Nineteenth Century Lumber Surveys for Bangor, Maine: Implications for Pre-European Settlement Forest Characteristics in Northern and Eastern Maine

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ABSTRACT

In the mid-19th century, Bangor, Maine, was a major center for the manufacturing and shipping of lumber, leading many to proclaim Bangor as the "lumber capital of the world." The raw material for this lumber was transported down the Penobscot River, which drains the largest watershed in Maine. Starting in 1832, lumber put up for sale and shipped from Bangor was surveyed. Between 1832 and 1872, over 3.36 billion board feet (bbf) of white pine lumber was tallied. In the 19th century, there were numerous inefficiencies and losses involved in the harvesting, transporting, and processing that converted a standing pine tree to lumber ready to be loaded on a ship; therefore, the 3.36 bbf surveyed provides only a minimum estimate for the volume of white pine in the pre-European settlement forest of northern and eastern Maine. Even this minimum volume estimate for pine suggests a magnitude of this resource that is inconsistent with descriptions developed from early land survey information and suggests that current interpretations of the pre-European disturbance regime may need re-evaluation.

Keywords: white pine, lumber records, pre-European settlement, natural disturbance regime

In the mid-19th century, Bangor, Maine, rose to prominence as a major center for lumber manufacture and export in the northeast United States (Figure 1). Situated on a tidewater of the Penobscot River, Bangor was the shipping port for the largest watershed in Maine starting in the late 18th century. River drives on the Penobscot and its tributaries provided log transportation from a forest area of nearly two million hectares (Figure 2). Starting in 1832, lumber put up for sale and shipped from Bangor was surveyed by the Surveyor General's Office for Penobscot County (Defenbaugh 1906, Smith 1972). The amount of pine (primarily white pine [*Pinus strobus* L.]) lumber surveyed in Bangor was considerable, and peaked in the middle of the 19th century (Defenbaugh 1906). The large volume of white pine lumber manufactured from logs cut in the Penobscot watershed has implications for understanding the character and composition of the pre-European settlement forests of northern and eastern Maine. The presence of white pine in forest stands is often attributed to regeneration events after major canopy disturbances such as fires, windthrow, and abandoned agricultural fields (Abrams 2001). White pine is a moderately long-lived species (Wendell and Smith 1990, Abrams 2001); therefore, the persistence of pine in stands preserves a record of relatively intense disturbance events in the regions past.

Based on early 19th century land survey records for a 1.65 million hectare area in northern and eastern Maine that had considerable overlap with the Penobscot watershed, Lorimer (1977) found that only a small proportion of witness trees were white pine. The dominance of witness trees by relatively shade-tolerant species such as spruce (*Picea* spp.), yellow birch (*Betula alleghensis* Britton), beech (*Fagus grandifolia* Ehrh.), and balsam fir (*Abies balsamea* [L.] Mill.) led Lorimer (1977, 1980) to conclude that the pre-European settlement forests were largely in a "climax state," and that the interval between major wind and fire disturbance events was quite long in this region. Lumber shipping records that summarize production for a large region, such as the Penobscot River watershed, provide one method of critically evaluating estimates of white pine abundance and natural disturbance regime determinations developed from the early land survey records.

Figure 1. Log boom on the Penobscot River near Bangor, Maine (Bangor Public Library).

Lumber Surveyed in Bangor, Maine, during the 19th Century

Europeans first settled the Bangor region in the 1770s. The Penobscot River and the forest it drained were a major draw for settlers; however, by 1816, only one million board feet (bd ft) of lumber were shipped annually from Bangor (Roberts 1875, Defenbaugh 1906). A surge of new settlers came into the Penobscot Valley in the 1820s, and by 1831, more than 30 million bd ft of lumber were shipped annually from Bangor (Roberts 1875, Defenbaugh 1906, Stanley 1963). Estimates are that at least 200 million bd ft of lumber had been shipped from Bangor before 1832 (Whitman 1873, Roberts 1875, Defenbaugh 1906). Figure 3 shows the volume of lumber manufactured from different tree species that was surveyed in Bangor between 1832 and 1872. The peak for white pine lumber surveyed occurred in the mid-19th century. During the period from 1832 to 1872 over 3.36 billion board feet (bbf) of white pine lumber were surveyed in Bangor. By the 1860s, much of the readily available large white pine in the Penobscot River watershed had been logged, and spruce had become the largest component of lumber manufactured and shipped from Bangor. By 1880, the era of large pine logging on the Penobscot was essentially over, and the bulk of pine surveyed was "second growth" and used for making pine boxes (Defenbaugh 1906, Smith 1972).

