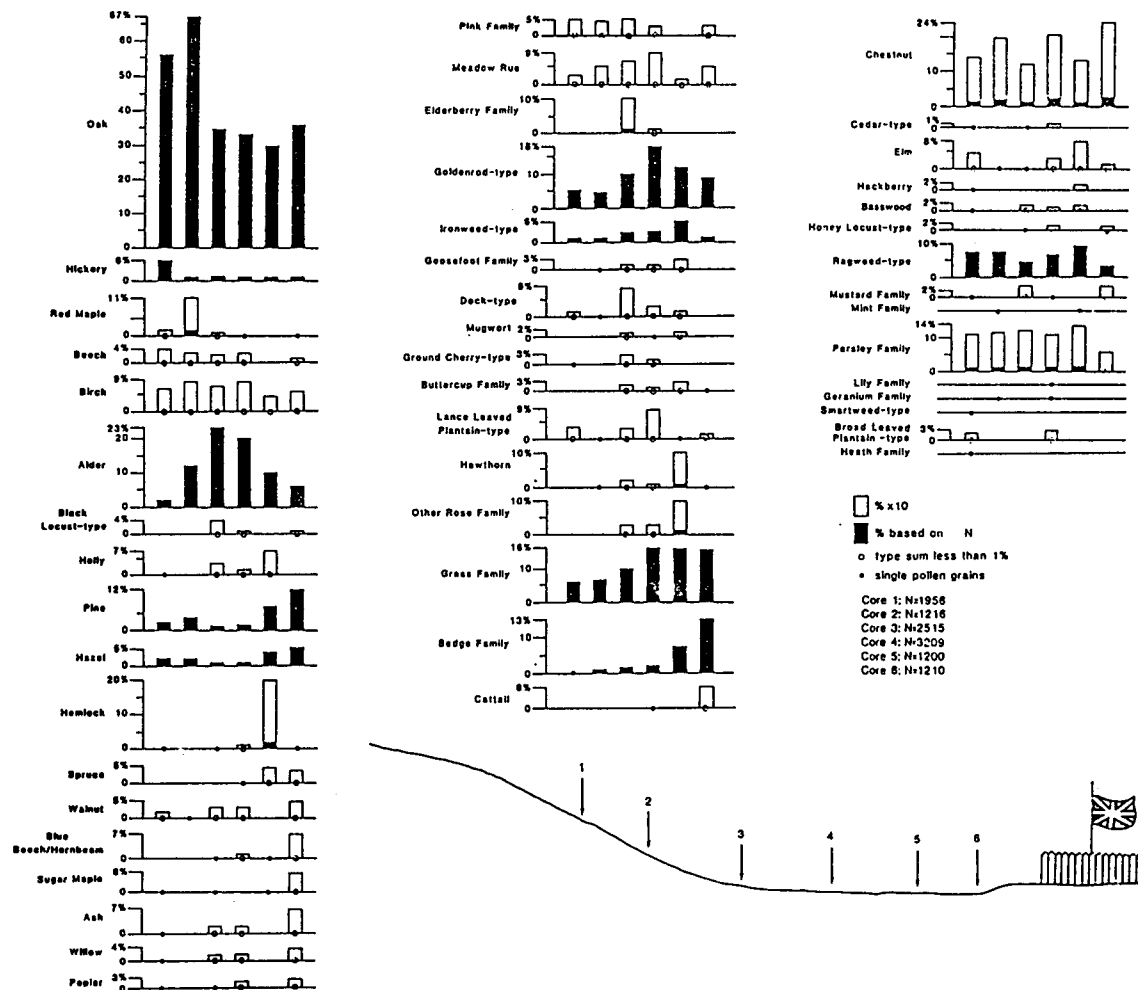


Figure 5. Pollen percentages of pre-clearance pollen samples of the Great Meadows feasibility study cores presented in topographic order down the hill and onto the meadow.

(Ranunculaceae), and lance-leaved plantain (*Plantago lanceolata*-type). A similar plant assemblage has taken over the meadow since the National Park Service stopped mowing. The grasses are now quite visible in the spring and early summer (when Washington was at the meadow) but they constitute an understory beneath the tall herbs on the dry portion of the meadow in the fall.

Rising frequencies of sedge (Cyperaceae) pollen, a poorly dispersed type (Handel 1976:422), in cores 5 and 6 and the presence of a few cattail (*Typha*) pollen grains in core 6 indicate that the ground became progressively wetter nearer the fort (Figure 5). The pollen contributions of most herbs, including those uniformly distributed across the rest of the transect (Figure 5, third column) were depressed in core 6, and the ground must have been too marshy for anything but sedges and grass.

The Record of Euro-American Land Use

Oak and grass pollen frequencies are highest at the bottom and top, respectively, of all six Great Meadows cores (Figure 6). Weed pollen, of one kind or another, is most prominent in the center of the cores. This tree-weed-grass pollen domination sequence clearly records forest clearance and park development, but it does not constitute the total land-use record at Great Meadows. In high, dry core 1, for example, the chestnut (*Castanea*) contribution increases as oak and hickory percentages decline but falls off after the pollen of the European cereals appear in the record. This coincides with the peak of the ragweed-type contribution at 14 cm below present ground surface. Ragweed is uniquely adapted to the harsh temperature and moisture regimen of cultivated ground and is normally the dominant weed in North American tilled agricultural fields (Bazzaz 1974), while chestnuts are stump sprouters. European cereal pollen, rye (*Secale*) excepted, is spread by cultural rather than natural mechanisms, and cereal pollen is not found in unfertilized fields (Vuorela 1973:2). The ragweed counts suggest that the hillside above Great Meadows was frequently plowed, and appearance of cereal pollen during the period of ragweed dominance probably reflects manure applied as fertilizer (Behre 1981:227). The increase in chestnut pollen following clearance indicates that the stumps on the hillside were neither grubbed out nor burned at initial clearance. Plowing around stumps was a sufficiently common practice during the 19th-century agriculture for farmers to express a preference for certain kinds of plows when working around stumps (Rogin 1931:10). The core 2 spectra record a very similar groundcover sequence.

Tree pollen also dominates the meadow cores (3-6), but the total arboreal sum is much lower here than in cores 1 and 2 (Figure 6). The tree pollen contribution thinned out as it blew into the meadow from the hillsides, and the pollen record of local clearance is partially masked by input from the broader pollen source area characteristic of open spaces (Martin 1963:Figure 2; Tauber 1965:33). Herbs and shrubs are more important in the land-use history in the original meadow. In cores 3 and 4 (Figure 6), for instance, alders, goldenrod, and ironweed are the primary types that decline during the agricultural period, but they may not have been

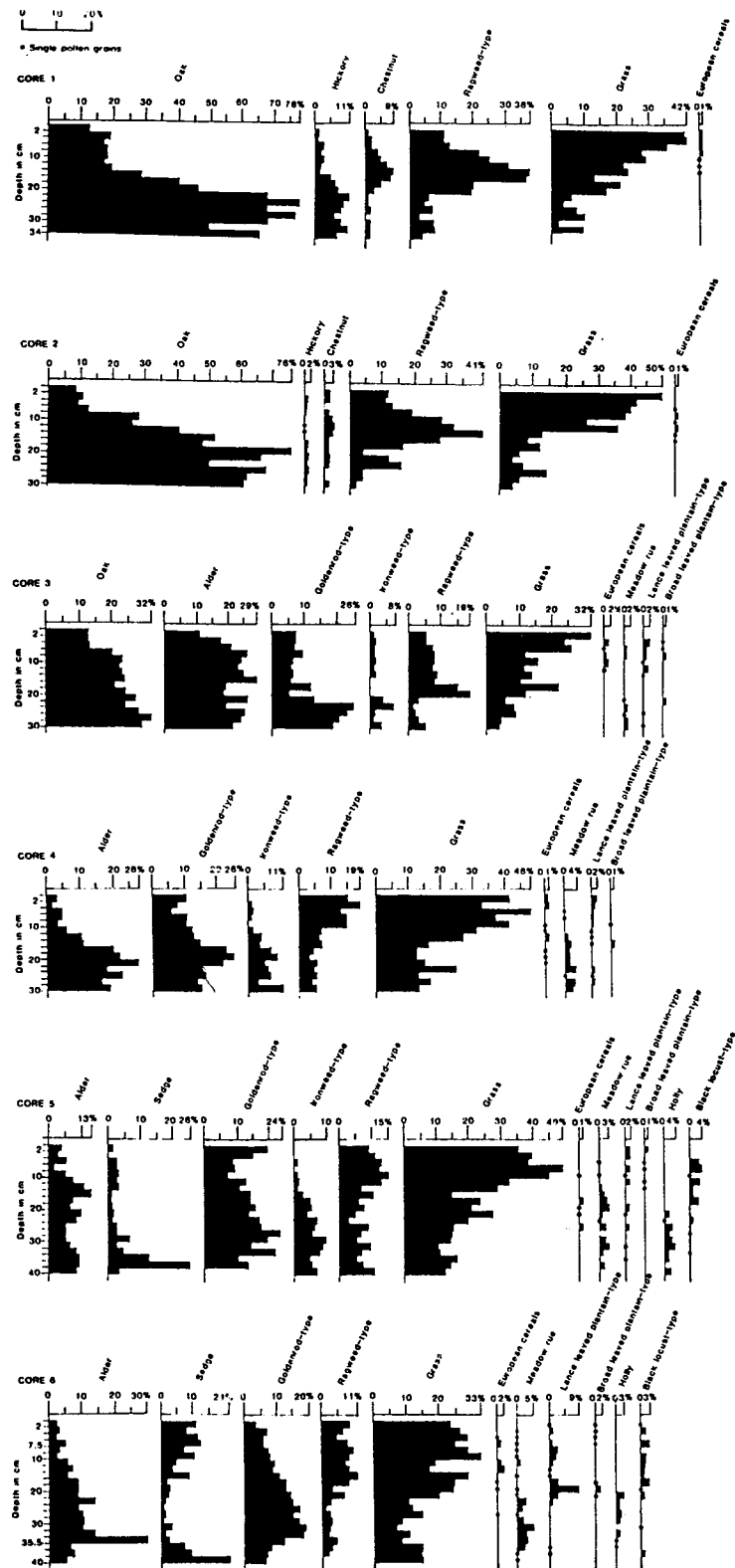


Figure 6. Percentages of pollen types critical for edaphic land-use interpretation in the Great Meadows feasibility study cores.

intentionally suppressed. All three types decline sometime after European cereal pollen appears. In the meadow proper this type probably reflects the presence of cattle and the alders, goldenrod, and ironweed may have been browsed off. The native meadow rue suffered a similar fate as soil disturbance indicators such as plantains (*Plantago lanceolata*/P. major) became regular elements in the counts. The ragweed contribution to cores 3, 4, and 5 increase where grass frequencies rise and may reflect cattle-related soil disturbance rather than plowing.

High sedge frequencies indicate wet meadow at the bottom of cores 5 and 6 (Figure 6). The decline in sedge pollen that records either the draining of the wet meadow or the raising of the surface through alluviation occurred much earlier than the decline in arboreal pollen that registered the 1856-1880 tree clearance on the meadow flanks or the grazing related vegetation changes on the dry meadow. The sedge decline may record land improvements by the proprietors of Mount Washington Tavern, established in 1828 on the eastern flank of the meadow (Harrington 1957:16).

The goldenrod (*Solidago*-type) population expanded when the meadow was drained, but this was later suppressed by thickening grasses. The native meadow rue also declined and alien soil disturbance plants such as the plantains increased. The appearance of cereal pollen (indicating the presence of cattle on the meadow) was followed by an increase in ragweed (a soil disturbance indicator) and by the extermination of holly, apparently by browsing. The subsequent increase in black locust suggests overgrazing slightly later in the sequence. The higher sedge frequencies at the top of core 6 record the reappearance of marshy ground when the National Park Service cut off drainage by raising the ground level to create the present lawn.

Summary and Recommendations

The most important aspect of the Great Meadows study for planning purposes in rural historical archaeology and rural landscape studies was that it demonstrated that the pollen record formation processes described by Dimbleby (1985:5, Figure 3) operate in North American temperate zone deposits. Pollen that falls on the surface of exposed, non-aggrading deposits is moved downward by percolating groundwater and is progressively destroyed as it moves. This should not be considered entirely deleterious. Erosion and wind deflation have been characteristic of the Euro-American agricultural regimen. It is unlikely that there has been much, if any, soil deposition on hillsides in the North American temperate zone during the agricultural period, and earthworms characteristically homogenize the pollen deposited in temperate zone basic soils (Havinga 1974:453). Pollen evidence for successive groundcovers on the slopes above Great Meadows would have eroded away or, at best, would have accumulated in an unreadable "palimpsest" in the upper few centimeters of the soil profiles if the spectra had not been stratigraphically separated by pollen percolation down into the soil. The Great Meadows pollen study indicated that it is possible to recover pollen evidence for edaphic changes and shifts in human land-use patterns across short spans of time and space.

The agricultural-era pollen spectra from Great Meadows preserve evidence for culturally related groundcover changes that are not registered in the literary record. This is significant for students of historical landscapes. Local agricultural practices, such as plowing around stumps and over-grazing, are documented in the pollen record, along with side effects, such as the cattle-browse extermination of holly and the eventual removal of sprouting chestnuts. Paleobotanical techniques are applicable to all historical landscape investigations and will permit groundcover restoration to a chosen period, even when a site has a long and varied history of occupation. Pollen records of several hundred years duration can be recovered from most temperate zone soils, and it is not necessary to resort to the intuitively assembled profiles of lumped, undated small samples that Schoenwetter (1990) recommends.

The most important aspect of this study from the National Park Service point of view was the pre-clearance vegetation record recovered from the deeper portions of the cores (Figure 6). These data indicate that the western hillside above the meadow was covered by an oak-dominated hardwood forest (cores 1 and 2), that the ground near the fort (cores 5 and 6) was a marsh dominated by sedges and grass, and that a mixture of shrubs and herbs, with a grass understory, occupied the portion of the meadow between the oak forest and the marsh (cores 3, 4, and 5). Most of the "bushes" removed from the meadow at Washington's direction (Fitzpatrick 1931/1944:I:54) appear to have been alders, arrowwood, and members of the rose family, including hawthorns. There were more alders at the fringe of the forest, while grass, meadow rue, goldenrod, and ironweed were thickest on the dry ground closer to the fort. The pre-clearance pollen spectra indicate it is possible to reconstruct the pre-clearance vegetation of Great Meadows with acceptable accuracy. A stylized artist's conception of that vegetation is presented in Figure 7.

