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white pine in the northern forests: AN ECOLOGICAL

AND MANAGEMENT HISTORY OF WHITE PINE ON THE BAD RIVER RESERVATION OF WISCONSIN

ABSTRACT

This essay examines eastern white pine (*Pinus strobus* L.) removal and recovery on the Bad River Reservation of northern Wisconsin. A key species in the environmental history of the Great Lakes region, white pine has greatly declined as a forest component since Euro-American settlement. Forests eventually did regenerate on much of the cut-over area, but their composition is quite different than the earlier forests, with aspen and other hardwoods dominating, rather than conifers. This interdisciplinary study examines biophysical, social, and political processes that influenced the loss of white pine. We find that on the Bad River Reservation, as across much of the Great Lakes region, the loss of white pine was not a result of the lumber era alone. Changing forest management goals, officials' projections of forest economic values, financial and technical resources available to managers, the political influence of paper companies, and shifts in land ownership composition all played a role in shaping the forests that returned on the reservation.

EASTERN WHITE PINE (*Pinus strobus* L.) played a central role in the environmental history of the Great Lakes forests, for it was the favored lumber tree during the logging era. The pineries of the Great Lakes became the cities of the Great Plains, and the depletion of the pine changed the region's ecological and human relations for generations. In 1854, when the 125,000-acre Bad River Reservation was established along Lake Superior, reservation forests contained unusually rich stands of white pine. By the 1930s, white pine had nearly disappeared on the reservation, as it had throughout the region. Recovery since then has been minimal. Today, white pine is not the dominant species on any stands at Bad River. The region is now more forested than at any time since the

Michelle M. Steen-Adams, Nancy Langston, and David J. Mladenoff, "White Pine in the Northern Forests: An Ecological and Management History of White Pine on the Bad River Reservation of Wisconsin," *Environmental History* 12 (July 2007): 595-629.

logging era, but the forests are very different places than they once were. The work of forest historians such as Michael Williams, Susan Flader, and Gordon Whitney has taught us a great deal about why and how the white pine was harvested, but we know much less about why it failed to recover.[1] Forests typically will recover if given a chance, so a central question in forest history should be not just "why were the forests cut?" but also "why are the forests that returned so different from those they replaced?"

This essay examines the history of white pine recovery after the lumber era on the Bad River Reservation in northern Wisconsin. Past studies have assumed that across the Great Lakes forests, the intensive harvests and slash fires of the lumber era created conditions that made it nearly impossible for white pine to regenerate, while the few that did survive were eradicated by the introduced blister rust fungus (*Cronartium ribicola*). Using ecological and archival records, we examine the ways ecological, social, and political processes interrelated to shape forest recovery. We find that although ecological conditions and white pine blister rust contributed to the disappearance of white pine, a series of political, economic, and social decisions actively prevented the recovery of white pine. We find that white pine had the potential to reforest a significant amount of its former extent; logging practices at the turn of the century did not predetermine the composition of the Lakes States forests today.

WHITE PINE

ALTHOUGH WHITE PINE occasionally grew in the extensive, pure tracts that popular forest history terms such as "the pinery" suggest, it usually grew in stands of mixed species. Eastern white pine constituted an important component of the hemlock-white pine-hardwood forest region that extended across the northern third of the United States and southern Canada.[2] Although white pine could establish on a range of soil types in the Lakes States, sandy soils typically supported the highest concentrations. Because of its competitive disadvantage with species that use nutrients more efficiently and are more shade tolerant, like sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis)*, hemlock (*Tsuga canadensis*), or basswood (*Tilia americana*), white pine usually occupied marginal sites, such as steep slopes and ridge tops, swamp edges and lake shores, and extensive sandy plains. Because seedling establishment required sunlight, white pines usually became the dominant species on sites where a fire, blowdown, or other disturbance had occurred.[3]

Even though hemlock rather than white pine was the most common tree within the northern Great Lakes forest, white pine was the most valued and commonly harvested tree.[4] An estimated 315 billion board feet of white pine was harvested from Michigan, Wisconsin, and Minnesota between the mid-1800s and 1930s. During the height of the white pine era in the Great Lake states, between 1869 and 1900, this species accounted for 60 to 82 percent of the region's total annual timber production.[5] Lumbermen preferred white pine for two reasons. First, white pine floats. When rivers functioned as highways, pine's buoyancy enabled timbermen to move logs cheaply from the forest to the mill and then to markets.

Second, white pine was an excellent building material, because it grows into tall boles of clear wood that are easily worked, flexible, light, yet strong and durable. As William Cronon argues in *Nature's Metropolis*, white pine cut from the upper reaches of the Lake Michigan drainage basin built Chicago and settlements on the Great Plains, and as the cities grew, the forests they depended upon shrank.[6]

ECOLOGICAL HISTORY OF WHITE PINE

WHITE PINE HAS DECLINED across much of the Great Lakes region.[7] Even as loggers cut the region's primary forest, special agent to the U.S. Department of Agriculture Filibert Roth reported in 1898 the widespread loss of the white pine component in Wisconsin's forests. A 2001 review of eight retrospective ecological studies throughout Michigan, Wisconsin, and Minnesota shows that the decrease has been dramatic in some areas. On one north-central Wisconsin site, 35 percent of the witness trees were white pine at the time of the General Land Office survey, but white pine has since disappeared from the modern forest.[8]

The vegetative communities that reforested the pine sites were very different from those that once covered the Great Lakes region. Fast-growing species such as aspen, paper birch, and pin cherry initially reclaimed the logged-over stumplands. As stands have aged, maple and balsam fir have grown in with the aspen to form the dominant assemblages; red pine also has become important in some former white pine-dominated areas, largely as plantations.[9]

The loss of white pine is part of a general trend that is occurring across the Great Lakes region: Forests have become more homogeneous. Whereas conifers and mixed conifer-hardwood forests grew across much of the northern Great Lakes region prior to Euro-American settlement, deciduous forests now predominate. Northern hardwoods (maple-beech-birch) currently cover 27 percent of the region's forest; aspen covers 25 percent. Along with these compositional shifts, species diversity and diversity of forest functions has decreased.[10]

Questions about these forest changes have intrigued many forest ecologists and historians. Why didn't white pine reforest the region where it once grew so abundantly? Most ecologists have highlighted the role of biophysical factors, and particularly the influence of intense logging on forest change. Late nineteenth-century logging left few seed trees and subsequent slash fires degraded soils, both of which minimized white pine natural regeneration.[11] Where foresters planted nursery stock in an effort to bring white pine back, blister rust prevented it from thriving. In addition to these factors, some ecologists have highlighted the adverse effects of twentieth-century fire suppression, which impeded the development of the open conditions that pine seedlings require. Other studies point out problems caused by browsing by herbivores, especially deer, on young pines.[12]

While all these ecological factors played some role across the Lakes States, to understand why modern Michigan, Wisconsin, and Minnesota forests contain much less white pine than in the nineteenth century, we need to consider ecological factors together with their social context. Changing forest management goals, officials' projections of the economic value of forest stands, financial and

technical resources available to managers, and land ownership characteristics all influenced forest composition. A close examination of a particular place can help us understand the ways ecological and social factors interacted on the ground. Using a combination of ecological and archival sources, this essay examines white pine removal and recovery on the Bad River Reservation of northern Wisconsin. The availability of a rich body of archival records promoted our ability to trace forest management decisions. Ecological and archival records allow us to examine how forest dynamics, harvest practices, lack of seed trees, slash fires, and blister rust interrelated with political decisions to influence the loss of white pine after the lumber era.