Inefficiencies and Losses. In the mid-19th century, there were numerous inefficiencies and losses involved in the harvesting, transporting, and processing that converted a standing pine tree to lumber ready to be loaded on a ship (Coolidge 1963, Smith 1972). These inefficiencies and losses mean that volumes of lumber surveyed in Bangor provide only a minimum estimate; actual standing volumes of white pine in the pre-European settlement forest must have been considerably higher.

Volume Left in the Woods. Merchantable log diameters and lengths as well as quality requirements of the mid-19th century meant that many white pines were considered too small or defective and thus left standing or lying the woods. Coolidge (1963) reports that nearly 50% of large pines had substantial rot or other defects. In addition, large sections of cut trees that would be considered merchantable now were left in the woods because of small sizes or defects. Conversely, some of the largest pine logs were too big to move or to drive in smaller streams, so they were left to rot in the woods (Springer 1851, Houpt 1964). Large white pines were also left standing in areas that were too far from drivable water or were too steep, making harvesting and transporting them difficult (Defenbaugh 1906, Houpt 1964).

Volume Lost in Transit and Milling. Merchantable logs were harvested in autumn and winter and were piled near drivable water bodies to be transported downstream during the spring snowmelt. In streams, rivers, and lakes, some portion of the logs sank during transit to and storage at collection points called log booms. According to Cayford and Scott (1964), "Time and effort were not wasted on second-grade material or any logs sunk while floating to the mill." It is not clear how much pine sank; however, a pine salvage operation recovered 2 million bd ft of sunken logs from a single site on the Penobscot River in the 1960s (Cayford and Scott 1973). There were four permanent and several temporary collecting booms as well as many storage booms for individual mills in and north of Bangor on the Penobscot River (Hempstead 1931, Smith 1972). These log booms sometimes failed, especially under pressure from floodwaters or ice flows, allowing a few or many logs to float downriver and out to sea (Houpt 1964, Smith 1972).

Nineteenth century manufacturing of lumber generated another point of inefficiency. According to Defenbaugh (1906), "As much pine was wasted in the flush days as is cut now, and the slabs that were thrown away were as thick as deal planks." Deal planks are squared timbers from which standard dimension lumber is cut (Houpt 1964). In addition, lengths of imperfect lumber called "scoots" were thrown into the river, and their volume not recorded (Houpt 1964). An 1868 address to the legislature by Governor Chamberlain illustrates the volume of lumbering waste thrown in the river.

> A bed of obstructions from slabs, edgings, and sawdust extends from Crosby's Narrows to Bangor, a distance of some three and one-half miles, covering an area of about 320 acres, and of an average depth of 10 feet, being in some localities more than 18 feet deep, forming an entangled mass of more than 5,000,000 cubic yards.

Nineteenth century sawmills were prone to fires, and frequent mill conflagrations consumed a considerable quantity of sawn lumber (Smith 1972). Transporting the manufactured lumber to Bangor from upriver mills required building lumber rafts and additional river transport, resulting in further losses (Hempstead 1931, Wood 1935, Houpt 1964). Even when rafts of lumber arrived in Bangor, additional losses occurred. According to Defenbaugh, "When a crew of stevedores got down to the muddy bottom of a raft they would set it adrift sooner than handle it or take the trouble of washing it." A report by the Harbormaster of Bangor in 1862 describes lumber theft, yet another point of volume loss prior to surveying.