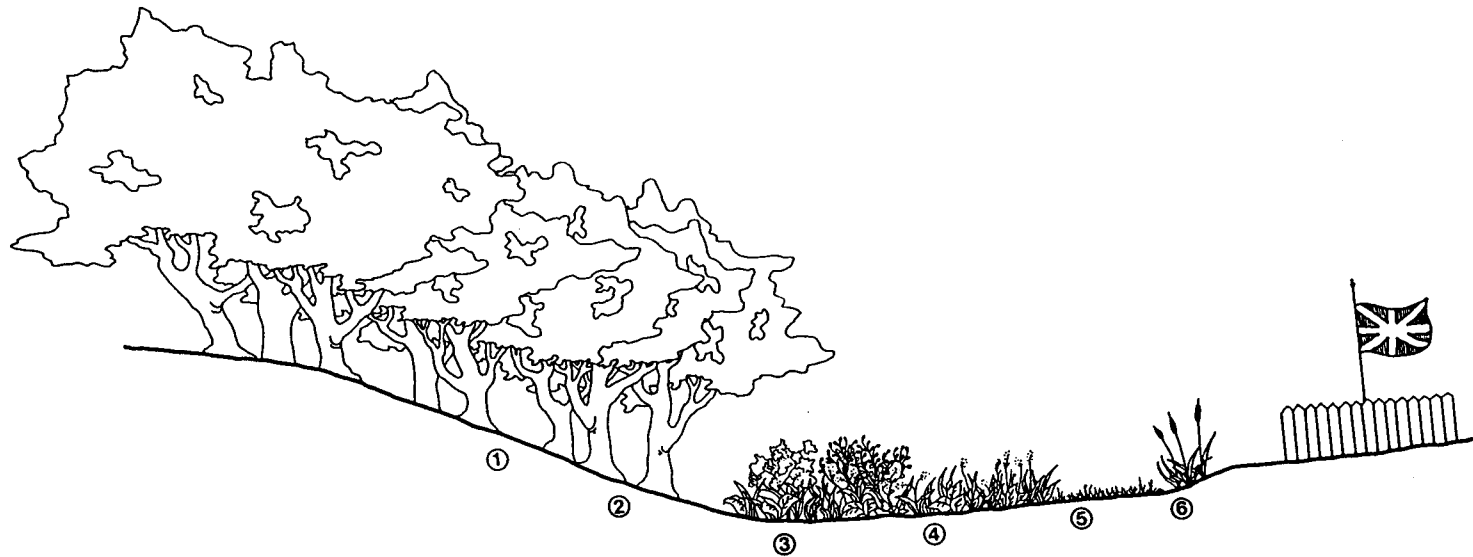


Figure 7. Stylized artist's conception of Great Meadows in 1754.

Full Analysis Stage

The second stage of the forest border location project focused on locating the forest/meadow edge with the greatest possible accuracy. Research in this stage was based on the feasibility study indicating that the plant communities occupying successive segments of the edaphic gradient from the edge of the watercourse up the slope to the dry hillside would be recorded in the pre-clearance pollen spectra at the bottom of cores taken in transects up the hillside.

Methods

Technical methods for this portion of the study were identical to those of the feasibility study. Much larger quantities of data were, however, employed. One hundred fourteen soil cores were taken in eight transects of seven to 18 soil cores each (Figure 8). These eight transects ran from the edge of Great Meadow Run up the adjacent hillsides, with the first core nearest the water course. Most cores were taken at 20-ft intervals. Two transects (No. 1,2) were located on the south side of the meadow, three (No. 3,4,5) were located on the west side of the meadow, and three (No. 6,7,8) were located on the northeast side of the meadow. The cores were taken by driving sharpened sections of 2-inch I.D. schedule 40 standard PVC pipe into the ground about 4.5 ft with a sledge hammer and pulling them out with a large "Handy Man" jack. At some core stations another 24 inch section was taken below the PVC core with a split spoon corer.

During the coring process it was discovered that the modern floodplain section of Core Transect No. 7 ran across a filled area that proved to be a parking lot during the 1950s. Three exploratory cores, off-set to the east and numbered 1E, 2E, and 3E, were taken at 80-ft intervals in the floodplain. Six additional cores were later taken to fill in this easterly transect and clarify vegetation data for the upper floodplain edge. Three of these, 5E, 6E, and 7E (all taken at 20-ft intervals between 2E and 3E) were used in the analysis. During analysis it was found that seven cores in the critical forest/meadow transition section of Core Transect No. 8 did not reach unequivocal pre-clearance pollen spectra. Split spoon cores (24-inch) were subsequently taken in the same holes at these loci.

Pollen analysis is time consuming and, therefore, expensive. The cost of full analysis of all samples in the 114 cores that were selected for examination was prohibitive. In this portion of the project, analysis started at the bottom of each core and proceeded until pollen spectra indicating forest clearance or meadow drainage were noted. One hundred to 400 grain counts, depending upon pollen density, were done on each sample, and the pre-clearance or pre-drainage counts of each core were combined and graphed as a single sample. This produced sums of 100 to 1000 pollen grains for each core (Figures 11-18). For reasons of financial and time constraint, the split-spoon sections of cores 7-11 in core Transect No. 8 that were reevaluated during the last part of the project received only 100 grain counts of single samples.

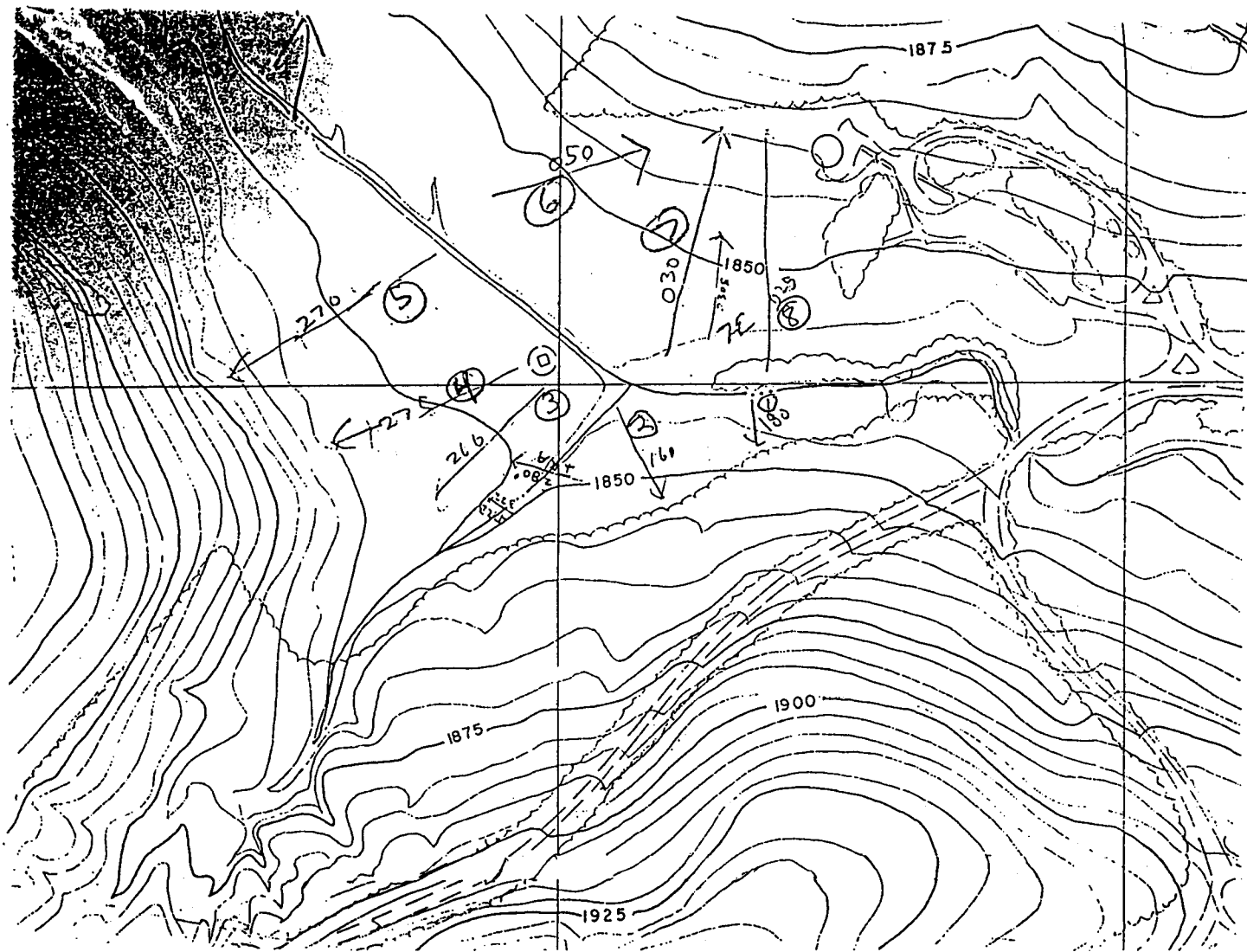


Figure 8. Full analysis core transect locations at Great Meadows.

Pollen percolation varies with bioturbation, and the pollen spectra of successive groundcovers do not replace each other abruptly in soil profiles. They overlap stratigraphically, and it is often possible to determine the nature of a replaced groundcover from the pollen grains remaining from largely replaced spectra. The hillsides above Great Meadows had suffered considerable erosion. The ground was rocky and the soil was shallow. A number of cores in these portions of several transects did not reach pure pre-clearance pollen spectra, but retained enough old pollen to ascertain the nature of the pre-clearance flora. These have been retained in the analytical sample series, with the contamination noted in the text.

Pine, spruce, and hemlock pollen are over-represented in the floodplain sections of most transects. No source reports stands of these trees on the flats, and there is relatively little of these types in the cores on the oak dominated hillsides. The pine and spruce pollen did not originate where it was found and it did not blow or wash down from the slopes above the meadow. It is also unlikely that it could have blown in from the stands of conifers reported on Laurel Hill to the east during the early 19th century (Torres-Reyes 1970:10) without depositing significant quantities on the hillside as well. Pine, spruce, and hemlock pollen is saccate (i.e., possessing bladders). In pine, at least, these bladders act as water wings and facilitate the post-depositional water transportation of the pollen over long distances (Traverse and Ginsburg 1966). This pollen was transported down Great Meadow Run and Indian Run by floodwater and deposited on the floodplain with alluvium. This exotic pine, spruce, and hemlock pollen distorts the local pollen record of vegetation. These types appear in the diagrams (Figures 11-18) but were excluded from the sums upon which the percentages of the other types are based.

Theoretical Considerations

The combined spectrum employed in this study reduces the random variation from minor shifts in vegetation over time at each locus, and the sums are large enough to recover evidence of the presence of plants shedding the less abundant pollen types (Duffield and King 1980). The resolution that these counts provide for the minor types cannot be as good as that of the very large sums (1210-3209 grains) employed in the pre-clearance diagram of the feasibility study (Figure 5). For the purpose of this stage of the analysis, primary reliance will be placed on the distribution of the two types most characteristic of the forest and meadow: oak and grass.

Both oak and grass pollen are wind-dispersed and travel some distance from the parent plant. Oak pollen is particularly noted for long-distance transport. This reputation is a product of the reliance of paleobotanists on tree pollen from lake deposits for the reconstruction of regional climate. When pollen deposition on ground surfaces at edges of individual woodlands is considered, however, a different image of oak pollen dispersal emerges. A European study of oak pollen transport from a woodland out onto a heath (Tinsley and Smith 1974; Edwards 1982:7, Figure 2) clearly indicates an abrupt drop in the oak pollen contribution between the edge of the woodland and the first sampling station 33 ft out into the meadow. Oak pollen percentages decline from the 40-55% range to about 15% of the

spectrum very close to the woodland edge (Figure 9). Dispersal studies of birch pollen (Caseldine 1981:Figure 3), comparable in size to oak pollen, also showed a drop off within 33 ft of woodland edge and yielded similar results (Figure 10). The decline of the oak pollen contribution in the Great Meadows feasibility study ecotone spectra indicated that an abrupt drop in the percentages of the dominate tree pollen type should record woodland or forest edge in any sample series. Great Meadow, unlike the reported European study areas, was surrounded by trees. The pollen in the meadow samples came from multiple directions and transport was facilitated by the elevation of the hillsides. The percentages of the oak pollen blown out onto Great Meadows in the feasibility transect never declined below 30%, and the pattern of shift at the woodland edge is more important to this study than actual pollen percentages.

Grass pollen starts out closer to the ground than oak pollen. Wind velocities are lower at ground level, and the chance of pollen loss through impact with vegetation in the dense populations characteristic of grasses is much higher. It is improbable that grass pollen is transported as far or in as large a quantity as oak pollen, but there are data indicating that, like oak, it is wind-dispersed some distance and declines in percentage with distance from its source. The amount of grass pollen still in the air over bare ground at 33 ft from the edge of a discrete timothy (*Phleum pratense*) population declined to about 25% of that detected at 3.3 ft from the edge of the grass plot and further declined to about 6% at 198 ft from the source (Raynor et al. 1972: Figure 9). This is comparable to the Tinsley and Smith (1974) pattern for oak and the Caseldine (1981) pattern for birch. Grass pollen transport into a woodland should decline in the same way that the percentages of tree pollen transported out onto a meadow fall off. The Great Meadows feasibility data suggested that this is the case (Figure 5). Grass pollen percentages drop off where grasses are shaded out under the alders at the forest border and decline further under the oaks.