STUDY AREA

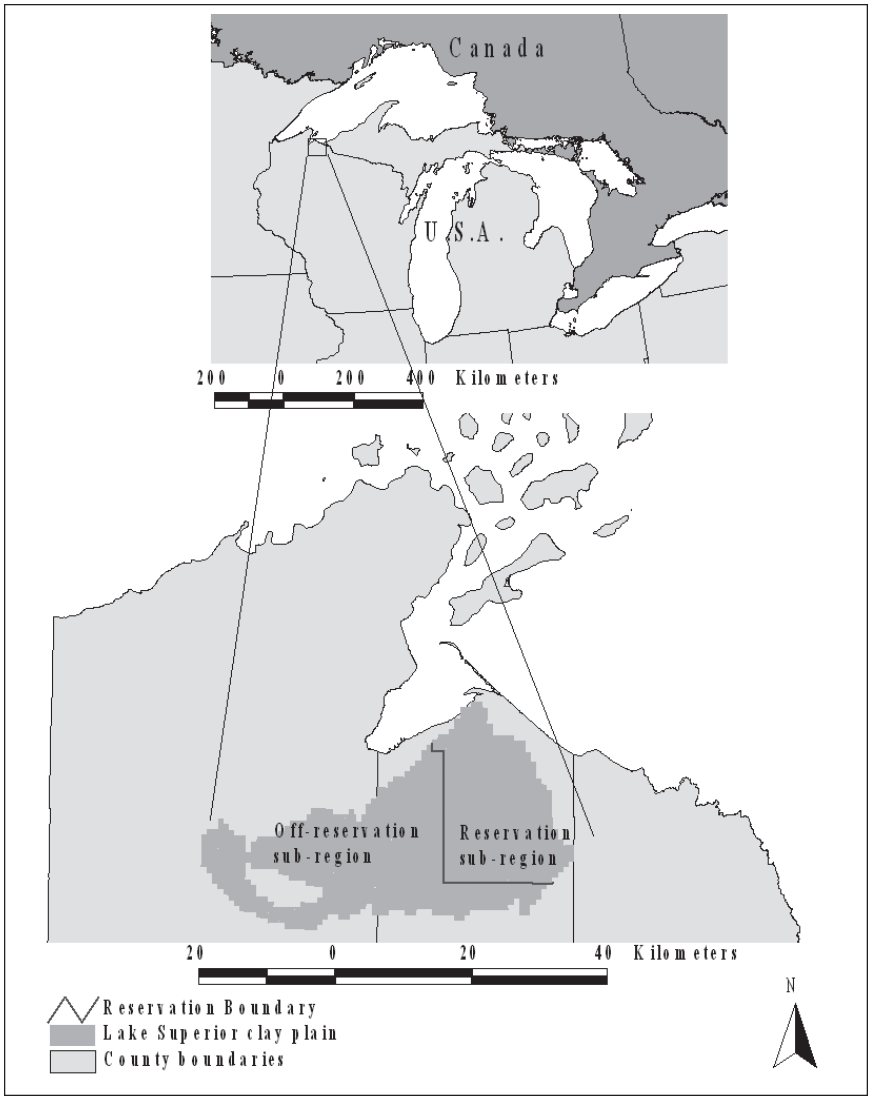
THE BOUNDARIES OF THE STUDY AREA lie within the Lake Superior clay plain of northern Wisconsin, an area with relatively uniform soil and landform characteristics, but varied forms of land ownership, including tribal lands and private lands owned by industrial and non-industrial landowners (see Map 1).[13] The landform, part of the geological formation called the Superior Lowland, is a gently inclined plain with an undulating surface and some small, V-shaped river valleys. Soils comprise a fine-textured, impermeable clay substrate, overlain by loams and sandy outwash deposits on some sites. The clay deposits are a legacy of the region's glacial history, including a period when Glacial Lake Duluth once submerged this lowland region.[14]

The Lake Superior clay plain encompasses two subregions with distinct human histories: the Bad River Reservation, home to the Bad River Band of Ojibwe, and an off-reservation landscape logged and farmed by European immigrants. Soil and landform characteristics are relatively uniform across the two subregions. By controlling for physical variation, we focus on ways that human history influenced landscape change. This essay highlights the Bad River Reservation portion of the clay plain because an unusually rich body of extensive, frequently updated records of forest management history was available. These documents enabled us to closely trace relationships between management goals, practices, and outcomes. The forest management history of the off-reservation portion of the study area is much more obscure. In related studies, we compare landscape change on and off the reservation.[15]

The Bad River Reservation lies in the eastern part of the Lake Superior clay plain. In the Treaties of 1837 and 1842, the Wisconsin Ojibwe lost the northern half of Wisconsin. The Treaty of 1854 (La Pointe Treaty) established four reservations for the Wisconsin Ojibwe, along with others for the Michigan Ojibwe. The reservations, including the 125,000-acre Bad River Reservation, were carved from these earlier cessions. The 1854 Treaty stands out from preceding treaties because it confined the Indians to a reservation; this change reshaped Ojibwe culture, economy, and environmental relationships.[16] Euro-Americans and European immigrants settled the western, off-reservation part of the study area.

Although the Bad River Reservation forests are generally representative of the northern Great Lakes region, they are distinct in several respects. The clay

Map 1. Northern Wisconsin, USA, Study Area on the Lake Superior Clay Plain



Map by Michelle Steen-Adams, Ted Sickley, and the Forest Landscape Ecology Lab at the University of Wisconsin-Madison.

soil substrate differs from the loamy soils and outwash sands that characterize most of northern Wisconsin.[17] The study area also has a slightly milder climate than sites further inland, because relatively warm air from Lake Superior moderates the near-shore land during fall and winter. The clay plain therefore has more frost-free days than the rest of the cutover region, making agriculture somewhat more viable.[18] During the summer, the moderating effect of Lake Superior maintains an unusually cool, wet microclimate.

The Bad River Reservation forest also stands out from the northern Great Lakes region for its human history. The combination of the Lake Superior-moderated climate, fur-bearing mammals, abundant fish populations, lush wild rice beds, and dense forests made the clay plain an attractive location for both the Great Lakes Ojibwe and Europeans.[19] Yet, while the forests of the Bad River Reservation are not identical to other tribal, public, and private forests in the Lakes States, the broad dynamics of political, social, and ecological factors shaping forest history that we identify here are likely to hold true across the region.

METHODS

OUR INTERDISCIPLINARY FRAMEWORK enabled us to examine relationships between human history and forest ecology. Advances in integrative research by environmental historians and scholars from other fields informed our methodology. Landscape ecology, a field that investigates how spatial patterns relate to ecological processes, provided the conceptual approach and methods to measure change of eastern white pine and other land cover types. We used a Geographic Information System (GIS) as our primary tool to analyze the landscape history of the Bad River Reservation.[20] We also examined archival materials and the results of oral history interviews. Integrating environmental historical and landscape ecological approaches allowed us to relate our observations of landscape change to economic, political, and forest management history.