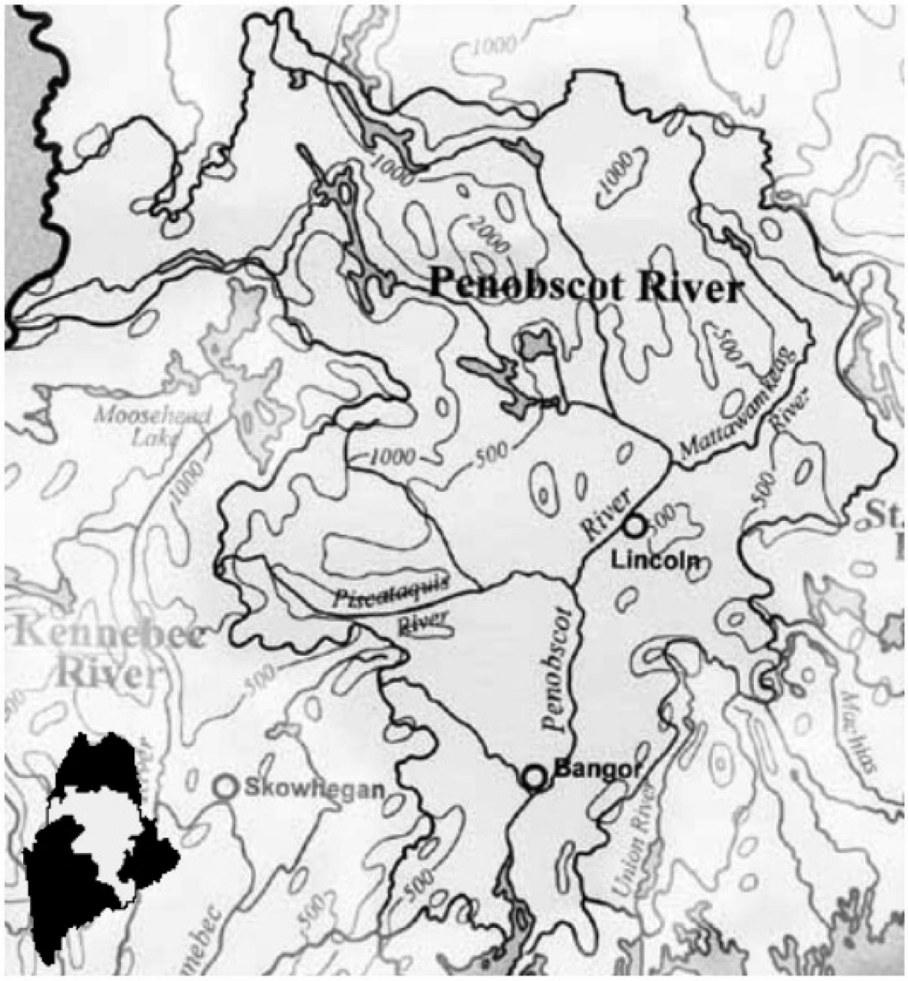

Figure 2. Penobscot River watershed area (Maine Rivers 2003: www.mainerivers.org). The Penobscot drains roughly 1.871 million hectares of forested land above Bangor. The total area of watershed is 2.219 million hectares, 2.057 million hectares above Bangor (National Oceanic and Atmospheric Administration 2003: spo.nos.noaa.gov/projects/gomaine/gome_wtshd.html), and forested land accounts for 91% of the total land area in northern and eastern Maine (Laustsen 2003).

> There is a practice extensively followed in our harbor by a class of persons called "wreckers" of pilfering lumber of various kinds from rafts, which, in the aggregate, amounts to quite a large sum in value.

Volume Not Measured. The tally of lumber surveyed in Bangor does not include lumber volumes used locally or lumber manufactured outside of Penobscot County (e.g., below Bangor on the Penobscot). Furthermore, substantial harvesting of large pine in the Penobscot watershed took place in the decades before 1832 (estimates suggest 200 million bd ft) and continued for another decade beyond 1872 (150 million bd ft; Defenbaugh 1906, Smith 1972). There may have been some double counting in the Bangor lumber survey (Whitman 1873). This could have occurred when lumber was surveyed but did not get shipped. This lumber might be surveyed again—double counted—the next time it was prepared for shipment. Harvested volumes of large pines occurring before and after the 1832 to 1872 period would balance the 10% to 15% double counting that has been estimated for the survey (Whitman 1873).