Some of the grass pollen in the pre-clearance levels at Great Meadows probably percolated down from post-clearance spectra. This will have the greatest effect on the counts inside the forest and should not completely mask the increase in the grass contribution predictable at the forest edge. An abrupt drop in the oak pollen contribution and an equivalent increase in grass pollen percentages were visible at the forest edge in the feasibility transect (Figure 5) and should serve as an effective marker for the forest border on other slopes around the meadow.

Results

Vegetation Community Distributions

Core Transect No. 1: This seven-core series is the most easterly transect on the south side of Great Meadow Run (Figure 8). The transect of seven cores taken at 20-ft intervals ran due south (180° magnetic) from the run to the present woodland edge. The first core was taken 5 ft from the water course. It struck rock at 3 ft depth, approximately the depth of the rocks visible in the bottom of the run, and attempts to core at other spots close to Great Meadow

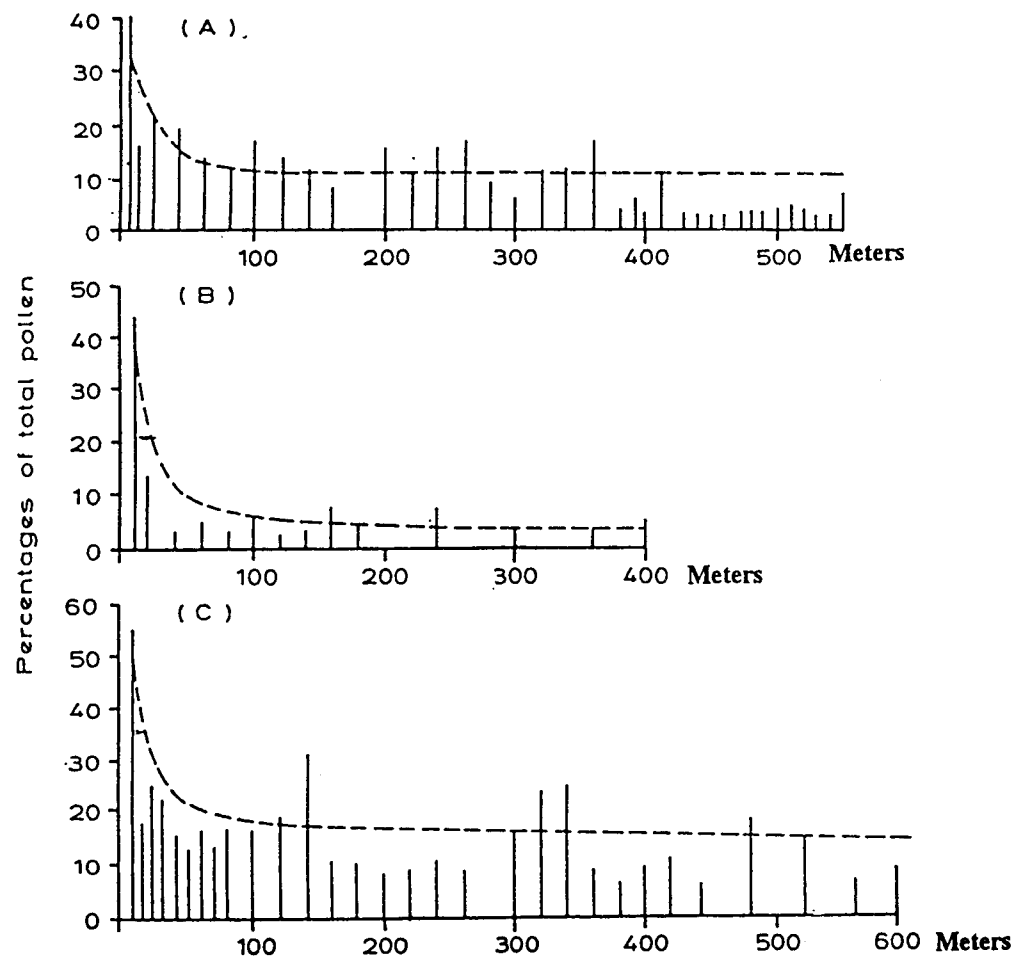


Figure 9. The frequency of oak pollen deposited at increasing distance from the woodland edge (after Tinsley and Smith 1974 and Edwards 1982).

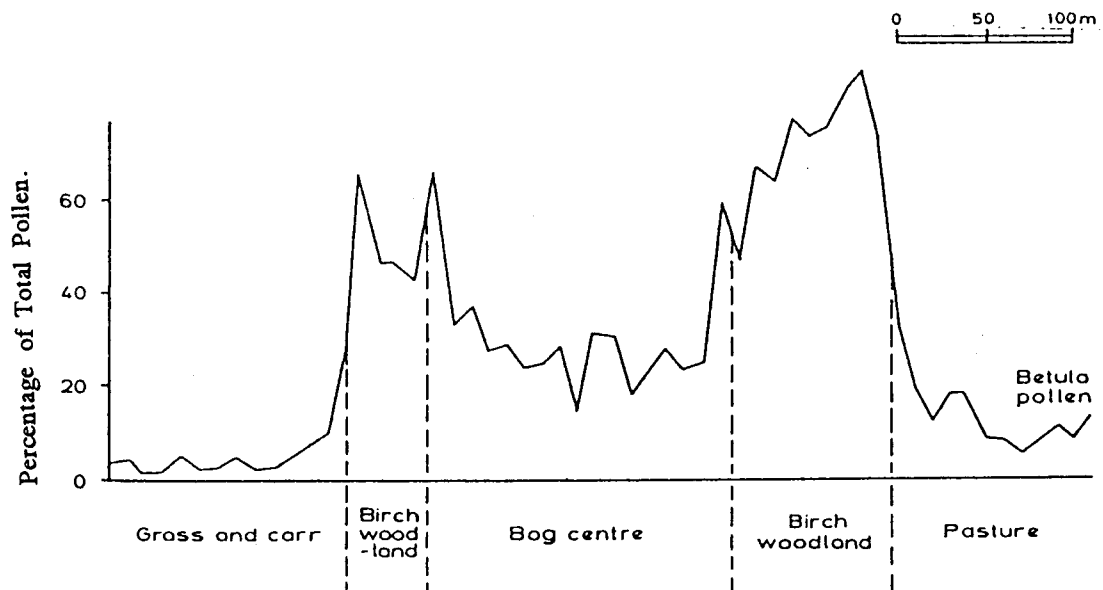


Figure 10. Birch pollen dispersal at Bankshead Noss, Scotland (after Caseldine 1981 and Edwards 1982).

Run were also thwarted by stones. The core furthest up slope, core 7, was located 5 ft inside the current tree line.

Grass never exceeds 5% of any count in Transect No. 1 (Figure 11). This is comparable to the grass pollen frequencies inside the forest in the feasibility study (Figure 6), suggesting that the pollen was either blown or percolated to its present location. It appears unlikely that there was a grass population large enough to qualify as meadow anywhere on Transect No. 1. The distributions of other types do, however, reflect changes in the plant communities along the transect.

The five Transect No. 1 spectra (cores 7-3) furthest from Great Meadow Run are dominated (74-83%) by oak pollen. This type drops off to 25% in core 2 but rebounds to 53% in core 1. Beech, hickory, pine, and spruce counts are highest in the cores dominated by oak. Chestnut, alder, hazel, ragweed-type, goldenrod-type, ironweed-type, rose family, parsley family, and meadow rue frequencies were most prominent in core 2. Birch, hemlock, ash, willow, and cattail percentages were highest in core 1.

The majority of the oak pollen grains in core 1 were perfectly preserved. This condition indicates a rapid deep burial, and strongly suggests that the core 1 matrix is alluvial fill in an old Great Meadow Run channel. The channel may have wandered back and forth, cutting and filling many times. All of the pollen types best represented in this matrix (hemlock, ash, birch, and some of the willow) probably reflect tree populations upstream rather than at the transect locus, and the pollen is probably not contemporaneous with that of the other plant communities reflected in the transect.

The types best represented in core 2 (goldenrod-type, ironweed-type, rose, parsley, meadow rue, alder, hazel, and probably willow) reflect a fringe of shrubs, herbs, and smaller trees between the banks of Great Meadow Run and the forest proper. The chestnut count in this sample is a problem. Chestnut belongs up slope in the forest proper, rather than here with ecotone taxa, and the isolated 4% of the type in core 2 is reminiscent of the post-clearance stump-sprouter induced peak of chestnut pollen in feasibility study cores 1 and 2. With the exception of this count, the core 2 spectrum appears to predate clearance. Chestnut pollen is small. It appears to percolate faster than other types and has been recognized as a percolation contaminant in otherwise normal spectra (Dimbleby 1985:3,11).

Almost all of the oak pollen grains in cores 7-2 were poorly preserved, indicating that they percolated down to the depth at which they were recovered from the former surface. They are in situ, and the abrupt decline in oak counts in Core 2 indicates that the pre-clearance edge of the oak dominated forest (also incorporating hickory and beech, at least, and probably some birch, pine, and spruce) was located between cores 2 and 3, perhaps 35 ft from the current south bank of the watercourse.

Core Transect No. 2: The 8 cores of Transect No. 2 were collected on an axis of 160° magnetic. Core 1 was driven through the present fort lawn on the north side of Indian Run.

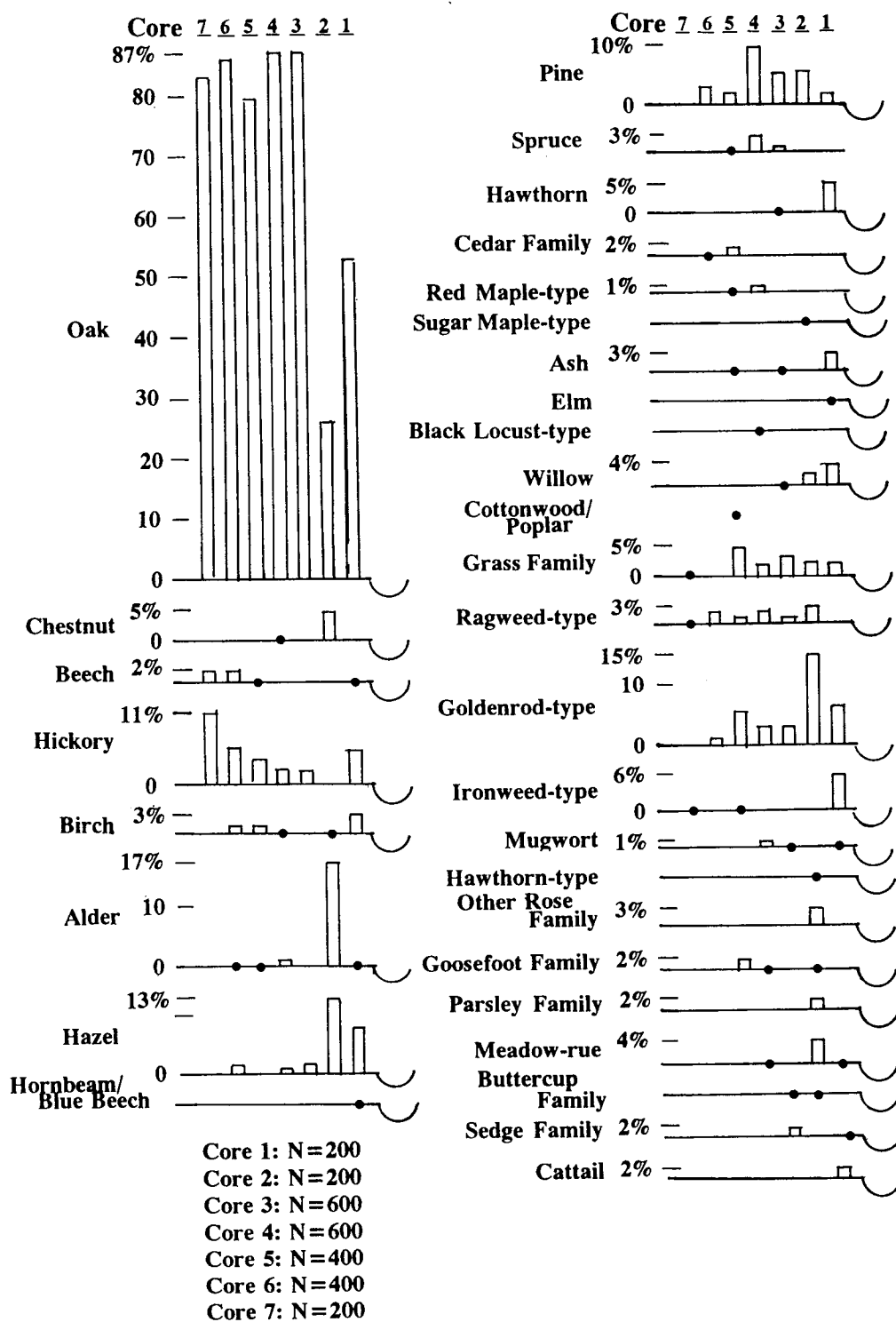


Figure 11. Core Transect No. 1 pollen spectra.

The remaining seven cores (2-8) were located on the south side of Indian Run, west of the confluence with Great Meadow Run and east of the current foot bridge over Indian Run (Figure 8). The core transect was collected in 20-ft intervals; starting with core 2, 10 ft south of the present bank of Indian Run and ending with core 8, one ft north of the present tree line.

Most of the 4.5 ft of matrix in core 1 was fill introduced to raise the ground level during the initial reconstruction of the fort in the early 1930s. It was dominated by grass pollen with significant amounts of oak, alder, hazel, and some ash and pine (Figure 12). The deepest two samples were dominated by pine, with more spruce and correspondingly fewer grains of the other types. The differences between the pollen content of these two samples and that of the known artificial fill of the upper core are sufficient to indicate that the deepest 4 cm of matrix is the natural soil of the area preceding the construction of the fort lawn. The domination of the spectrum by pine pollen does not mean that the immediate vicinity was populated with pines before reconstruction of the fort. Pine pollen is transported further than most other types when deposited on moving water (Traverse and Ginsburg 1966). The pine pollen in core 1 originated somewhere up Indian Run and is over-represented because the other, less buoyant, types from the same area sank before reaching the fort. Pine, spruce, and hemlock pollen was excluded from the sums from which the other Transect No. 2 pollen percentages were calculated.