We developed several mapped data layers to use in a computer system (GIS) to analyze land cover change since Euro-American settlement. We integrated data from the Public Land Survey (PLS) records (collected between 1852 and 1873 in this study area, average date for all records is 1857), the Wisconsin Land Economic Inventory (ca. 1930), and satellite imagery (ca. 1987). These records enabled us to represent land cover at three important benchmarks: before the lumber era (ca. 1857), soon after the lumber era (ca. 1930), and following substantial reforestation, about 65 to 125 years after initial forest clearance, depending on location (ca. 1987). Besides describing land cover of three distinct dates, the GIS also allowed us to describe changes in land cover between 1857 and 1930 and between 1930 and 1987 and to compare changes of these two intervals (1857-1930 versus 1930-1987). Because Public Land Survey records are relatively sparse, we use the quarter-section (160 acres), which derives from the Township and Range land survey system, as the unit of analysis of vegetative composition. The particulars of this framework and our methodology, including a discussion of potential bias in PLS records, are described in greater detail elsewhere.[21]

Records of the white pine blister rust program were collected from the National Archives (College Park, Maryland, and Washington, D.C.), the Great Lakes Branch of the National Archives (Chicago), and the Ashland, Wisconsin, field office of the Bureau of Indian Affairs.[22] We also collected records from the University of Wisconsin-Madison Steenbock Library Archives, the Wisconsin State Historical Society, and local historical societies. In addition, we conducted semi-structured oral history interviews with reservation members and industry foresters.

RESULTS

ECOLOGICAL CHANGE IN NORTHERN WISCONSIN

THE GIS LAYERS and the statistical tests for analysis are described in greater detail elsewhere; here we review the results to provide context for the historical material.[23]

Before the lumber era, at the time of the public land survey, conducted between 1852 and 1873 on the clay plain, white pine dominated a large proportion of the land that became the Bad River Reservation. The dominant species on 41 percent of the reservation forest area was pine, primarily white pine (see Table 1). In comparison, on the off- reservation portion of the clay plain, where soil conditions were similar, white pine dominated only 17 percent of the quarter-sections.[24] Several other forest classes also grew on the reservation, including lowland forest –17 percent of reservation study area, composed of cedar (*Thuja* occidentalis), black ash (*Fraxinus nigra*), and tamarack (*Larix l*aricina); aspen (*Populus tremuloides)* paper birch (*Betula papyrifera*) (15 percent); boreal conifer (10 percent, composed of balsam fir *(Abies balsamea*) and spruce (*Picea glauca*)), hemlock (*Tsuga canadensis*), yellow birch (*Betula alleghaniensis)* (9 percent); and northern hardwood (6 percent, composed of sugar maple (*Acer saccharum*), basswood (*Tilia americana*), and elm (*Ulmus americana*).

Table 1. Land Cover on Bad River Reservation Portion of Study Area in 1857, 1930, and 1987*

LAND COVER CLASS	DATE		
	1857	1930	1987
Agriculture-Grassland	0	3	2
Aspen-Paper Birch	15	83	40
Boreal Conifer(Balsam fir-Aspen)**	10	0	30
Hemlock-Yellow birch	9	0	0
Lowland forest	17	0	2
Northern Hardwood	6	11	1
Pine species***	41	1	0
Upland Shrub-Herb	0	0	11
Other or No Data	3	2	14

Cells present the proportion of the reservation study area in each land cover class.

Some columns in this table do not equal 100 percent due to rounding.

* These data are derived from our analysis of 72 percent of the Bad River Reservation.

** In 1857, "Boreal Conifer" comprised fir and spruce species; in 1930 and 1987, this class comprised balsam fir-aspen. We group these classes together in the interest of making a comparison among the 1857, 1930, and 1987 datasets; these are the most comparable classes.

*** "Pine species" refers primarily to white pine in 1857 (90 percent of the quarter-sections dominated by pine were white pine; 10 percent red pine). In 1930, this class refers to red pine, rather than white pine.

In 1930, after the logging era, Bad River forests were dominated by early successional forests of aspen-birch (83 percent), rather than by pine forests (1 percent).[25]

The conversion of pine stands to other forest types largely explains the dramatically different forest composition between 1857 and 1930. On over one-

third (34 percent) of the reservation study area pine forests shifted to aspen-birch; that is, 84 percent of the quarter-sections dominated by pine in the 1850s became aspen-birch stands by the 1930s. Many sites that had supported lowland forest, boreal forest or hemlock-yellow birch also became aspen-birch forest. (These transitions occurred on 13 percent of reservation study area, 9 percent, and 7 percent respectively.)

In 1987, aspen-birch forest remained one of the major forest components, covering 40 percent of the reservation study area. Other vegetative classes also became important, including balsam fir-aspen (30 percent) and upland herbaceous-shrub vegetation (11 percent).[26]

Between 1930 and 1987, as the forests that grew up after the logging era aged, many aspen-birch stands shifted to northern conifer-hardwood forest (24 percent of the reservation study area). This change is consistent with the process of forest succession: Communities that require sunlight tend to gradually shift to more shade-tolerant communities as understory, shade-tolerant species mature. Much of the reservation failed to change in ways that were consistent with forest succession, however. On 34 percent of the reservation study area, aspen-birch remained the dominant forest community type between 1930 and 1987. This stasis in forest ecological composition is significant. According to the theory of forest succession, more shade-tolerant communities should replace aspen-birch stands. The discrepancy between actual compositional change and shifts predicted by the theory of forest succession highlights the role of human activities in the forest history at Bad River, as across much of the Great Lakes region.

LOGGING WHITE PINE ON THE BAD RIVER RESERVATION

WHEN THE BAD RIVER Reservation was established in 1854, the white pine had not yet been logged off, even though loggers were beginning to search surrounding forests for harvestable pine. Indian Agency officials viewed the reservation white pine as the critical resource for the tribe because it would provide employment and capital for farm development. In an era when tribal members had few economic opportunities, white pine represented a rare source of natural wealth, and the Indian Agency oversaw the logging of the reservation forests with economic development as its primary goal.

The forest history of the Bad River Reservation, like many other Indian reservations in the Great Lakes states, stands out from the surrounding off-reservation area. The timing of the harvest history differed. Whereas much of the region's forests had been harvested by 1900, valuable pine and other species remained in the Wisconsin Ojibwe reservations, like islands amid a cleared landscape. Because logging regulations of the Indian Agency ostensibly held lumbermen at bay (although widespread timber theft frequently thwarted these regulations), the white pine harvest at Bad River persisted until 1921-1922. At Bad River, the white pine harvest rose to more than 114 million board feet in 1907-1908, fifteen years after the regionwide peak of 1892.[27]

In contrast to the cutover elsewhere in the Lakes States, where logging companies left devastation behind when they moved onto the next lumber frontier,

Indian Agency foresters intended that logging on the reservation would occur in a regulated, systematic way and be guided by the principles of scientific forestry.[28] The Morris Act of 1902, which legally applied to lands that the Ojibwe had ceded in neighboring Minnesota but also influenced the Indian Agency foresters on the Bad River Reservation, directed that forest clearance should be carried out in a scientific manner. Loggers were required to retain at least 5 percent of the volume of standing timber to encourage reforestation.[29] The Morris Act marked the beginning of a short period (1902-1909) when the Indian Agency, supervised by the Department of the Interior, worked cooperatively with the Forest Service, supervised by the Department of Agriculture.[30]

The Indian Agency's desire to turn Bad River Ojibwe into farmers overrode their desire to practice scientific forestry and work cooperatively with the Forest Service, however. For example, the agency urged that the harvest be designed to "secure the highest returns in money possible for the allottee, and to reduce the forest cover as much as possible so that clearing the land for farming would be cut to the minimum of time and effort."[31] Some foresters wanted white pine seed trees—the large trees that produced seed for the next generation of the forest—to be left behind. Nonetheless, to prepare the forest land for farming, contracts stipulated that loggers harvest all merchantable timber, including pine as small as six inch diameter at breast height (DBH)—a practice that discouraged natural reforestation of the pine stands.