Growth and Interwatershed Log Transfers. A complicating factor in using 40 years of lumber records to evaluate standing wood volume across a large watershed is the volume growth of trees that occurred during the recording period. There would certainly have been growth of white pine volume in the watershed between 1832 and 1872; however, the early logging focused on removing large pines that were growing relatively slowly (Defenbaugh 1906, Coolidge 1963). The net volume growth of these large trees would have been greatly reduced by decay, mortality, and disturbance (e.g., wind, fire, and lightning) losses occurring over the same period. Substantial net growth of white pine volume could have occurred if there were a considerable component of intermediate-sized relatively fast-growing trees in the pre-European settlement forest; however, some of these trees would have needed to attain large size within the 40-year period for that volume growth to become merchantable. This scenario seems unlikely because pine harvests peaked in the 1850s, and by the turn of the century (1903), the Maine Forest Commissioner estimated that there were only 153 million bd ft of pine standing in the Penobscot river system (Defenbaugh 1907).

Another confounding factor is the transfer of logs between watersheds in Maine. The Penobscot gained some logs from areas in the headwaters of the Allagash through the Telos Canal, but also lost logs to the Kennebec (Defenbaugh 1906, Smith 1972, Rolde 2002). Defenbaugh (1907) reports, "By means of a sluice at Northwest Carry a large number of logs cut on the north and South branches of the Penobscot are conveyed into Moosehead Lake, towed across the lake and thence sent down the Kennebec." Without more detailed information, a balanced interwatershed transfer is assumed.

A Minimum Benchmark and a Rough Estimate. Estimates deriving how much standing volume of large pine was needed to survey shipments of more than 3.36 bbf of pine lumber from Bangor between 1832 and 1872 require multiple assumptions and are prone to alternative subjective interpretations. Recognizing these limitations, rough estimates reflecting inefficiencies and losses associated with 19th century lumber production can provide some sense for the magnitude of difference between lumber surveys and standing volume. For example, we could conservatively assume that 50% of pine volume never left the woods (Coolidge 1963), 10% was lost during transit, 10% was wasted in the sawmills (above deductions assumed in the international one-quarter-inch log rule), and 10% was used locally or manufactured downriver. These estimates for inefficiencies and losses sum to 80% and generate a standing pine volume of approximately 6 bbf. The surveyed lumber records from Bangor provide a solid minimum benchmark—3.36 bbf of pine lumber. The rough estimate

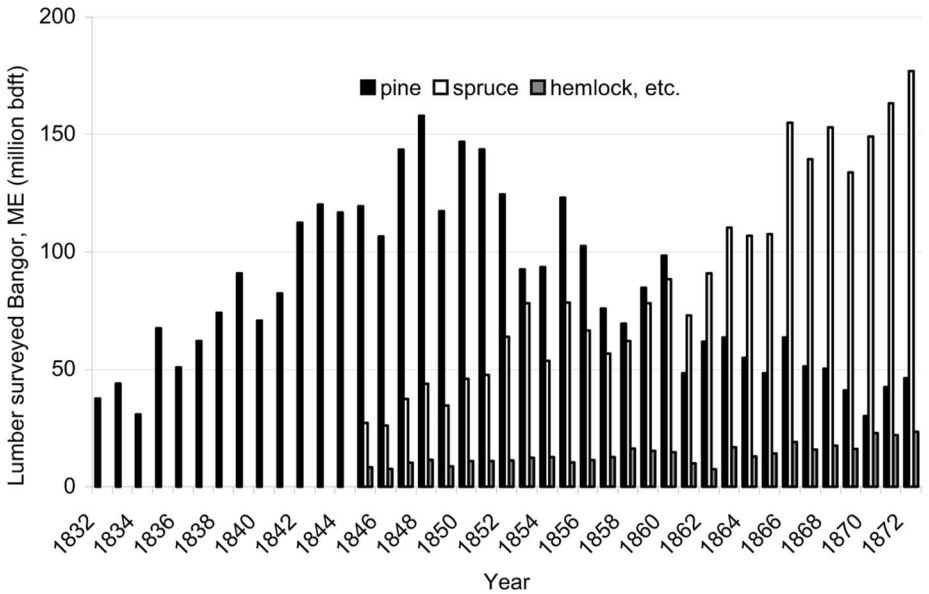

Figure 3. Lumber surveyed in Bangor, Maine, from 1832 to 1872 (City of Bangor various dates, Whitman 1873, Roberts 1875, Defenbaugh 1907, Smith 1972). The logs for this material were driven to the Bangor area on the Penobscot River. The first spruce logging on the Penobscot River was reported in 1845 (Defenbaugh 1907, Hempstead 1931, Smith 1972). Before 1851, records do not distinguish between species. Pine proportions have been estimated for 1845 to 1850 by extrapolating post-1851 trends in species proportions.

of standing pine volume, 6 bbf, provides some sense for the magnitude of the pre-European Penobscot River watershed pine resource that was required to manufacture that much lumber.