A fairly clear succession of vegetation up slope from Indian Run is evident in cores 2-8 (Figure 12). A significant amount of sedge pollen (7%) in core 2 registers wet ground immediately along the watercourse, while the peak (18%) of alder pollen in the same core, declining progressively in cores 3-6, indicates the same fringe of alders along the run that was recorded in Transect No. 1, to the east. Both ironweed and goldenrod were present along the watercourse. These two taxa are insect-pollinated and are not dispersed great distances from the parent plants. They were present along the upper transect as well. In cores 3-6 where the ground was better drained, the pollen percentages, but not necessarily the plants themselves of these two taxa, were statistically suppressed by the pollen contribution of the larger grass population, indicated by higher grass pollen percentages. Grass pollen drops off abruptly where oak frequencies increase in cores 7 and 8. This strongly suggests that the pre-clearance edge of the woodland lay between cores 6 and 7, at about 100 ft from the present edge of Indian Run. A peak of chestnut pollen, comparable to that of core 3, Transect No. 1, is evident in core 6. It does not belong in the grass dominated segment of the transect and may reflect differential percolation contamination from post-clearance pollen spectra.

Core Transect No. 3: Transect No. 3 was located north of the low, wet ground bordering Indian Run. It consisted of 14 cores taken at 20-ft intervals and ran 260° magnetic from 1 ft outside the edge of the present fort lawn, across a relatively flat portion of the meadow, and up the slope on the west side of the meadow (Figure 8). The cores were numbered from 1, at the edge of the fort lawn, to 14, at the top of the transect just below the visitor path on the

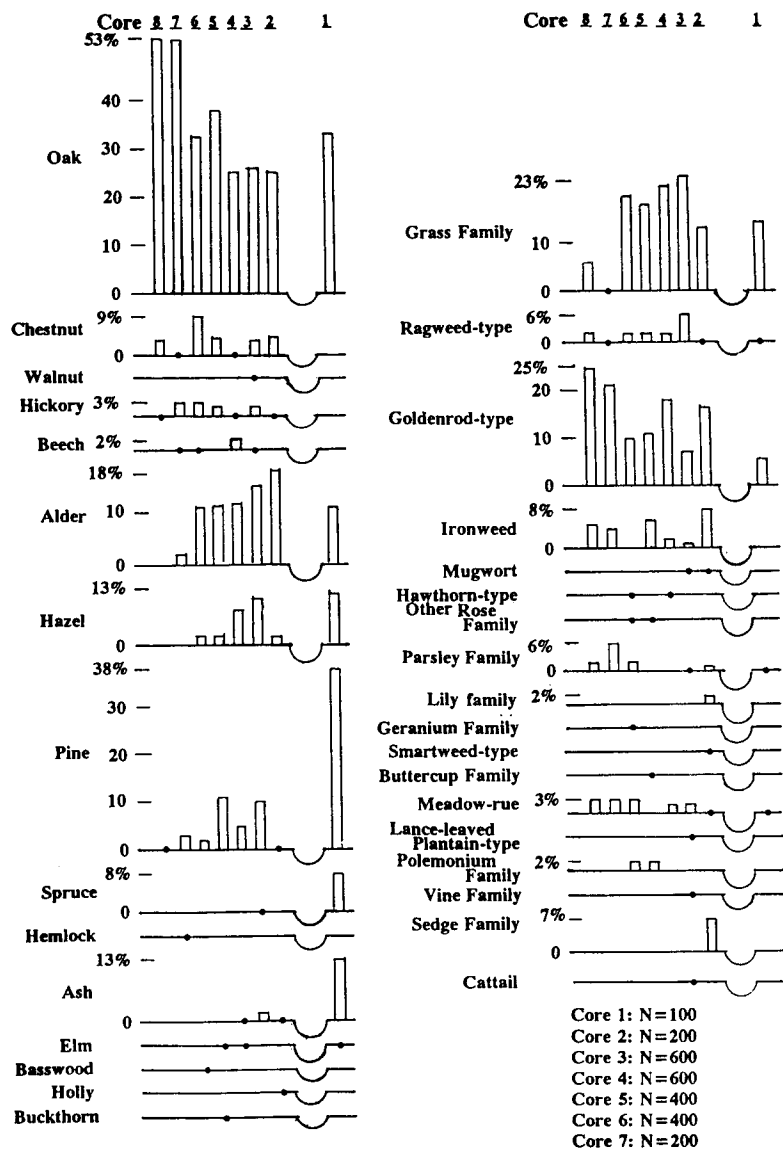


Figure 12. Core Transect No. 2 pollen spectra.

hillside. There are several anomalous counts in the transect that must be placed in perspective (Figure 13).

All samples of core 8 contained large amounts of chestnut pollen (Figure 13). The feasibility study indicated that such chestnut peaks result from sprouted stumps and are characteristic of the early post-clearance pollen rain at Great Meadows. Core 8 apparently did not reach pre-clearance spectra, but the possibility exists that the chestnut stump sprouting at this location records clearance for the Braddock Road. The hillside at the Transect No. 3 locus was very rocky, and the soil was very shallow. At least part of the matrix at the core 8 location may be slopewash off the hillside during the agricultural period. The core 8 spectra were retained in the diagram because they are significant to the interpretation of other cores.

The deepest samples of core 14 at the top of the transect contained some ragweed pollen percolated from post-clearance spectra, but the contamination is slight and does not mask or replace the pre-clearance spectra. The quantities of oak and beech pollen in the spectrum are adequate to establish that the locus was forested during the pre-agricultural period.

The biggest problem with Transect No. 3 is the high percentages of pine and spruce pollen recovered from cores 1-11 (Figure 13). This conifer pollen, like the pine in the deeper two samples of core 1 in Transect No. 2, was, almost certainly, preferentially water-transported down Great Meadow Run and Indian Run and deposited during floods with alluvium on the relatively flat, lower portions of the transect. This essentially exotic pine and spruce pollen masks local pollen production in cores 1-11. It, together with hemlock, has been left out of the sums from which the percentages of other pollen types were calculated. These types are, however, important to interpretation of the transect because their horizontal distribution across the transect indicates the horizontal extent of alluviation on the meadow.

Some of the other pollen grains in the cores 1-11 spectra are also, undoubtedly, alluvial in origin, but cannot be identified with certainty. When the most obvious water-transported types (pine, spruce and hemlock) were removed from the spectra, the other pollen types become more regular, and a clear change in the vegetation at the peak of chestnut pollen in core 8 emerges. From core 1 to core 7 the counts are dominated by grass pollen, with a significant sedge element in all but cores 3 and 4. The counts also indicated scattered willows from core 1 to core 9. This records a broad wet meadow with, apparently, fewer tall weeds shedding goldenrod and ironweed-type pollen than noted in the other transects (to be discussed). From core 9 to 14, at the top of the transect on the hillside, the counts are dominated by oak pollen. The shift from grass to oak appears to indicate that the forest/meadow border lay somewhere between core 9 and core 7. Two percent sedge pollen was recovered from core 8. This moist-condition indicator rarely travels more than a meter from the plant of origin (Handel 1976), and the presence of sedge pollen in core 8 suggests that the meadow edge was closer to core 9 than to core 7. The extremely high chestnut count in core 8 implies the close presence of a stump and supports this inference. In either case the data suggest that the forest extended some distance out onto what is now relatively flat ground. The ground at Transect No. 3 is now about 4 ft higher than during the pre-clearance

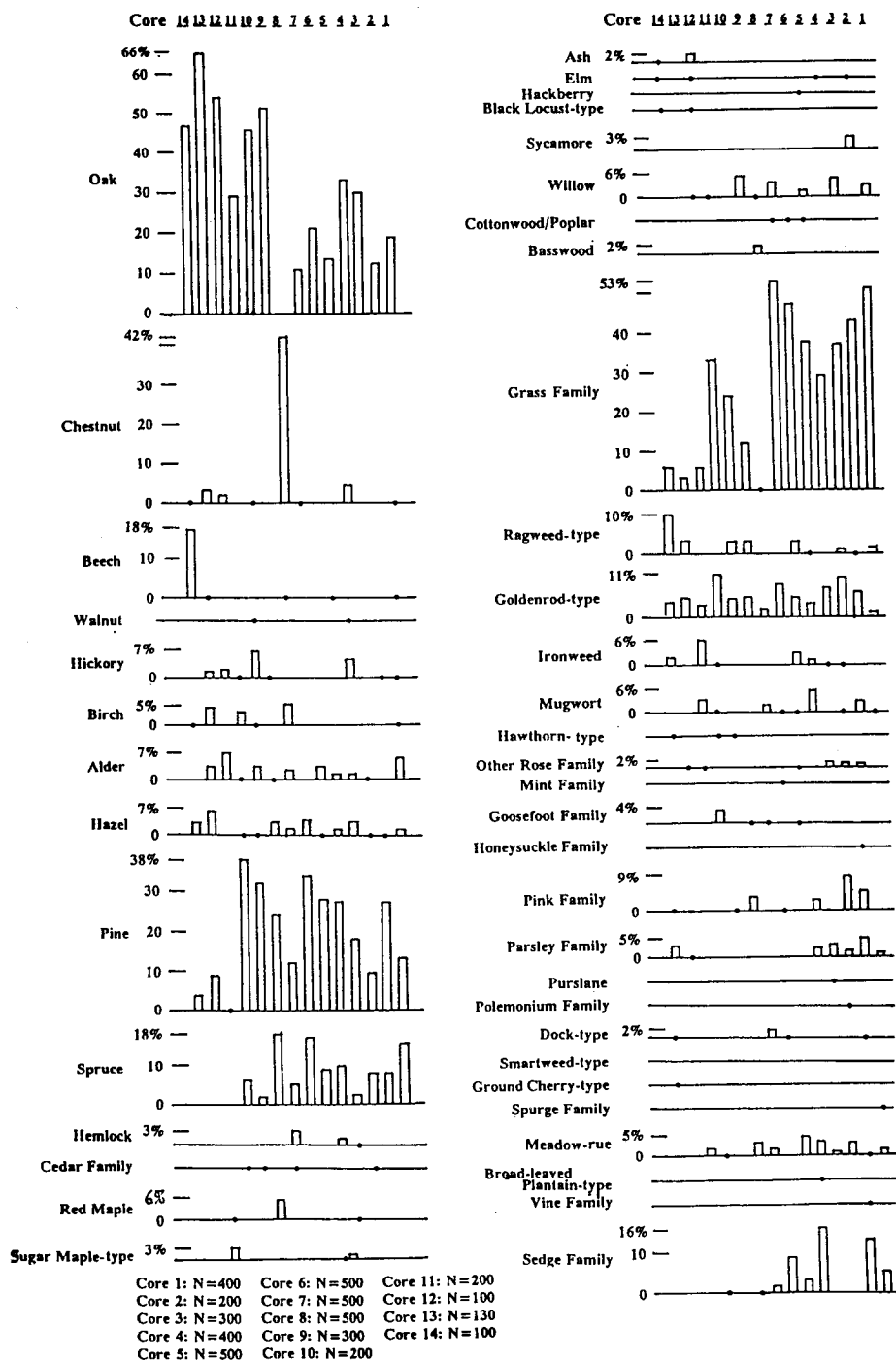


Figure 13. Core Transect No. 3 pollen spectra.

period, and it is possible that a, now buried, hill slope extended further out into the meadow at that time. The grade must, however, have been slight, because the pine and spruce contributions record a large amount of alluvial pollen deposition 40 ft inside the tree line suggested by the oak/grass shift.

Core Transect No. 4: Transect No. 4 was located on the west side of the meadow, north of Transect No. 3 (Figure 8). Most of the 16 cores of the transect were spaced at 20-ft intervals. A 30-ft gap between cores 10 and 11 was dictated by the presence of a drainage ditch running along the side of the hill. Core 1 was taken 20 ft west of the edge of the present fort lawn, and core 16 was collected about half way up the hillside. The axis of the transect was 275° magnetic, centered on the storehouse inside the fort palisade.

Cores 11 and 12 did not reach pre-clearance spectra and have not been diagramed (Figure 14). The over-representation of pine and spruce in cores 1-10 indicate that the lower reaches of this transect have, as was the case in Transect No. 3, been biased by alluvial pollen transport. Pine and spruce, although appearing in the diagram (Figure 14), have been excluded from the sums from which the percentages of the other types were calculated. This yields a vegetation gradient similar to that of the feasibility study transect. Sedges and cattails, with grass, dominated the flora on the formerly marshy ground nearest the fort, while a number of minor herbs (meadow rue, bluebells, currants, pinks, dock, smartweed, groundcherry, goosefoot, mint, mugwort, ironweed, and goldenrod) were interspersed among the grasses on the dryer meadow. Most of these plants appear to be annuals but some, hawthorns and other rose family members, are woody perennials. There may have been willows and alders growing with the sedges in the wet ground closer to the fort, but a number of minor arboreal pollen types not normally associated with moist ground (buckthorn, black and honey locust, hackberry, elm, ash, cedar, hazel, and three kinds of maple [sugar, silver and red]) were also found in this part of the transect. Cottonwoods were growing on the meadow just outside the tree line, but the distributions of the other arboreal pollen types, including alder and willow, closely parallel those of pine and spruce. It is not clear which tree pollen was produced on the meadow and which was water transported from upstream. Above core 7 or 8, an oak dominated forest incorporating hickory, chestnut, and, probably, some beech is clearly recorded. This last vegetation change on Transect No. 4 is most critical for the purposes of this study. From core 8 or 9 up the hillside, the spectra are clearly dominated by oak pollen. From core 8 or 7 down toward the fort, the spectra are clearly dominated by grass. The oak contribution begins to drop off in core 8 while grass percentages do not plummet until core 9. The forest/meadow edge appeared to have been somewhere between cores 8 and 9, perhaps a little closer to 8.