Foresters believed that harvest practices that encouraged forest regeneration would also provide a source of revenue to the tribe, even as they would slow the transformation of forest-dwellers into farmers, and so the Indian Agency foresters were conflicted over the kind of forestry they should encourage. As foresters, they wanted to implement good forestry practices. Yet the poor logging practice of clearing stands of all seed trees simultaneously promoted farms, which the Indian Service strongly supported. These conflicting goals put foresters in a bind.

SEED TREE RETENTION

BETWEEN 1900 AND 1909, the Forest Division of the Indian Agency retained seed trees on some Bad River allotments.[32] The seeds of a few trees protected from harvest might one day reforest the stand, officials hoped. J. C. Cavill, superintendent of the Great Lakes Agency described this practice in historical overview of the Bad River Reservation. In his report to the commissioner of Indian affairs, Cavill noted, "[e]fforts were made by officers in charge of timber sales to leave seed trees … At that period … [seed tree retention] was considered a satisfactory method of insuring a second forest crop." Support for the practice extended to the top of the agency hierarchy. E. B. Merrit, then assistant commissioner of Indian Affairs, favored seed tree retention, even as he worried that fires might destroy seed trees before they could help regenerate a future forest.[33]

Many foresters were skeptical that the seed tree retention policy could work, however. Their field-based perspective made them keenly aware of the impact of fire, which repeatedly broke out from the large accumulations of logging slash.

These burns swept across the Bad River Reservation during the 1890s and first decade of the twentieth century.[34]

Slash fires hindered the seed tree retention practice in two ways. First, the repeated, high-temperature fires altered forest soils. A 1943 document reported that some soils were so damaged that not even aspen, a species that fire usually promotes, would reach maturity.[35] Second, slash fires burned the seedlings directly, sometimes killing them. The relatively thin bark of pine seedlings makes them susceptible to mortality by fire. Where slash fires swept over seedlings, they probably killed them, at least until effective fire suppression capacities took hold. Yet fires were patchy, and many trees did survive them.

Good fire suppression capacities were in place by the 1930s. Through a cooperative arrangement with the Wisconsin Conservation Department, a fire tower was built and manned on the Bad River Reservation. The Indian Agency developed and coordinated fire control plans, including fire detection, transportation, communication, labor, and logistics.[36] Between 1936 and 1940, thirty-one fires occurred on the reservation. Still, all but four of the fires were held to twenty-five acres or less.

Although fire suppression may seem to encourage reforestation, ultimately this practice may have discouraged pine reforestation at Bad River. Repeated, high-intensity slash fires discourage pine, as previously discussed. Low-intensity, less-frequent fires perform important functions to favor white pine, however. In the absence of stand-opening disturbances, a mid-shade tolerant species like white pine cannot compete with more shade-tolerant species.[37] Fires, which open the stand, allow sunlight to reach the pines and thus compete with species that can survive in shady conditions. At Bad River, 24 percent of the reservation study area shifted from aspen-birch to balsam fir-aspen stands between 1930 and 1987.[38] Fire suppression probably reinforced the ecological legacies of initial logging and slash fires, since white pine was unlikely to establish under the shady conditions of a dense fir canopy.

Some forest scientists concluded that white pine reforestation of cutover sites required more than seed tree retention alone. Precise treatments must be applied, which trained foresters would most capably implement. After surveying sixteen Minnesota sites managed in accordance with the Morris Act, Raphael Zon, a USDA forest scientist, recommended that loggers conduct two successive cuts. First, they should thin the stand. This treatment would produce large crowns, which would encourage seed production. It also would provide a canopy shelter that would protect the seedlings from excessive sunlight and storm damage. When the seedlings reached a height of two to three feet, Zon recommended that loggers should clear the stand of the mature trees, thus allowing the saplings to grow in full sunlight. In addition, trained foresters could capitalize on the effects of surface fire to remove competing vegetation: "[I]t may seem paradoxical, yet it seems true that fire, which is largely responsible for the deterioration of our forests, in the hands of a forester, if intelligently applied, may become the means of their recovery."[39]

Zon thought that specific prescriptions were especially important for white

pines, compared to red pines, to which the act also applied. If loggers simply retained seed trees without these follow-up treatments, competition from other vegetation limited reproduction. Unlike red pines, which grew well on the nutrient-poor, coarse sands, white pine was a more successful competitor on richer sandy-loam sites. Logging opened land to the sunlight. Fast-growing species such as aspen and shrubs quickly covered the soil. Because these pioneer plants competed with the pines for sunlight, nutrients, and water, they threatened the survival of the pines. In Zon's opinion, when it came to white pines, the Morris Act's goal to reforest future stands required more than retaining seed trees alone; this objective required the specific treatments that trained foresters could provide.

Zon's report highlighted a key consideration that foresters in the Indian Agency, the U.S. Forest Service, and state forest departments shared in common: Economics shaped the perception of management success. Market considerations are reflected in his criteria to continue managing an area as a pine stand: "I wish to emphasize that in speaking of reproduction, I do not mean a few seedlings, or even a few hundred seedlings, to the acre. I mean a reproduction which is sufficient to produce a ... merchantable stand of timber. ... If ... reproduction is poor and not capable of producing a merchantable stand, the natural reproduction must be recognized as a failure."[40] Zon's guidelines reflect the assumption of early twentieth-century forest science that forests should function as a marketable crop. Even though white pine may have reproduced on logged-over sites, unless pine seedlings were abundant enough to produce a merchantable stand, Zon recommended shifting the focus to other species.

Although conditions after the lumber era primary promoted aspen, under certain conditions the seed tree retention policy appears to have promoted white pine. On many sites, pine thrived in the understory of the aspen. In the 1930s and 1940s, foresters reported that patches of young red and white pine grew under the aspen stands, suggesting that surviving pine trees had seeded their surroundings. In 1933, state forest ranger William Morris conducted a timber cruise and report for the Wisconsin Land Economic Inventory. He reported, "[o]ne splendid feature from the forest management point of view. ... on all this popple [aspen] area is that there is a good understory of Norway [red] and white pine, balsam and spruce."[41] The future for pine reforestation looked promising: Red or white pine trees grew on 50 percent of the reservation timberland, either in the understory or in a mid-story layer with the aspen.