Comparison with 2001 Inventory Levels. Forest inventory information for Maine in 2001 is available for comparison with estimated historical levels of white pine in the Penobscot River watershed (Laustsen and Griffith 2002). Large trees (50 cm dbh) dominated the white pine harvest in the middle of the 19th century (Woods 1935, Stanley 1963, Houpt 1964, Smith 1972). The category of large sawtimber in the 2001 forest inventory includes trees ≥38.1 cm dbh; therefore, the current large sawtimber categories include some smaller trees than those typically harvested between 1832 and 1872. Figure 4 provides a comparison of 2001 standing volumes of white pine with the 1832 to 1872 lumber survey volume and the rough standing volume estimate for the Penobscot watershed. The 3.36 bbf of lumber surveyed in Bangor suggest that the volume of large pine in the pre-European settlement forest of the Penobscot watershed was at an absolute minimum more than three times greater than today's large sawtimber pine volumes in the eastern and northern regions of Maine. The Penobscot watershed includes roughly equal areas in both of these regions. White pine currently represents 51% and 22% of conifer volume in large sawlogs in the eastern and northern regions, respectively (Laustsen and Griffith 2002). The 6 bbf standing volume estimate suggests that the pre-European settlement Penobscot forest had standing volumes of large pine that exceeded current forest conditions in southern Maine, where abandoned agricultural fields and forest fires have generated considerable amounts of white pine.

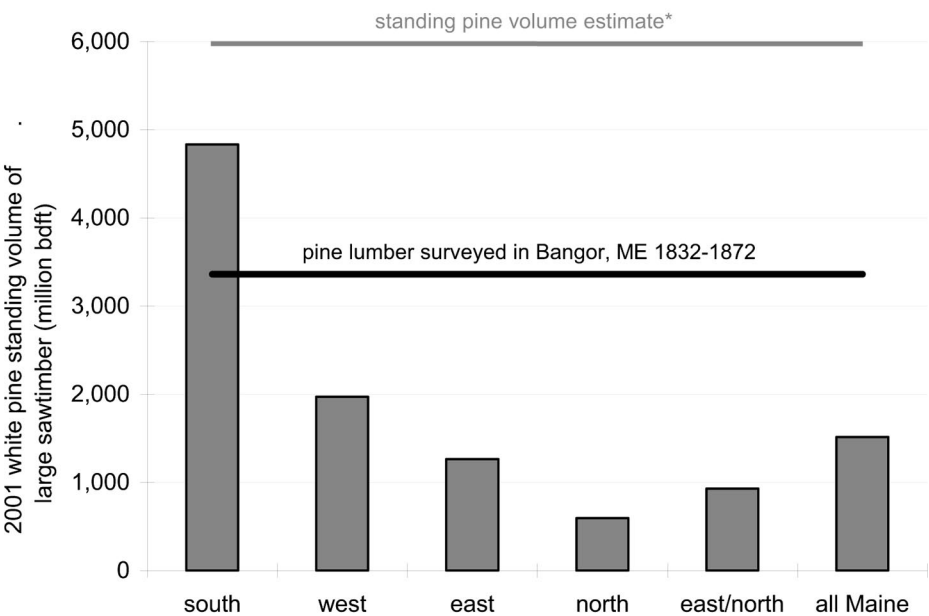

Figure 4. Standing volume of large pine (38.1 cm dbh) if current inventory estimates (average volume of large pine per hectare) from different regions in Maine are used to populate a Penobscot River watershed-sized area (1.871 million hectares of timberland) with pine (Laustsen and Griffith 2002, Laustsen 2003). An asterisk indicates that standing pine volume estimate assumes that inefficiencies and losses during the harvest, transport, and processing of lumber amounted to 80% of total volume.