Core Transect No. 5: Transect No. 5 was the most northerly transect on the west side of Great Meadow Run. It consisted of 17 cores (numbered 0 to 16) on an axis of 270° magnetic from the run up the hillside west on the meadow (Figure 8). Most cores were taken at 20-ft intervals, but the presence of several drainage ditches in the very marshy ground of the lower part of the transect required some variation in spacing. A dense arrowwood (*Viburnum*) thicket in the upper part of the transect dictated considerable variation in coring interval and

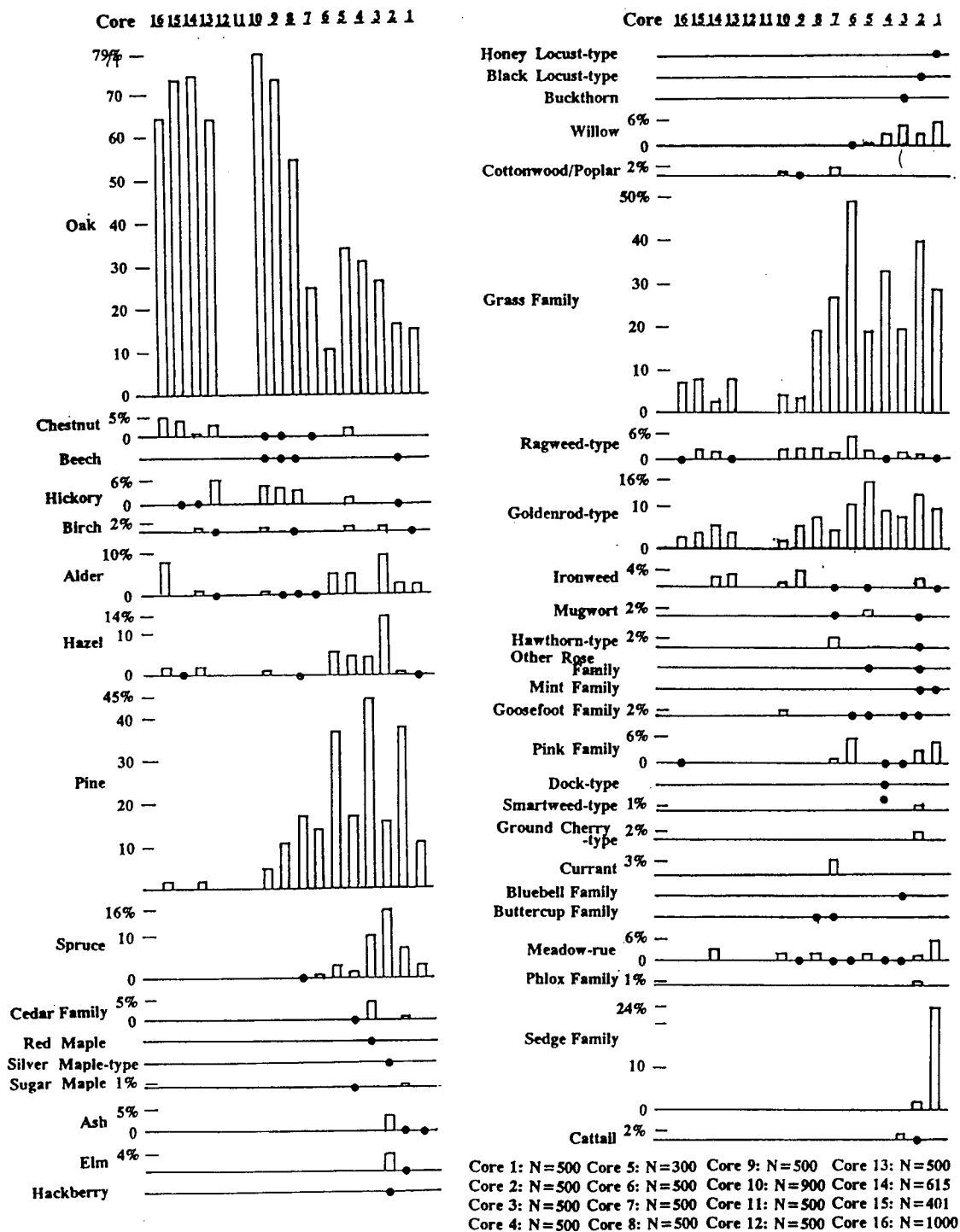


Figure 14. Core Transect No. 4 pollen spectra.

direction. Core 0 was taken 15 ft from the water course. There was a 23-ft interval between core 0 and core 1 and a 42-ft interval between core 1 and core 2. At the top of the transect, core 12 was spaced 26 ft above core 11 and core 13 was offset 30 ft to the south. There was a 24-ft interval between core 14 and core 15 and a 40-ft interval between core 15 and core 16 (Figure 8). The pollen spectra of the meadow portion of this transect, like those of Transects No. 3 and No. 4, were distorted by upstream pine and spruce pollen deposited by floodwater (Figure 15). This pine and spruce pollen appears in the diagram but was not included in the sum from which the percentages of the other pollen types were computed.

The Transect No. 5 pollen sequence resembles that of the nearby feasibility transect. Cores 16-10 (down the hillside) are dominated by oak pollen and most of the chestnut, cedar family, red maple, sugar maple, beech, walnut, hickory, and hazel pollen noted in the transect was found in these cores (Figure 15). The oak percentages drop off somewhat in cores 13-9, where there is a cluster of relatively high alder counts. The highest hazel percentages of the transect were noted in cores 12-11, where the oak contribution falls off. A few grains of cottonwood pollen were recovered from core 10, while willow pollen, the highest counts on the meadow, was concentrated in cores 7, 6 and 5. Birch pollen appears in cores 9-4, but not elsewhere in the transect. Pine and spruce were prominent, regular elements in cores 0-8, and made small contributions to cores 9-12.

Significant quantities of mugwort, pink family, and parsley family pollen were evident in cores 0-5 from what is now marshy ground along the watercourse. Cores 2 and 4 contained significant quantities of sedge pollen. Fairly high counts of ragweed-type, goldenrod-type, and meadow-rue were noted in cores 3-8, but cores 0-9 were clearly dominated by grass. The grass contribution drops off in core 9, but the type continues to be a significant element in the counts up through core 13. At that point ragweed and goldenrod-type also decline abruptly and no herb pollen, beyond single grains of ragweed and goldenrod-types, was recovered from cores 14-16.

A series of overlapping vegetation communities and deposition environments appear to be registered in the Transect No. 5 pollen sequence. The clearest demarkation is between the oak dominated forest (incorporating chestnut, beech, walnut, and hickory) from core 10 up the slope west of the meadow and the meadow of grass, goldenrod, other herbs, and small trees from core 9 down to the edge of the watercourse. At the upper end of the transect, the virtual absence of herb pollen in cores 16-14 reflects the dense shade of thick forest. The relatively prominent alder and hazel counts and the persistence of significant grass and goldenrod contributions in the oak dominated cores 10-13 upper section of the transect suggest an open woodland/ecotone community. The grass dominated lower portion of the transect (cores 9-0) conformed to the floodplain indicated by the consistently high pine and spruce pollen counts in cores 9-0. The dryer portion of the meadow (away from the sedges) was dotted with birches, roses, and members of the honeysuckle family (possibly elderberry). There was a clump of willows close to the forest edge of the meadow and a fringe of alders along the run. The wetter portion, indicated by sedges, supported significant populations of mugwort, pinks, and members of the parsley family.

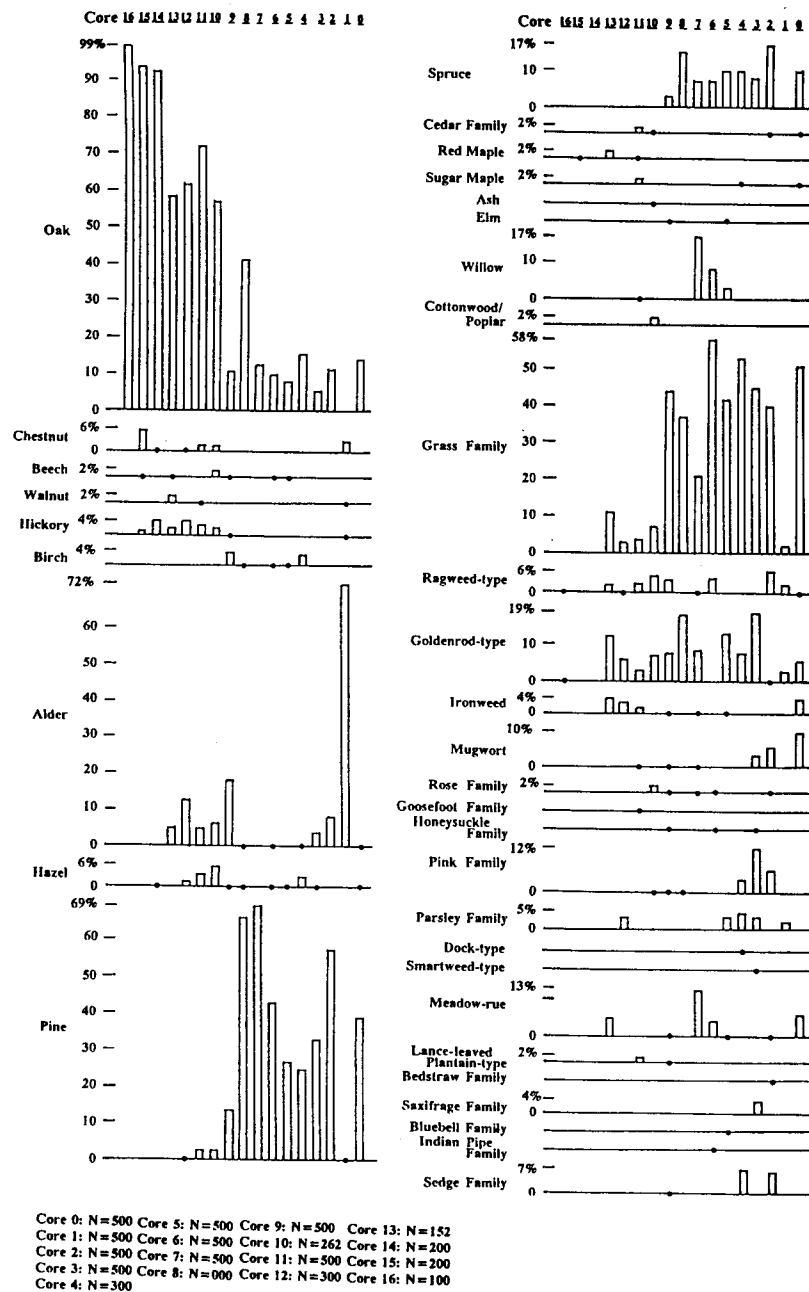


Figure 15. Core Transect No. 5 pollen spectra.

Core Transect No. 6: Transect No. 6 is the most northerly transect on the northeast side of Great Meadow Run (Figure 8). Sixteen cores were laid out at 20-ft intervals on a 50° magnetic axis from the edge of the run to the current tree line. Core 1 was located 10 ft from the bank of the present watercourse. Core number seven was missed during the numbering process, and the core sequence jumps from 6 to 8. The erroneous numbering system has been retained in this report because the stakes are numbered this way, and they have not yet been surveyed (Figure 16).

Most of the topsoil had been eroded off the upper two thirds of the transect and the remaining sediment was very rocky. The matrix could not be penetrated at cores 16 and 17, in spite of repeated attempts. Depressed oak percentages in cores 15-11, high ragweed-type percentages in cores 9-15, and the over-representation of goldenrod-type in cores 13-15 also suggest that uncontaminated pre-clearance pollen spectra were not reached in the cores in the upper part of the transect. The recovered data are, however, adequate to define the basic edaphic communities and depositional environments along the transect.

The three most important indicators among the Transect No. 6 pollen spectra were the domination of cores 1-9 by grass pollen, the regularity and relative prominence of oak pollen percentages in cores 10-14, and the prominent pine, spruce, and hemlock contributions from core 6 down to the water course (Figure 16).

The high pine, spruce, and hemlock counts in the transect closest to the water are significant because they indicate that cores 1-6 were taken from the pre-clearance floodplain of Great Meadow Run. This interpretation is consistent with the existence of a visible break in the hillside slope between cores 6 and 8, and is supported by the evidence for moist conditions indicated by the concentrations of sedge pollen in cores 1-5 and cattail pollen in cores 1-8. Scattered hollies and willows, together with a significant number of cottonwoods and alders, appeared to have been growing on the floodplain, but water transport from upstream best explains the presence of percentages of beech, birch, chestnut, walnut, alder, and hickory scattered through cores 1-6. Much of the oak pollen in these cores is also well preserved compared to that of cores 6-15, indicating that it also came down the run and was rapidly buried by alluvium.

The somewhat higher oak pollen counts in cores 10-15 are clearly the remnant spectrum from the oak-dominated pre-clearance forest, and the accompanying birch, hickory, beech, and chestnut pollen probably reflect the presence of the parent trees in the forest, even if the chestnut is from stump sprouts. Alder pollen is more consistently, if not as prominently, represented in this segment of the transect than on the floodplain and appears to indicate that the trees at this location formed an open woodland rather than a closed canopy forest.