The seedlings that Morris observed probably grew from seed produced by mature seed trees that had survived the slash fires of the logging era. Mature white pine trees have relatively thick bark, which enables them to withstand the effects of moderate surface fires, in contrast to young pines, which have thin bark and are intolerant to fire. For example, a scale inspector reported of a burnt-over site that he did not think the trees were damaged "even in the least degree. The tops are all green and the trees are looking fine and healthy. [42] Even if seed trees eventually succumbed to fire or windstorm, they may have dropped a substantial quantity of seeds before their death, which may have encouraged future stands to regenerate.

Morris noted that most of the anticipated white pine stumpage would be "widely scattered" rather than clustered. In addition, white pine reproduction was patchy. On some sites, the young, three- to six-inch diameter white pine grew "quite densely," according to the state forester, numbering about one hundred trees per acre. On other sites, reproduction was sparse, averaging just one seedling per acre.[43]

In 1960, the U.S. Forest Service scientists reported that an estimated 553,000 acres of white pine were growing in northern Wisconsin, mostly in mixed, patchily distributed stands.[44] Thirty-nine percent of the surveyed stands were over thirty years old, which suggests that they had established through native regeneration, seeded by the few large white pines that had survived the lumber era. Since the practice of creating white pine plantations did not become widespread until the 1930s, and was never very common, these stands probably predate plantations.

Although the logging era strongly impeded white pine regeneration, the loss of white pine in the Great Lakes forest was not due to the lumber era alone. In fact, the slash fires that followed timber harvest of the logging era must have been quite patchy, occurring heavily in some sites and sparsely in others. The spatial variability of this harvest history has ecological significance: The logging era impeded white pine reforestation on many sites, but did not do so uniformly across the Great Lakes region. On some refugia sites, such as existed at Bad River, pine seedlings promised to develop into future stands, and yet they did not mature. While the effects of the logging era partially explain why the Great Lakes forests lost much of their historic white pine component, events of the twentieth century also contributed to this ecological change.

WHITE PINE BLISTER RUST CONTROL PROGRAM

IN THE 1930s, state and federal scientists believed that the decline of white pine since the logging era could be reversed, through a combination of natural reseeding and plantations. USDA Forest Service scientists S. R. Gevorkiantz and Raphael Zon argued that white pine plantations would be an ideal use of the 2,018 square miles of rough, stony land in northern Wisconsin that was unfit for agriculture. Plantations made sound economic sense, Gevorkiantz and Zon argued, because of the productive nature of white pine: "No other coniferous species in Wisconsin produces as high yields of wood per acre as does white pine and at the same time retains its rapidity of diameter and height growth until old age."[45]

The emergence of white pine blister rust as a serious pest undermined the nascent effort to encourage white pine plantations. Foresters made extensive and costly investments to control blister rust, and when those programs seemed to fail, the efforts of foresters shifted away from white pine toward aspen. Blister rust, an exotic fungus from Asia that can kill eastern white pine, was first discovered in the United States in 1906 and on planted pines in Geneva, New york in 1909.[46] Infected nursery stock introduced this disease to the United States.[47] The fungus attacks white pine through the needles, then moves into the interior of the tree, where it girdles the stem or branches, eventually killing the tree. The needles, which remain on the infected branches, turn a copper or rust color. As

the disease takes hold, spore pustules or blisters develop on the bark.[48] This combination of factors explains the name "blister rust."

The USDA-led blister rust control program was the most costly tree disease control program in U.S. forest history. During the program's fifty-six-year history (1912-1967), the USDA spent an estimated $150 million. Like the threat that other rust fungi posed to other important crops in the Americas, such as wheat and coffee, blister rust threatened to damage an important marketable resource. The threat of adverse ecological and economic repercussions prompted officials to strive to check this pathogen, beginning with the Plant Quarantine Act of 1912, which prohibited the importation of five-needled (i.e., white) pines.[49]

The blister rust fungus requires two plant host species to reproduce and spread, using each during distinct parts of its life cycle. Besides attacking pines, blister rust infects an alternate host, currant and gooseberry shrubs (*Ribes*). Managers primarily strove to control this pathogen by eradicating the alternate host from infected sites near white pines. Workers fanned out across infected areas to unearth the shrubs. Because *Ribes* frequently resprout, efforts to eradicate this alternate host required multiple follow-up treatments. In all, the program was tremendously labor-intensive.

Several state and federal agencies cooperated to carry out the USDA-led program. On the Wisconsin Indian reservations, the Great Lakes Indian Agency collaborated with the U.S. Department of Agriculture Bureau of Plant Pathology, the Civilian Conservation Corps, the U.S. Forest Service, and the Wisconsin State Department of Agriculture to control blister rust. The program was implemented at Bad River between 1935 and 1967.[50]

The blister rust program initially enjoyed broad political support. Between 1935 and about 1950, USDA Bureau of Plant Pathology scientists and program directors developed the scientific rationale that served as the program's foundation. The pathologists argued that blister rust could be controlled, which would in turn promote second-growth white pine. For example, a Wisconsin statewide report found that the number of *Ribes* had decreased dramatically between initial and second treatments. As a consequence of this work, "[t]he acreage of white pine of young age classes is definitely on the increase in Wisconsin."[51]

Besides developing the rationale for the blister rust control program, USDA pathologists bolstered the work at Bad River with technical support. A Memorandum of Understanding between the Great Lakes Indian Agency and the U.S. Department of Agriculture Bureau of Entomology and Plant Quarantine outlined the responsibilities of the two agencies. USDA pathologists provided leadership and technical direction. They supervised the preparation of work plans and maps, trained crews and reviewed completed work, maintained permanent records, and made periodic reports. The Indian Agency developed site-specific plans and carried out the work.

At Bad River, field leaders mapped white pine stands and oversaw *Ribes* eradication crews (see Figure 1), in counterpart with the administrative and scientific work of regional offices. Controlling blister rust was worth the cost,