Comparison with Analysis of Land Survey Information. Lorimer (1977) found that only 1.3% of the witness trees in land surveys of northeastern Maine were pine; however, he did note a discrepancy between the proportion of pine witness trees and the frequency that pine was mentioned in the land surveyors' descriptive lists of vegetation. In these descriptive lists, pine was the third most commonly mentioned conifer after spruce and cedar. Lorimer (1977) downplayed the importance of pine in these descriptive lists because records from 1826 to 1846 timber cruises of 21 townships in or adjacent to his study area produced an average merchantable pine volume of 6.7 million bd. ft. per township. This corresponds to one large pine (1,000 bd ft per tree) for every 1.4 hectares (Lorimer 1977). The Penobscot watershed above Bangor encompasses an area the size of roughly 220 townships. Using the average pine volumes from the 1826 to 1846 timber, cruises would provide an estimate of standing pine volumes for the entire watershed of roughly 1.4 bbf.

This is less than one-half of the 3.36 bbf of pine lumber surveyed, yet still represents more large pine sawtimber than is currently found in a combination of eastern and northern Maine (Figure 4). These early 19th century timber cruises included some townships where harvesting had already taken place (Lorimer 1977). In fact, by 1846, 1.38 bbf of pine lumber had already been surveyed in Bangor. The timber cruises also represent a small proportion of the watershed, and were probably conservative estimates (Lorimer 1977). These factors could help explain the difference between estimates from surveyed lumber records and early timber cruises.

In his evaluation of the timber cruise information, Lorimer (1977) described low numbers of pine when average volume estimates were spread evenly across a township-sized area. It seems more reasonable to assume that there would be some concentrations of tree species between or across townships given pronounced variation in soil, topography, and disturbance history found throughout the region. In fact, Lorimer (1977) reported that the merchantable pine estimated in timber cruises ranged from 600,000 to 30 million bd ft across the 21 townships he examined. The tremendous range in pine volumes reported across the township suggests that concentrations of pines occurred at a variety of spatial scales. The prominence of pine in the land surveyor's descriptive lists would be consistent with estimates from the Bangor lumber survey records if volumes of large pine were concentrated on some portion (e.g., 10%–30%) of a township or the entire watershed area. Using the 3.36 bbf minimum benchmark to populate 15%, or the 6 bbf standing volume estimate to populate 27% of the Penobscot River watershed, white pine numbers per hectare would still be relatively low (i.e., 12 trees per hectare); however, 12 large pines (1,000 bd ft per tree or roughly 70 cm) could easily have a crown projection area equivalent to 10–15% of a hectare, representing an important component of any forest canopy (Figure 5).

Surveyor Bias. Early land surveyors may have been biased against choosing white pines as witness trees for many reasons, including reluctance to impact high-value trees, alternate species preferences, unequal sampling based on topography, and preferences for mid-sized (20–40 cm dbh) trees (Lorimer 1977, Manies and Mladenoff 2000, Black and Abrams 2001, Schulte and Mladenoff 2001). More importantly, simple proportions of different tree species, such as those created from witness tree counts, may not accurately reflect the significance of a species that is found in relatively low numbers but includes many large dominant individuals (Figure 5).