Grass pollen is a prominent element in cores 9-1. In cores 8-9, above the apparent floodplain edge at core 6, the grass pollen is accompanied by significant quantities of parsley family, goosefoot family, ragweed, and ironweed pollen, as well as higher counts of goldenrod-type

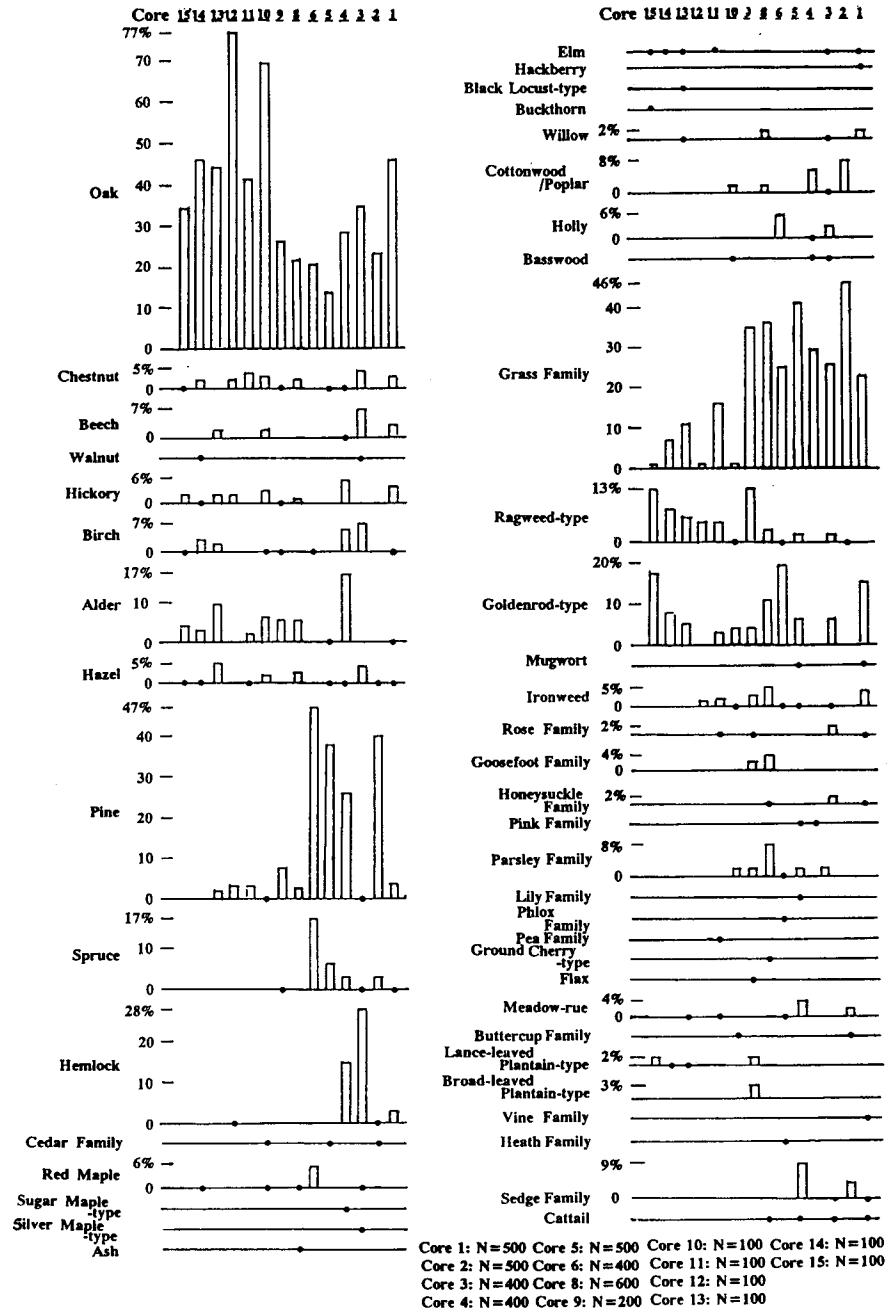


Figure 16. Core Transect No. 6 pollen spectra.

pollen in cores 6 and 8. This distribution appears to indicate a dry, open meadow between the top of the floodplain at core 6 and the woodland edge at about core 10.

Core Transect No. 7: Twenty three cores were originally laid out at 20-ft intervals for Transect No. 7. The transect began just east of the confluence of Great Meadow Run and Indian Run and ran on an axis of 30° magnetic from Great Meadow Run to the present tree line (Figure 8). The soil on the upper portion of the transect proved to be shallow and extremely rocky. Several sewage and other buried lines also ran through this area. Cores 19, 20 and 22 could not be collected, while cores 23, 21, 16, 14, and 12 did not reach pre-clearance pollen spectra. There was an abnormal hump in the floodplain topography at cores 7-1 that later proved to be a parking lot during the 1950s. The seven cores on the hump were abandoned, and three exploratory cores, (1E, 2E and 3E) offset 82.5 ft to the east, were taken from the floodplain. The first core (1E) was collected 10 ft northeast of the run. Core 2E was collected 80 ft northeast of the run. Core 3E was on the slope above the floodplain, 3 ft below and 82.5 ft to the east of core 8. Six additional cores, (numbered 5E-7E and 9E-11E) were later taken in the eastern offset transect. Cores 5E, 6E, and 7E, all lying at 20-ft intervals between cores 2E and 3E, were subsequently analyzed and appear in the diagram (Figure 17). Exploratory analysis of core 3E indicated that there was a little less grass pollen in core 3E than in core 8 and a little more oak pollen in core 8 than in core 3E. This was predictable from their topographic positions on the slope above the floodplain. The spectra were very similar otherwise and the core 3E spectrum differed little from that of core 7E. The analysis of core 3E was not carried further.

The deepest samples of cores 21, 16, 14, and 12 were severely contaminated with post-clearance pollen and were not incorporated in the diagram (Figure 17). The data provided by the other cores were, however, adequate to define a series of depositional regimen and plant communities on the transect. Forest, or at least woodland, is evident where oak pollen dominates cores 10-18. Alder, goldenrod-type, and ironweed-type frequencies are all higher in cores 6E-9 than in other parts of the transect, while grass percentages increase down slope from core 8 and stabilize at their highest levels in cores 1E-5E. The parsley family, pea family, and meadow-rue were also best represented in these same cores. Pine, spruce, and hemlock representation is also highest in cores 1E-7E, and there are concentrations of sedge pollen in cores 1E and 2E. Birch pollen in the 6% range was noted in cores 2E-7E, and a spike of cottonwood/poplar pollen was evident in core 2E. Small, but significant percentages of willow pollen were recovered from cores 5E-7E.

The pine, spruce, and hemlock pollen of Transect No. 7 was, as elsewhere on the meadow, probably water transported. Its distribution suggests that the pre-clearance floodplain extended from the edge of the watercourse up the transect to somewhere between core 7E and core 8. There is a break in the present topography at this point. The floodplain was dominated by grass, with some meadow-rue, pea family, goldenrod and ironweed and parsley family members. The two percent of sedge pollen noted in cores 1E and 2E indicates moisture in the lower floodplain. There is, however, much less sedge pollen here than was

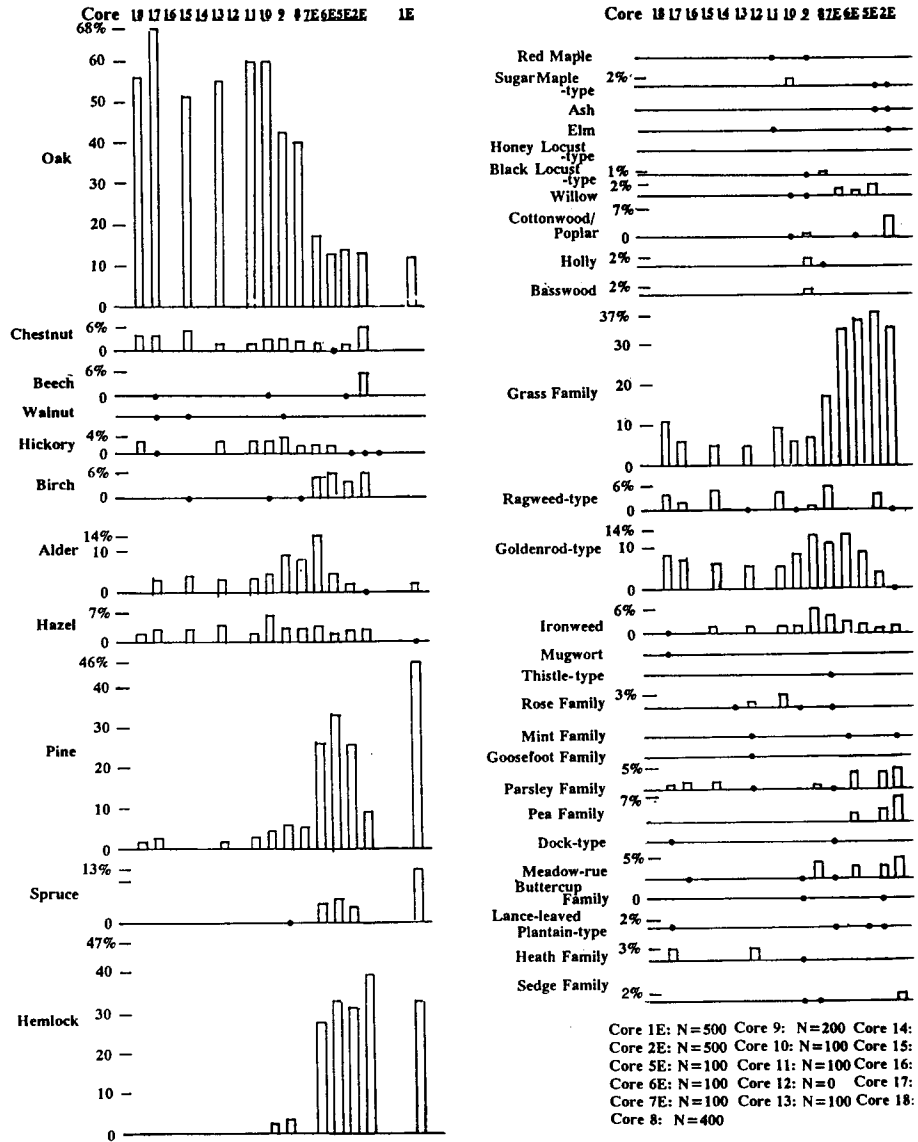


Figure 17. Core Transect No. 7 pollen spectra.

noted in the other cores from both sides of the meadow. The floodplain at this point may have been dryer than elsewhere. Birches were scattered across the floodplain, willows grew in the center, and cottonwoods grew closer to the run. The high goldenrod-type, ironweed-type, and alder frequencies combined with the grass counts of cores 6E-9 suggest a dryer community of grass, tall herbs, and small trees on the upper floodplain. The grasses became an understory as this community merged with the oak-dominated forest to form an open woodland in the cores 8-10 segment of the transect. Alder pollen was found in oak-dominated cores 11-18, but the ragweed-type, goldenrod-type and grass contributions to the upper portion of the transect suggest that some post-clearance pollen has percolated down into the deeper parts of these cores. Alder counts are smaller than those from what appear to be open woodland on the other side of the meadow, and the uniformity of the alder percentages here suggest the homogenization that accompanies wind transport (Janssen 1973:33). The alder pollen in core 11-18 may have blown up from the edge of the run during the agricultural period. The pre-clearance closed canopy forest probably started around core 11 or core 12.

Core Transect No. 8: Transect No. 8 was the most easterly core series on the northeast side of Great Meadows Run (Figure 18). Seventeen cores were laid out on an axis of 25° magnetic from 15 ft northeast of the watercourse (core 1) to a point just south of the present tree line. The broad modern floodplain at Transect No. 8 was cored at 40-ft intervals (cores 1-5) while the sloping center of the transect was cored at 20-ft intervals (cores 5-14, 15-16). Forty-foot intervals were used between cores 14 and 15 and cores 16 and 17 to avoid buried utility lines.

The hillside portion of Transect No. 8 had apparently suffered considerable erosion during the agricultural era. The soil was shallow and rocky and pre-clearance pollen spectra were not reached in cores 12, 14, and 15. Relatively large percentages of goldenrod-type, ragweed-type, and meadow-rue in the oak dominated segment of the transect (cores 11-17) indicate some percolation contamination of the pre-clearance spectra by later pollen (Figure 18). The relatively large quantities of hickory, hazel, beech, and birch pollen in cores near the watercourse suggest that the minor arboreal pollen types have been masked by post-clearance pollen in the forest spectra on the higher portions of the transect. Clear patterns are, however, evident among the distributions of the major tree and herb pollen types, and general pre-clearance vegetation patterns can be reconstructed from the pollen data.

The major elements of the counts are the domination of core 11-17 spectra by oak pollen, the prominence of alder pollen in cores 1-5, the peak of the alder pollen in core 10, the relatively high pine, spruce, and hemlock pollen counts in cores 1-4, large quantities of grass pollen in cores 8-2, and increases in goldenrod-type, ironweed-type, parsley family, lance-leaved plantain, and dock-type in cores 6-11. Sedge pollen, it should be noted, was not recovered on this transect.

The pine, spruce, and hemlock pollen in the lower portion of the transect were probably water-transported and indicate the existence of a pre-clearance floodplain out from the watercourse to at least core 4. High oak pollen counts are also noted here. Much of this pollen was perfectly preserved and was probably water transported from upstream as well. The floodplain at this point supported a significant alder population, and these trees were more important close to the run (cores 1-3). The absence of sedge suggests a relatively dry soil, and grass was probably the most important plant on the floodplain. The increase in grass percentages in cores 6, 7, and 8 may partially reflect statistical expansion of the grass contribution by the decrease in the alder input, but it does appear to indicate a thicker grass cover in this transect segment. Goldenrod-type counts increase in cores 6 through 8, where grass was most important. The data appear to indicate the presence of a band of grass and tall weeds on the slope above the alders on the floodplain, with grass more important at the lower end of the community. The decline in the grass pollen contribution in core 9, where oak percentages increase, signals a change in the vegetation, but it does not necessarily indicate an abrupt woodland/meadow border. Grass and goldenrod-type remain significant elements in cores 9-11 and a peak of alder pollen is evident in core 10. Rose and parsley frequencies are also highest in this portion of the transect. The spectra appear to indicate an open woodland of oak and alder with a grass and herb understory between the open meadow below core 9 and the oak-dominated woodland above core 10. The presence of alder pollen (10% or less) in cores 11-17 suggests that the oak canopy was not completely closed at any point on the transect, but this pollen is probably post-clearance contamination that was wind-transported from alder communities along the watercourse. The closed canopy forest probably started about core 11.

Forest Composition

The graph bars in the Great Meadows pollen diagrams (Figures 4-6, 11-18) indicate the percentages of individual pollen types calculated from a particular sum (i.e., 50% of 400 pollen grains). Changes in these percentages are considered to reflect changes in the abundance of the contributing plant taxa in the vegetation community through time or across space (with due consideration for statistical distortion by changes in the percentages of other pollen types). When the percentage of a type goes up or down, we assume that the parent plant constituted a correspondingly larger or smaller proportion of the vegetation (Davis 1963:905). A change from 15% pine to 20% pine is interpreted as indicating a little more pine in the catchment, and a further increase from 20% to 50% indicates that there was a lot more pine present. The percentage of a pollen type does not, however, reflect the actual proportion of the parent plant in the vegetation community. Fifteen percent pine pollen in a count does not mean that pines constituted 15% of the trees in the forest. Different plants produce different amounts of pollen (Erdtman 1969:117; Potter 1964:39), and pollen from heavy producers may be blown in from some distance to mask the pollen contributions of local plants that shed less pollen (Davis 1969:322).