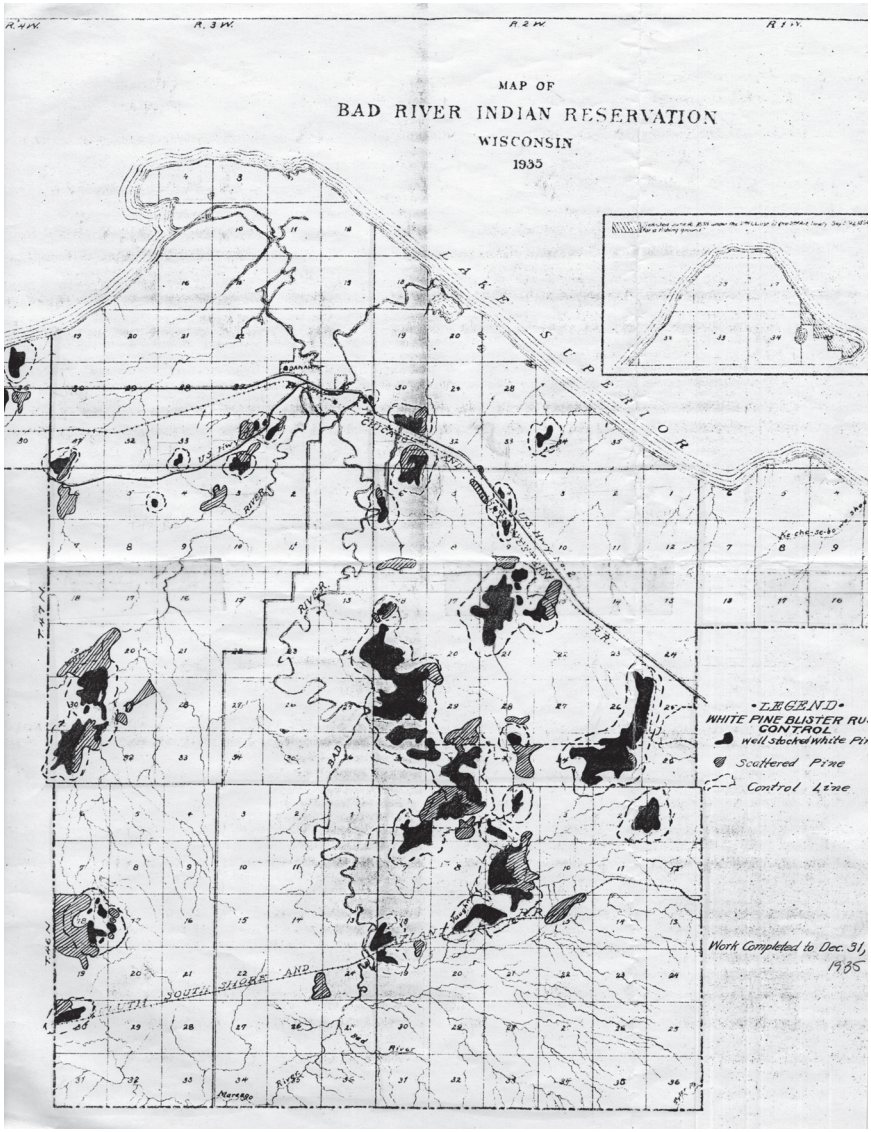
field leaders argued, because of the unusually high resource value of white pine stands. Earl Nielson, author of a 1935 reconnaissance, preeradication survey argued that "[t]he extent and value of the White Pine on the Bad River Reservation certainly warrants the expenditures that have been made and that may be made for blister rust control. This is doubly so because forest crops are the only natural resources on the reservation, other than game and fur bearing animals. Due to the extreme lack of hardwoods, White Pine is by far the most valuable timber species present on the Bad River Reservation."[52] To these officials, white pine stood out as one of few natural resources that could provide revenue to the band, and thus merited the cost of blister rust control.

The argument that white pine benefited Wisconsin's citizens as an important economic resource bolstered political support for blister rust control work. Of the 35 million acres that comprise the state of Wisconsin, approximately 1 million acres supported white pine stands. In 1944, Wisconsin resource managers estimated that the state's white pine was worth more than $36.9 million. The author of the 1944 annual blister rust control report concluded that at least 382,478 acres supported stands that were dense enough to merit the costs of disease treatment.[53] Restoring Wisconsin's status as a white pine lumber producer and exporter, rather than an importer, especially justified the program. T. F. Kouba, leader of the Blister Rust Control program in Wisconsin, observed, "even though the virgin [white pine] forests are gone, we continue to have the same land and climate that produced these excellent forests."[54] He noted that Wisconsin had become an importer of white pine, in contrast to the era when this timber type was one of the state's most important export resources. White pine could once again become an important forest resource, Kouba argued "if logging is restricted to mature and nearly mature trees, and if fire, insects, disease and wildlife can be controlled."

Depression-era federal funding made the labor-intensive blister rust control work possible, and when that funding dried up, the control programs faltered. Emergency Conservation Work programs, such as the Civilian Conservation Corps-Indian Division (CCC-ID), provided a pool of inexpensive labor, particularly between 1933 and 1941, when Emergency Conservation Work funding was available. Henry Putnam, the first blister rust control leader for the Forest Service's North-Central region, observed: "The emergency programs were a godsend, for we had many acres mapped and all we needed was lots of labor with strong legs and good eyesight to get out the *Ribes*."[55]

Although the blister rust control program benefited from cheap labor provided by the CCC programs, the scattered distribution of white pine made work difficult.[56] Ownership patterns also posed a statewide challenge to the blister rust program. About 50 percent of pine stands grew on small, privately held tracts. For the program to be successful, private and public land owners needed to remove all *Ribes* in a coordinated way. If not, surviving *Ribes* in an uncontrolled area would negate the *Ribes* eradication in a neighboring controlled area. State leader T. F. Kouba observed, "it becomes increasingly clear that [to achieve] success, the work must be applied uniformly over all land areas, regardless of ownership."[57]

Figure 1. White Pine Presence on the Bad River Reservation, 1935



From Earl E. Nielson, *Addendum to Blister Rust Spotters Report*. Bureau of Indian Affairs Ashland, Wisconsin field office, 1935.

The emergency conservation work funds enabled the program to justify projects to protect white pine stands that were more remote or heavily infested with *Ribes* than might have been otherwise feasible.[58] Once emergency conservation funds dried up, much less work could be accomplished, especially on remote sites, although the program did not entirely close down. Other agencies,

such as the U.S. Indian Service, continued to fund some work.[59]

Through 1951, the blister rust program mapped increasingly expansive white pine acreage at Bad River, from 3,477 acres in 1935 to 8,547 acres in 1951, and an increase in the control area from 12,477 acres to 15,023 acres.[60] ("Control area" refers to the protective zone surrounding pines where eradication treatments occurred, usually encompassing a nine-hundred foot radius.) Many of these stands were well-stocked.[61] The acreage subject to blister rust control steadily grew: "new areas of reproduction [were] mapped and protected, and all other areas [were] reworked as needed."[62]

After 1951, the program hit a plateau. Reports of the next twelve years, through 1963, show that program workers did not detect any additional white pine; the acreages of white pine and its control area held constant.[63] By 1964, the program began to fold at Bad River: No blister rust control work was performed that year. In 1965, for the first time in the history of this program at Bad River, officials reported less white pine acreage than they had in previous years.[64] That year, administrators decided to discontinue work on the Bad River Reservation.

The implementation of a more stringent cost-to-benefit ratio dealt an insurmountable blow to the blister rust control program. In 1935, when the program was introduced at Bad River, the minimum allowable size requirement for native white pine stands was twenty acres. Pine stands had to reach a minimum stocking level as well. Density requirements varied in relation to tree height: pines that measured one to six feet needed to support two hundred trees per acre; seven to fifteen foot pines needed to support one hundred pines per acre. For pines taller than seventy-five feet, the minimum stocking level fell to a range of fifty to seventy-five trees per acre. In the 1960s, a more rigid formula was implemented to determine whether a site merited treatment. This step required managers to explicitly weigh labor costs against the prospective yield. No more than 0.1 man days could be expended per one thousand board feet of expected yield. The 1965 report by Wisconsin Department of Agriculture area supervisors Andrew Depta and George Lehrer demonstrated this trade-off: "In some cases the allowable man-days are too low for the amount of control area involved to protect a small stand of white pine. This is true even though the MBM [1,000 board foot measure] is fairly good."[65]

Even though a site might support a reasonably high volume of white pine, managers could not justify carrying out blister rust protection if the stands were too scattered. Consequently, in 1965 the reported extent of white pine at Bad River fell from the 1951-1963 high of approximately 8,500 acres to 3,101 acres and the control area declined from about 15,000 acres to 4,678 acres.[66] Whereas thinly stocked white pine stands could be protected under the formula applied in the 1930s, these same stands could not be protected under the more stringent cost-to-benefit ratio of the 1960s. Since much of the second-growth white pine at the Bad River had a scattered distribution, in effect, blister rust funding was largely discontinued.