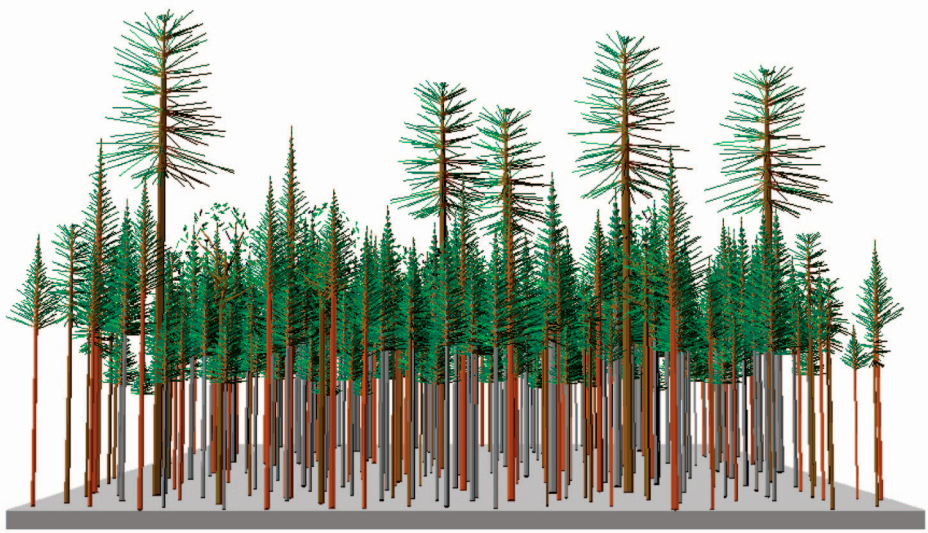

Figure 5. Stand visualization representing 0.4047 hectares. Density of emergent white pine (1,000 bd ft per tree) is equivalent to 12 trees per hectare. Minimum estimates of large white pine from lumber survey records generate this amount of white pine across 15% of the Penobscot watershed. Pine volume estimates assuming 80% inefficiencies and losses in lumber manufacture generate this same amount of white pine across 27% of the watershed.

Why Was There Pine in the Pre-European Settlement Forest?

The presence of white pine in forest stands has long been attributed to its regenerative success and rapid growth rates in openings created by major canopy disturbances (Nichols 1935, Cline and Spurr 1942). Disturbance events associated with historic pine regeneration include fires, windthrow, windthrow followed by fire, and abandoned agricultural fields or pastures (Lutz 1930, Henry and Swann 1974, Foster 1988, Abrams 2001). White pine is considered intermediate in shade tolerance and is most often found to have originated after major canopy disturbances (Lutz 1930, Cline and Spurr 1942, Wendell and Smith 1990, Abrams 2001). In certain situations, two or more age cohorts of white pine have been found in a stand after more moderate canopy disturbances; however, these tend to be in areas where white pine is one of the more shade-tolerant species (Braun 1950, Holla and Knowles 1988, Abrams 2001). In northern and eastern Maine, many species that occur with white pine are considered very shade tolerant, making them more successful competitors in canopy gaps created after less intense disturbance events.

The volume of pine lumber surveyed in Bangor during the mid-19th century, early 19th century land surveyors' descriptive lists of vegetation, and even timber cruise information from the first one-half of the 19th century suggest that pine was a substantial component of the pre-European settlement forest in the Penobscot watershed. Estimates of standing volume based on the 19th century lumber surveys produce white pine volumes that would easily represent an important constituent of the forest canopy over large portions of the watershed (15–30%). The presence of considerable white pine implies that major canopy disturbances were a factor influencing forest dynamics and shaping forest characteristics in pre-European settlement in northern and eastern Maine. Calculating an average return frequency for major canopy disturbances would be inaccurate based on the limited single-species volume information available and misleading given the varied topography and soils of the region (Lorimer and White 2003). Comparisons with current forest inventory estimates suggest that the harvesting and management practices of the 19th and early 20th century regenerated substantially less pine relative to the pre-European settlement disturbance regime. This implies that before European settlement, the watershed experienced pulses of more intense canopy disturbance events than those related to early harvesting tech-

niques (high grading and then diameter-limit cutting) in these forests.

The Penobscot River watershed pine harvest is not unique in the region; substantial white pine harvests in the 18th and 19th centuries occurred on every large river systems in Maine, including the Saco, Androscoggin, Kennebec, St. John, and the Machais (Defenbaugh 1906, Wood 1935, Coolidge 1963, Smith 1972, Judd 1989).

Increasingly in Maine and many other regions, there are calls for adjusting forest management to more closely emulate the pre-European settlement disturbance regime. Current interpretations of the pre-European settlement disturbance regime in northern and eastern Maine suggest long return intervals between major fire and wind events, and that forest dynamics and characteristics were driven by minor to moderate canopy disturbances and subsequent gap colonization (Lorimer 1977, Lorimer 1980, Seymour 1992, Seymour et al. 2002, Lorimer and White 2003). These current interpretations of the pre-European settlement disturbance regime for northern Maine should be re-evaluated to ensure that they do not contradict the presence of substantial white pine in the pre-European settlement forest. The large volume of white pine in the mid-19th century lumber survey records for Bangor, Maine, suggest that before European settlement, major canopy disturbance events influenced forest dynamics and shaped forest characteristics across a sizeable portion of the Penobscot River watershed.

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