These factors make it difficult to accurately reconstruct the composition of a forest. One way of dealing with these complications is by calibrating pollen to vegetation through "analogues"

(Leopold 1964:43; Mehringer 1967:138,141). In this method a series of surface soil samples are taken in a transect across a vegetation gradient, and the pollen spectra from the surface samples are considered to be characteristic of the vegetation community in which they were collected. When similar spectra are encountered in a fossil pollen sequence, the analyst interprets the fossil pollen as reflecting a vegetation community comparable to that which produced the similar modern pollen spectrum.

Logically, it should be possible to refine the analogue method to the point that the actual proportions of particular taxa in a past plant community can be reconstructed from fossil pollen spectra. "R-values" (Davis 1963:906) or "pollen representation Rates" (Anderson 1967:267) were developed for this purpose. "R-values" are generated by calculating the ratio between the percentage of particular pollen types in surface samples and the proportion of the basal area of the parent plants (trees in all studies to date) in a particular pollen catchment. This is the percentage of pollen on the ground compared to the percentage of ground covered by the parent tree. To facilitate comparisons between taxa, the pollen percentage/basal area ratio of one taxon is selected as a baseline and assigned a value of 1.0. The over-representation or under-representation of the pollen contribution of the other trees is calculated relative to this value. In the most successful study of this type, Anderson (1967:270) used beech as his baseline (pollen to basal area ratio = 1.0). He calculated the following raw ratios: birch (4.4), oak (3.6), alder (2.3), ash (0.4), beech (1.0), and basswood (0.5). Regression analysis yielded pollen productivity rates ("R-values") of 4.1 for birch, 4.1 for oak, 1.5 for alder, 0.7 for basswood, and 0.6 for ash (related to beech = 1.0). Anderson (1967:271) recommended that pollen diagrams be corrected by dividing birch and oak percentages by four, dividing alder percentages by two, and multiplying basswood and ash percentages by two.

The "R-value" or "pollen productivity" method worked well in soil samples from a small, essentially cultivated Danish forest containing only a few taxa, where it was possible to control for pollen blown into the area by establishing the radius at which pollen percentages are not influenced by individual pollen sources. It did not produce good results when tree basal areas were compared to lake muds in Vermont (Davis and Goodlett 1960:355). The main problem was the greater species diversity of native North American forests compounded by the variable pollen production in the greater number of edaphic situations contributing to the counts in the broader pollen catchment of a lacustrine deposition situation (Davis and Goodlett 1960:356).

Great Meadows lies somewhere between these two situations. The pollen spectra here are based on soil surface samples, and most of the pollen within the tree line is locally produced. On the other hand, the large number of arboreal pollen types in the spectra indicate that forests around Great Meadows were as complex as those in Vermont. Chestnut and hickory, the most important trees after oak in Great Meadows were not considered in the European study. An edaphic gradient was clearly visible down the hillside at Great Meadows, and the factors affecting the relative pollen productions of alder and oak inside the forest are clearly different from those affecting the relative representation of these types at the edge of the

meadow. There is also the problem of tree pollen from the much modified agricultural era woodlands wind-transported to Great Meadows and percolated into the pre-clearance spectra.

These factors are not insurmountable, and it may be possible to reconstruct the composition of the pre-clearance forest around Great Meadows from "R-values" from soil (not lake or bog) samples and tree basal area data if a plot of primordial forest can be located in southwest Pennsylvania. An environmental gradient down a hillside and onto a meadow, or at least a situation in which forest gave way to grassland via an ecotone of brush and small trees, is required. A second-growth forest will not serve this purpose because the pollen spectra of a regenerated forest do not exactly duplicate the spectra of the replaced forest (Iversen 1956:Figure 4). It will also be necessary to adjust the spectra for the absence of chestnut in the analogue area. These trees were wiped out by an introduced blight between 1904 and 1950 (Anderson 1974), and it is not certain how important these trees were in the primordial forests of eastern North America. They were sufficiently numerous to take over the secondary growth forests of southern New England (Paillet 1982), but they were not important elements in prehistoric pollen diagrams, because they produced little pollen relative to the oaks.

Transect No. 5 is the best source of reconstruction data. Its pollen spectra have not been seriously contaminated by percolated agricultural-era pollen. The pre-clearance pollen spectra that were deposited by the various plant communities that were growing on the transect are reasonably clear and relatively easy to separate. The percentages of the tree pollen taxa based on the arboreal sums only (no herb pollen) in the Transect No. 5 pre-clearance forest (no. 16-14) and ecotone (no. 13-10) cores are presented in Table 2.

Summary

The objective of this study was to locate the pre-clearance forest border around Great Meadows with the greatest possible precision. A feasibility study involving the complete analysis of six cores indicated that pre-clearance pollen spectra were preserved and could be recognized in the soil and alluvial profiles on and around the meadow. Wet meadow, dry meadow, brushy ecotone, and dense forest communities could be recognized in sequence from the fort, across the meadow, and up the western hillside at Fort Necessity. Oak pollen dominated all forest spectra and grass pollen was most characteristic of all meadow plant communities in the feasibility study. Empirical studies of pollen dispersal indicate that the quantities of tree and grass pollen deposited on open spaces falls off abruptly within 33 ft of the edge of a woodland or grass plot. The point at which oak pollen percentages decline and grass pollen percentages increase in transects of pre-clearance samples down the hillsides at Fort Necessity and out onto the meadow should indicate the location of the primordial forest/meadow interface within 33 ft of its true location. The trees around the meadow were on higher ground than the meadow grasses and, because gravity is an important force in pollen dispersion, more pollen blew out and down onto the meadow from trees than blew up and into the forest from grasses. All error should, therefore, be on the meadow side of the interface and can be reduced by considering the distributions of other meadow plants. Most

Table 2. Tree pollen percentages based on arboreal pollen only (no herbs) in the Transect No. 5 pre-clearance forest (no. 16-14) and ecotone (no. 13-10) cores.

Species	Forest	Ecotone
Oak	94.6%	80.4%
Chestnut	2.97%	1.27%
Beech	---	0.71%
Walnut	---	0.71%
Hickory	2.22%	2.8%
Alder	---	5.7%
Hazel	---	4.5%
Pine	0.74%	2.6%
Cedar	---	0.71%
Red Maple	0.74%	0.71%
Sugar Maple	---	0.47%
Blue beech/Hornbeam	0.74%	---
Ash	---	0.24%
Willow	---	0.24%

of the pine, spruce, and hemlock pollen in the meadow cores appear to have been preferentially transported by water from up stream on Great Meadow Run and Indian Run and deposited with alluvium on the meadow. Pine, spruce, and hemlock are used in this study to mark the width of the floodplain in the pre-clearance period.

To locate the forest/meadow interface at Fort Necessity, soil cores were collected in 8 transects across the meadow from the edge of the watercourses or the fort lawn and up the hillsides around the meadow. Two transects were located on the south side of the meadow, three transects were located on the west side of the meadow, and three transects were located on the northeast side of the meadow.

Core Transect No. 1 ran from Great Meadow Run up the hillside south of the meadow between the confluence of Great Meadow Run and Indian Run and the bridge over Great Meadow Run leading to the visitor center (Figure 8). The core closest to the watercourse (core 1) consisted of alluvium or former channel fill. The pre-clearance spectra of the second core recorded a community of weeds, wetland plants, and small trees favoring wet environments. Cores 3 through 7 recorded what appeared to be oak/hickory forest, with some beech, and a canopy dense enough to shade out most herbs. The forest border at this point lay between core 3 and core 2, approximately 25 to 45 ft south of the present bank of Great Meadow Run.

The first core in Core Transect No. 2 was located in the fort lawn on the north side of Indian Run. The other seven were taken at 20-ft intervals on the south side of the run. The transect started 10 ft from the watercourse, just east of the bridge to the fort, and ran to the tree line (Figure 8). The pollen spectra indicate moist soil supporting sedges, alders, and grasses in the first 10 to 30 ft (cores 1-2) from the run, grass interspersed with tall weeds in the next 80 ft (cores 2-6) and oak-dominated forest beginning around 90 to 110 ft from the run (i.e., between cores 6 and 7).

Core Transect No. 3 lay on the north side of the Indian Run wetland and ran from the edge of the fort, across the meadow and up the hillside west of the fort. The pollen spectra indicate a broad, wet, grass-dominated meadow with a significant sedge population and scattered willows. The tree line appears to have been located close to core 8, on flat meadow approximately 70 ft out from the sharp break at the present foot of the steep hillside. Archaeological excavations and the pollen spectra indicate that some 3 to 4 ft of alluvium have been deposited on the meadow during the historical period, and floodwater-transported pine and spruce pollen reached the base of the present steep hillside during the pre-clearance period. At present there is a slight slope 40 ft from the base of the hill. The trees recorded in cores 9 and 8 may have been growing on an extension of this slope that has been buried by accelerated alluviation during the agricultural era.

Core Transect No. 4 was located north of Transect No. 3. It ran, at 20-ft intervals, from the fort lawn up the hillside west of the meadow. The pollen spectra indicate a wet grass-dominated meadow with sedges, cattails, willows, alders, and hazel near the fort (cores

1-4) and a dryer meadow of grass and tall weeds, probably goldenrod, further away (cores 5-8). The upper portion of the transect (cores 9-14) was covered with oak forest incorporating chestnut, hickory, some beech, and, probably, birch. Oak pollen frequencies decline almost 20% from core 9 to core 8 and decrease another 30% from core 8 to core 7, while grass percentages drop abruptly from core 8 to core 9. This indicates that the pre-clearance forest/meadow interface lay between core 8 and core 9, probably closer to core 9. Core 9 was taken on what is now flat ground, and the water-transported pine and spruce counts indicate that floodwater penetrated beyond the tree line to core 10 on the slight slope at the base of the hill. Considerable sediment has accumulated on the west side of the meadow during the historical period and a pre-clearance extension of this slope 20 ft out to core 9 may be buried under agricultural era slopewash and alluvium.

Core Transect No. 5 was the most northerly sample series on the west side of Great Meadow Run. The 17 cores of this transect, spaced at various intervals because of natural and cultural obstacles, ran from within 10 ft of the watercourse to about halfway up the western hillside. The pollen spectra of the 10 cores closest to the run (cores 0-9) reflect a grass and tall weed (probably goldenrod) meadow with alders along the run. The lower end (cores 0-4) was wet, there were scattered roses, elderberries, and birches growing on the dryer part (cores 4-9). A clump of willows at least 40 ft broad grew toward the middle (cores 5-7). These communities generally conform to the extent of the pre-clearance floodplain that is indicated by large quantities of pine and spruce pollen (cores 0 to 8 or 9). Oaks appear to have dominated the landscape from core 10 to the end of the transect. The lower end of the tree cover, from core 10 through core 13, appears to have been open woodland incorporating alders, hazels, and some grass and tall weeds (indicated by goldenrod and ironweed-type pollen), as well as hickory, walnut, cedars, red and sugar maples, beech, chestnut, and, probably, ash. A closed canopy oak-hickory forest with a some red maple, beech, and chestnut, but little or no herbaceous groundcover, occupied the slope above core 13. The edge of the woodland was between 220 and 240 ft west of the present bank of the run and the dense canopy began about 300 to 320 ft from the watercourse.

Core Transect No. 6 was the most northerly of the transects on the northeast side of Great Meadow Run. It was laid out in 20-ft intervals, starting at 10 ft from the present northeast bank of the run. The rocky soil at the top of the transect could not be penetrated, leaving a gap between the current treeline and the highest core (core 15). The core stations were misnumbered during transect layout. Station number 7 was dropped and the numbering skips directly from 6 to 8. This numbering scheme has been retained in the report to prevent confusion until the core stations are surveyed (Figure 8). Pure pre-clearance pollen spectra may not have been reached in the eroded soils of the upper transect, but the surviving data are adequate to define the primary plant communities of the pre-clearance period.

Sedge, cattail, and water-transported pine, spruce, and hemlock pollen indicate that a moist floodplain existed in the 120 ft between the edge of the run and core 6. A band of dry grassland with tall weeds (indicated by goldenrod-type and ironweed-type pollen) existed for some 40 to 60 ft between the edge of the wet meadow/floodplain and the tree line, between

cores 9 and 10. The tree cover, starting 140 to 160 ft from the run, consisted of open woodland of alder, hickory, hazel, beech, and chestnut, as well as the dominant oaks. The closed canopy forest is not recorded in Transect No. 6. It is probable that it is masked by percolated agricultural-era pollen. In Transect No. 5, on the other side of the run just opposite this location, the open woodland below the closed-canopy forest was only about 80 ft broad.

Core Transect No. 7 ran from just east of the confluence of Great Meadow Run and Indian Run up the hillside on the northeast side of the meadow (Figure 8). The eroded upper portion of the transect was very rocky, and the area was disturbed by a number of utility lines. The five cores nearest the present tree line could not be collected or were too short to reach pre-clearance data. Three other cores (16, 14, and 12) were too contaminated by agricultural-era pollen to be of value. Later pollen had percolated into the pre-clearance spectra of several other cores, but data adequate to define the earlier vegetation distribution across the transect remained.

The distribution of water-transported pine, spruce, and hemlock pollen in cores 1E-7E indicates a pre-clearance floodplain extending northeast from the watercourse at least 150 ft, roughly equivalent to the modern floodplain. The floodplain was at least periodically wet but does not appear to have been marshy at this point. Grasses dominated the meadow but significant populations of sedge, meadow rue, pea family members, and parsley family members were present. Birches were scattered across the whole meadow, willows grew in the center, and cottonwoods or poplar were evident nearer the watercourse. Grasses, still dominant but perhaps of a different kind, were mixed with alder and tall weeds shedding goldenrod-type and ironweed-type pollen on the upper, possibly dryer, meadow around core 7. These grasses were shaded out as the alder merged with oaks in an open woodland around cores 8 and 9, roughly 190 ft to 210 ft from the watercourse. The pollen spectra from the upper part of the transect appear to incorporate some post-clearance pollen, but the pre-clearance closed canopy forest may have started around core 11 or core 12, at about 250 to 270 ft from the watercourse.