The reported decrease in the amount of white pine acreage needs to be understood in relation to the changing definition of a white pine stand. When

the program had ready access to labor and funds, such as were available during the New Deal era, program officials had motivation to liberally map stands that could develop into mature white pine sawlogs. Relatively high estimates of white pine could justify access to labor, which was abundant and inexpensive to employ. When funding and labor allocations to the program dried up, officials were forced to apply a more conservative standard to identify a white pine stand. By redefining the stocking level necessary to label a stand white pine, the extent of this species appeared to diminish, even though the actual acreage may not have meaningfully changed.

The purchases of tribal forests by paper companies exacerbated land fragmentation, and made it increasingly difficult for blister rust control programs to succeed. The paper companies wanted aspen, not pine, for pulp, and they were unlikely to encourage forest work that would increase pine over aspen. On some sites, the patchwork of alienated, private parcels interspersed with allotted and tribal trust parcels inhibited access to manage the protective buffer surrounding pine stands. In 1965, when Depta recommended a critical evaluation of the future of the blister rust control program on the Bad River Reservation, he noted, "the ownership problem is the most difficult to cope with."[67] Depta highlighted the on-going land turnover from the Bureau of Indian Affairs (BIA) to private and industrial paper company ownership when he justified why eradication work had not been performed on the Bad River Reservation in 1964: "With this type of intermingled ownership, the job of setting up control zones around B.I.A. pine areas is very difficult because the zones overlap into these other private land holdings."[68]

Paper company acquisition of tribal forest land, spatial patterns of vegetation and ownership, and political and economic factors of the blister rust control program compounded one another, leading to the decision by Wisconsin Department of Agriculture supervisors and Bureau of Indian Affairs supervisors and foresters to discontinue the program at Bad River. Vegetative pattern characteristics, especially the scattered distribution of white pine and the abundance of *Ribes*, contributed to a high cost-to-benefit ratio. To protect just a few, scattered white pine trees, work crews had to eradicate many *Ribes*. As the allowable cost-to-benefit ratio became more stringent, the inherent economic inefficiency of protecting thinly stocked white pine stands, especially across an undulating topography and amid a checkerboard land ownership pattern as at Bad River, ultimately killed the program.

Was the effort to control blister rust at Bad River viable? A substantial body of fungal pathology research shows that blister rust is most likely to break out on cool, humid sites, such as those near Lake Superior.[69] Yet several researchers have shown that despite this regional trend, local infection varies widely: On some high-risk sites, white pine is free or nearly free of infection.[70] At Bad River, managers probably faced a greater challenge than they realized. Onshore winds could carry fungal spores far beyond the typical nine-hundred-foot zone within which USDA protocols directed workers to pull *Ribes*. Exposed ridgetop sites were especially susceptible to infection. On many Bad River sites where pine seedlings

grew on exposed northward facing ridges and slopes, which sometimes lacked a hardwood overstory (i.e., after a clear cut), *Ribes* eradication efforts may have been thwarted in part because the fungal spores may have traveled farther than supervisors expected.

Although the control program did not eradicate blister rust, it may have inhibited the pathogen long enough to provide a critical window for regeneration. In 1935, when officials began to control blister rust at Bad River, just thirteen years had passed since the Stearns Lumber Company, the primary contractor at Bad River, completed its harvest of the reservation's primary forest (in the winter of 1921-1922). Few pines survived in the canopy at that time. This period constituted a critical window for pine regeneration: Had the few remaining trees died, the seed source within the reservation would have been lost. By protecting the surviving white pines, the program may have encouraged some regeneration, making an important difference to the persistence of a small, vulnerable population. The three-decadelong program would have persisted through several seedling cohorts. Because of the program's opportune timing, it potentially encouraged seedlings that sprouted from the early twentieth century seed trees and any remnant pines that loggers had left behind.

SHIFTING MANAGEMENT OBJECTIVES

ASPEN AND WHITE PINE interacted in a complicated way on the Bad River Reservation. After the lumber era, aspen promoted pine in some respects, yet it was because of aspen that white pine eventually declined. When white pine blister rust control efforts failed, forest managers clear-cut to encourage aspen, and in doing so, they suppressed pine. Paper companies were becoming increasingly important political players in the region, and paper companies preferred aspen to pine. As paper companies acquired tribal forests and encouraged aspen, the options available to tribal foresters shrank, and tribal foresters began to manage in favor of aspen.

White pine seedlings grow best in shelterwood conditions: A partially open canopy allows some sunlight to reach the pines while helping to protect them from blister rust. As early as 1912, foresters observed that the survival of white pine seedlings depended on sites characterized by intermediate conditions between those of open and closed canopies. Pulpwood management flies in the face of this proscription and thus the widespread pulpwood management practices across the Great Lakes region may help to explain the loss of white pine.[71]

In the 1930s and 1940s, the Great Lakes Agency aimed to develop a permanent industry for the Bad River Band based on lumbering and pulp cutting. This renewed interest in forest products embodied a shift away from the goal to develop an agricultural foundation to the reservation economy, and thus a new economic strategy. Agency officials decided that forest management would initially focus on aspen, since it had regenerated so well after the lumber era.[72] By the 1930s, aspen accounted for 83 percent of the reservation area. Yet pine seedlings grew under the aspen overstory on half of the reservation's timberland according to

state forester William Morris, and by the 1950s and 60s, that pine would be mature. In the 1940s, some planners believed that by the 1960s pine would constitute a large enough proportion of the stumpage volume that managers could shift primarily harvesting aspen to a mixture of timber types that included pine.[73]

William Morris, forest ranger for the state of Wisconsin, contended that short-term practices to favor an aspen overstory could promote white pine reestablishment in the long-term. In his 1933 survey for the Wisconsin Land Economic Inventory, Morris noted, carefully "cutting ... [the aspen] ... will greatly stimulate the growth of the pine."[74] Aspen would function as a nurse crop, he reasoned, providing the moderately shady conditions that encourage white pine to regenerate. An aspen canopy also protected seedlings from white pine weevil (*Pissodes strobi* Peck), which often attacks in open conditions. Research shows that aspen usually senesces in sixty to eighty years, at which point long-lived pines can emerge into the forest canopy.[75] Morris recognized that management practices favored aspen, but believed that this would benefit pine, if the second-growth forests were managed on long rotations that first removed aspen overstories and allowed the pine to mature, so it could be harvested decades later.