Core Transect No. 8 was the most easterly transect on the northeast side of Great Meadow Run (Figure 8). The modern floodplain was very broad in this sector and was cored at 40-ft intervals (cores 1-5) beginning with core 1 at 15 ft from the north bank of Great Meadow Run. The sampling interval for the rest of the transect was 20 ft with 40 ft between cores 14 and 15 and cores 16 and 17 to avoid utility lines. Cores 12, 14, and 15 (the upper portion of the transect) did not reach pre-clearance spectra and were abandoned. The low tree pollen counts of the other cores (11,13,16, and 17) appear to contain post-clearance pollen. The pre-clearance data surviving in the contaminated spectra are, however, adequate to reconstruct the distributions of the major plant communities on the transect.

The pine, juniper, and hemlock counts indicate a pre-clearance floodplain at least 135 ft wide (cores 1-4) that conforms to the floodplain of the present day. The absence of sedges suggests a relatively dry soil, but there were a significant number of alders among the grasses

on the floodplain. Alders were more important nearer the creek. A community of grass and tall weeds, shedding goldenrod-type pollen perhaps 60 ft wide, occupied the slope above the floodplain (cores 5-9). This, in turn, gave way to an open woodland indicated by a peak of alders among the higher oak counts at about 255 ft from the watercourse (cores 9-11). The closed canopy forest seems to have started about core 11, at about 295 ft from the present bank of Great Meadow Run.

Recommendations

The Great Meadows pollen data appear adequate to reconstruct the location of the forest/meadow edge and the shift from alder ecotone to closed canopy in most transects within the space of one coring interval (20 ft). The coring locations are presently indicated by wooden stakes with pencil or magic marker labels. It is imperative that a permanent transit survey record of the coring locations be made before these data are lost.

Plantings should generally follow the distributions indicated in the previous summary, but some variation to conform to modern conditions and topography may be advisable.

An "R-value" analysis of native woodland in southeastern Pennsylvania should be conducted, provided a plot, that is not secondary growth, can be located.

The pollen data indicate an ecotone or open woodland with alders between the oak-dominated forest and the meadow proper on most transects. Ditches and buried drains installed during the 19th and early 20th centuries and the current eroded, stony upper portion of the meadow on the northeast side of Great Meadow Run have created conditions that are probably inhospitable to alders. It may be necessary to improve conditions for alders or to substitute some similar small tree for alders in the open woodland.

Coring field notes indicate a break in the slope between cores 9 and 10 on Transect No. 8. This may be the remnant of 19th or early 20th century agricultural terracing. The pollen data indicate that the open woodland ecotone on this transect began around core 9, and it is possible that this topographic break is a fossil feature related to pre-clearance vegetation distributions. A close interval topographic survey of the hillsides should be made when the coring locations are surveyed. With these data, it may be possible to relate former plant communities to fossil topography in a way that will help fill in vegetation distributions between transects.

The pollen data for Transects 3-5 on the west side of Great Meadow Run indicate that the pre-clearance tree line was 40 to 60 ft out on what is now relatively flat floodplain. The distributions of water transported pine, spruce, and hemlock pollen indicate that floods reached some distance up into this tree line. Trenching in the meadow yielded burned barrel staves considerable distance below the present surface, indicating significant alluviation on the meadow during the historical period. The presence of oaks on this alluvial flat seems inconsistent with the distribution of oaks on the other side of the run. An extension of the

slope, better drained and more hospitable to oaks, may be buried under alluvium and slopewash from the agricultural period. It may be difficult to get oaks to grow on the relatively moist flats overlying the pre-clearance tree line, and it may be advisable to set the oak line to the base of the slope.

Pre-clearance pollen spectra completely clear of percolated agricultural-era pollen were not recovered at the tops of any of the transects on the west (Transects 3-5) and northeast (Transects 6-8) sides of the meadow, and in some cases the location of the shift from open woodland to closed canopy forest is not clearly indicated. More research is needed in this area. The data for Transects 4 and 5 can be improved by extending the current cores down two ft with the split spoon corer. The tops of Transects 3, 6, 7, and 8 were too rocky to core. Backhoe trenches should be excavated in this area for sampling. Continuous trenches are not necessary. Holes 7 ft deep at the original core locations will suffice.

A number of the spectra in Transects 7 and 8 are based on 100 grain counts of single samples. These should be expanded to at least 500 grains each.

The forest immediately abuts the south bank of Indian Run, and any evidence of former meadow on that side of the stream will have been removed by shifts in the watercourse. A wetland lies between Indian Run and the upland on the north. The pre-clearance breadth of this meadow has yet to be investigated. Two exploratory transects of about 15 cores each should be taken across the meadow and up the hillside to the north/northwest. The research potential of these transects can be evaluated with single 100 grain counts from the bottom of each core.

Literature Cited

- Anderson, S. T. 1967. Tree Pollen Rain in a Mixed Deciduous Forest in South Jutland (Denmark). *Review of Palaeobotany and Palynology*, 3:267-275.
- Anderson, T. W. 1974. The Chestnut Pollen Decline as a Time Horizon in Lake Sediments in Eastern North America. *Canadian Journal of Botany* 11:678-685.
- Bazzaz, F. A. 1974. Ecophysiology of *Ambrosia Artemisiifolia*: A Successional Dominant. *Ecology* 55:112-119.
- Behre, K-E. 1981. The Interpretation of Anthropogenic Indicators in Pollen Diagrams. *Pollen et Spores* 23(2):225-245.
- Benninghoff, W. S. 1962. Calculation of Pollen and Spores Density in Sediments by Addition of Exotic Pollen in Known Amounts. *Pollen et Spores* 6(2):332-333.
- Braun, E. L. 1950. *Deciduous Forests of Eastern North America*. Blakestron Company, Philadelphia.
- Caseldine C. J. 1981. Surface Pollen Studies Across Bankhead Moss, Fife, Scotland. *Journal of Biogeography* 8:7-25.
- Cushing, E. J. 1964. Redeposited Pollen in Late Wisconsin Pollen Spectra from East-Central Minnesota. *American Journal of Science* 262:1075-1088.
- Davis, M. B. 1963. On the Theory of Pollen Analysis. *American Journal of Science*. 261:897-912.
- _____. 1969. Palynology and Environmental History During the Quaternary Period. *American Scientist* 57(3):317-332.
- Davis, M. B. and J. C. Goodlett. 1960. Comparison of the Present Vegetation with Pollen Spectra in Surface Samples from Browington Pond, Vermont. *Ecology* 41 (2):346-357).
- Day, S. 1843. *Historical Collections of the State of Pennsylvania*. G. W. Groton, New Haven, Connecticut.
- de Villiers, L. C. 1754. *Personal Journal*. (Excerpts reproduced in Harrington 1957:64.)
- Dimbleby, G. W. 1985. *The Palynology of Archaeological Sites*. Academic Press, New York.

- Dinwiddie, R. 1754. Official Records of Robert Dinwiddie. Vol. I, 239-241. British Public Records Office, London. (Reproduced in Harrington 1957:66.)
- Duffield, R. and J. E. King. 1980. Sample Size and Palynology: A Midwestern Test. Transactions, Illinois State Academy of Science 72(2):1-7. Springfield, Illinois.
- Edwards, K. J. 1982. "Man, Space and the Woodland Edge - Speculations on the Detection and Interpretation of Human Impact in Pollen Profiles," in Martin Bell and Susan Limbrey eds., Archaeological Aspects of Woodland Ecology. BAR International Series 146 (2). Oxford: B.A.R., 5-22.
- Ellis, F. (editor). 1882. History of Fayette County, Pennsylvania. Vol. 2. Philadelphia. (Cited in Strach 1987).
- Erdtmen, G. 1969. Handbook of Palynology. Hafner Publishing Co. New York.
- Fitzpatrick, J. C. (editor). 1931-1944. The Writings of George Washington. U.S. Government Printing Office, Washington, D.C. 39 Vols.
- _____. 1944. U.S. Government Printing Office, Washington, D.C.
- Goldstein, S. 1960. Degradation of Pollen by Phycomycetes. Ecology 41:543-545.
- Hamilton, C. (editor). 1959. Braddock's Defeat. University of Oklahoma Press, Norman, Oklahoma.
- Handel, S. N. 1976. Restricted Pollen Flow of Two Woodland Herbs Determined by Neutron Activation Analysis. Nature 260:422-423.
- Harrington, J. C. 1957. New Light on Washington's Fort Necessity. Eastern National Park and Monument Association, Richmond, Virginia.
- Havinga, A. J. 1974. Problems in the Interpretation of Pollen Diagrams of Mineral Soils. Geologie en Mijnbouw 53:449-453.
- _____. 1984. A 20 Year Investigation into Differential Corrosion Susceptibility of Pollen and Spores in Various Soil Types. Pollen et Spores 26(3-4):541-558.
- Hulbert, A. B. 1903. Washington's Road. Vol. 3 of Historic Highways of America. A. H. Clark Co., Cleveland, Ohio.
- Iversen, J. 1956. Forest Clearance in the Stone Age. Scientific American 194:36-41.
- Janssen, C. R. 1973. Local and Regional Pollen Deposition. In Quaternary Plant Ecology, ed by H.B.J. Birks and R.G. West, pp. 31-42. Blackwell Scientific, London.

- Leopold, E. B. 1964. Reconstruction of Quaternary Environments Using Palynology. In The Reconstruction of Past Environments. pp. 43-52. Fort Bergwin Research Center Publication No. 3. Taos, New Mexico.
- Lewis, F. 1816. October 21, 1816 Map of Fort Necessity. Photo-reproduced in J. C. Harrington New Light on Washington's Fort Necessity. Figure 2. Eastern National Parks and Monuments Association, Richmond, Virginia (1957).
- Martin, P. S. 1963. Geochronology of Pluvial Lake Cochise, Southern Arizona II, Pollen Analysis of a 42 Meter Core. Ecology 44:436-444.
- Mehring, P. J., Jr. 1967. Pollen Analysis of the Tule Springs Area, Nevada. In Pleistocene Studies in Southern Nevada, edited by H. M. Wormington and D. Ellis. pp. 120-200. Nevada State Museum Anthropological Papers 13. Carson City.
- Paillet, F. L. 1982. The Ecological Significance of American Chestnut (*Castanea dentate* (Marsh.) Birch.) in the Holocene Forests of Connecticut. Bulletin of the Torrey Botanical Club 109 457-473.
- Potter, L. D. 1964. Limitations of Palynology in Paleoecological Reconstruction. In The Reconstruction of Past Environments. pp. 43-52. Fort Bergwin Research Center Publication No.3. Taos, New Mexico.
- Raynor, G. S., E. C. Ogden, and J. V. Hayes. 1972. Dispersion and Deposition of Corn Pollen from Experimental Sources. Agronomy Journal 64:420-427.
- Rogin, L. 1931. The Introduction of Farm Machinery In Its Relation To The Productivity of Labor in the Agriculture of the United States During The Nineteenth Century. University of California Press, Berkeley.
- Schoenwetter, J. 1990. A Method for the Application of Pollen Analysis in Landscape Archaeology. In Earth Patterns: Essays in Landscape Archaeology, edited by William M. Kelso and Rachel Most. pp. 277-295. University Press of Virginia, Charlottesville, Virginia.
- Shaw, J. B. W. 1754. Deposition of John B. W. Shaw before Committee headed by Governor James Glen of South Carolina, August 27, 1754. South Carolina Archives Department. (Reproduced in Harrington 1957:67-68).
- Sparks, J. (editor). 1834. The Writings of George Washington. Volume II. Russell, Odiorbe, and Metcalf, and Hilliard, Gray and Co., Boston.
- _____. 1854. George Washington. Russell, Odiorbe, and Metcalf, and Hilliard, Gray and Co. Boston.

- Strach, S. G. 1987. A Preliminary Documentary Review of Historical Notations of the Great Meadows 1740-1970. Manuscript on file at Fort Necessity National Battlefield, Farmington, Pennsylvania.
- Tauber, H. 1965. Differential Pollen Dispersion and the Interpretation of Pollen Diagrams. Geological Survey of Denmark Series II, No. 89. Copenhagen.
- Thwaites, R. G. 1896. A Day on Braddock Road. The New England Magazine 15(3):299-308. (Cited in Strach 1987).
- Tinsley, H. M. and R. T. Smith. 1974. Surface Pollen Studies across a Woodland/Heath Transition and Their Application to the Interpretation of Pollen Diagrams. New Phytologist 73:547-565.
- Toner, J. M. 1893. Journal of Col. George Washington, 1754. Joel Munsell's Sons, Publishers. Albany, New York.
- Torres-Reyes, R. 1970. Ground Cover Study. Fort Necessity National Battlefield Pennsylvania. Office of Archeology and Historic Preservation, Division of History, National Park Service. Washington, D.C.
- Traverse, A. and R. N. Ginsburg. 1966. Palynology of the Surface Sediments of Great Bahamas Bank, as Related to Water Movement and Sedimentation. Marine Geology 4(6):417-459.
- Tschudy, R. H. 1969. Relationship of Palynomorphs to Sedimentation. In Aspects of Palynology, edited by R. H. Tschudy and R. S. Scott, pp. 79-96. John Wiley and Sons, New York.
- van Zeist, W. 1967. Archaeology and Palynology in the Netherlands. Review of Palaeobotany and Palynology 4:45-65.
- Vuorela, I. 1973. Relative Pollen Rain Around Cultivated Fields. Acta Botanica Fennica 102(27):1-27.
- Walch, K. M., J. R. Rowley, and N. J. Norton. 1970. Displacement of Pollen Grains by Earthworms. Pollen et Spores 12:39-44.
- Washington, G. 1754. Account of the Battle at Great Meadows. Virginia Gazette July 19, 1754.



As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.