Instead, by the 1960s, management shifted to short rotations that favored aspen at the expense of pine. In 1962, the Great Lakes Agency directed that a larger and larger proportion of the reservation forest should be dedicated to aspen regeneration clear-cuts. The 1962 Bad River forest management plan recommended clear-cutting more than three-quarters of the aspen stands over a fifteen-year period. To encourage aspen regrowth, the clear-cuts would remove the white pine understory along with the aspen. This meant that over half (58 percent) of the tribal timber land would be clear cut, since aspen stands accounted for most of the timber land on the reservation. Correspondingly, the aspen harvest increased from 434 thousand board feet in 1965 to a peak of 3,885 thousand board feet in 1974.[76]

The emphasis on aspen conformed to officials' interpretations of federal legislation. In 1934, the U.S. Congress passed the Indian Reorganization Act (IRA). Section 6 of this act directed foresters to practice sustainable management, that is, practices that would ensure a constant future timber supply. In the mid-twentieth century, no species covered more of the Bad River timber land than aspen or put on additional wood as quickly.[77] By focusing on aspen, forest management plans could harvest a high volume while preserving forest stands for future harvests. In response to a mill owner's inquiry to build a sawmill at Bad River, Secretary of the Interior Mastin G. White reflects this interpretation of Section 6 of the IRA: "Section 6 ... directs [compliance with] ... the principle of sustainable yield. It is our understanding that most of the land in question was logged and burned many years ago, and that the mature timber now on the land, which could be harvested under the principle of sustained yield management, is largely of the fast growing species such as poplar [aspen]."[78] Cognizant of the forest history at Bad River, as across much of the Great Lakes region, White realized that if officials aimed to harvest timber in the short-term, little else other than aspen could produce a sustainable yield.

In 1973, the Bureau of Indian Affairs adopted an agencywide policy change to promote aspen regeneration. The minimum allowable harvest height of aspen dropped from twenty-four feet to just eight feet.[79] This change required contractors to harvest much smaller aspen trees than they had in the past, thus leaving very few trees on site.

The repeated, large clear-cuts of the 1970s help to explain why little, if any of the young white pine that workers observed in the 1930s and 1940s matured. Although pines often establish in the aspen understory, pines and aspen cannot both thrive when aspen is clear-cut on thirty- to seventy-year rotations.[80] By deciding to harvest trees even as small as those containing a single, eight-foot merchantable log, managers removed or severely damaged most of the standing trees, including any white pine that had regenerated after the lumber era. With the loss of white pine trees came a loss of pine seed sources, which greatly impaired reproduction. Other than in a plantation, little pine was likely to reforest the reservation.

Forest management practices of the mid-twentieth century help to explain the 1930-1987 vegetative history at Bad River. Our 1930 land cover map (i.e., GIS layer) shows that aspen-birch stands reforested the vast majority of the reservation (83 percent of study area). In the absence of stand-clearing disturbances, forest succession theory predicts that these stands would probably have developed into more shade-tolerant forest types.[81] Yet many of the aspen-birch stands did not shift to a more shade tolerant type; on 34 percent of the reservation study area, sites supported aspen-birch between 1930 and 1987—for more than a half-century. The history of short-rotation, clear-cut practices (i.e., rotations) to promote aspen helps to explain why much of the landscape did not develop into a more mature successional stage, as theories of forest stand dynamics would otherwise suggest.

Land ownership changes of the mid-twentieth century reinforced the Indian Agency's growing emphasis on pulpwood management. The proportion of land held by forest companies dramatically increased, from 1 percent of the reservation study area in 1905 to 16 percent in 1960 to 27 percent in 1988.[82] During the primary forest harvest era (before 1922 at Bad River), logging companies did not need to own forestland to gain access to stumpage.[83] Companies could get mature timber by winning contract bids, which the Indian Agency advertised and awarded. Unlike stumpage on company-owned land, timber on Indian land did not saddle logging companies with the tax burden of cutover stumpland, a great financial advantage. By the 1940s, market conditions had changed, which promoted new thinking about land ownership. Timber companies no longer avoided land acquisition, rather they actively sought out timberland with long-term ownership in mind.

As a pulpwood market developed, land ownership became central to supporting this emergent forest industry: With the title in hand, companies could implement the clear cuts that would promote aspen and other pulp trees. Industrial owners positioned themselves to make the most of new pulpwood markets. At Bad River, industrial forest companies purchased reservation land. On many of these parcels,

managers implemented thirty-five- to fifty-year rotation cycles, thereby promoting pulpwood.[84]

Aspen was not merely a different species than pine; comparatively, it was an extremely low-value crop, and one that required frequent harvesting of abundant acreage to supply paper mills, which is essentially an agricultural model of production. Because the forest industry now depended on intensively managing a large land base, it adopted a new set of assumptions about land ownership.

By the 1980s, past conditions favorable to white pine reforestation had disappeared, largely due to the intervening three decades of pulpwood management. According to foresters' models of ecological succession, in the absence of disturbances, mid-shade tolerant species, such as white pine or hardwoods, should eventually become dominant on a site as the fast-growing, light-loving aspen die out. The increasingly frequent and large aspen regeneration clear-cuts of the decades between the 1950s and the 1980s interfered with this forest transition by removing available seed sources.

CONCLUSIONS

EVENTS OF MULTIPLE PERIODS in the twentieth century, not just the logging era, account for the decline of white pine at Bad River Reservation and across the Great Lakes region.[85] In the late nineteenth- and early twentieth centuries, heavy timber harvest and subsequent slash fires greatly reduced the proportion of white pine across the Great Lakes forests. Still, natural reforestation of white pine was possible in some areas. At Bad River the combination of the seed tree retention program, although sporadically implemented, and survival of primary forest pines on refugia sites provided strong potential for second-growth white pine to reforest some of its former extent.

By the 1930s, white pine reproduction was strong on many sites, especially where aspen functioned as a nurse crop. Good reproduction indicated that second-growth white pine had potential to reforest a significant amount of its former extent, promoting optimism that a marketable white pine timber crop would mature. Although many forest managers acknowledged that blister rust and weevil posed silvicultural problems, they believed that these threats could be controlled. Forest managers directed funds and labor resources to promote white pine, primarily through the blister rust control program. The dispersed, scattered white pine seedlings and complicated pattern of private land abutting tribal land made blister rust protection expensive, however. Rather than implement uniform practices across a large area, managers were obliged to coordinate with private landowners, thereby increasing administrative costs. Likewise, managers across the Great Lakes region confronted problems of controlling blister rust on private land: Of all ownership types, private land accounted for over half of the acreage where blister rust treatments were applied (51 percent) in Wisconsin, Minnesota, and Michigan.[86] As New Deal era funds dried up, administrators gradually withdrew support for the program.

The 1960s transformed forest management on the Bad River Reservation.

Managers of the 1930s and 1940s had promoted white pine reforestation as a component of diverse management goals, but by the 1960s they began to focus almost exclusively on pulpwood species. Growing interest in restoring white pine may help recover white pine—but only if foresters are able to maintain an active, on-going management program.[87]

To understand the ecological history of white pine, we need to consider the political, economic, and land tenure histories of the sites where this species once grew abundantly. At Bad River, political debates over the Indian Agency's objectives and the level of alignment with the Forest Service during the Gifford Pinchot-inspired conservation era influenced the practice of seed tree retention. These decisions affected the capacity for white pine populations to naturally regenerate. Forest managers also took political considerations into account when developing fire suppression policies; this decision probably discouraged white pine regeneration. Economics also played a role in Bad River's forest history. For example, cost-to-benefit trade-offs influenced the decision to discontinue the blister rust control program. Land tenure history also shaped forest changes. The checkerboard pattern of private and public land ownership stymied the coordinated, comprehensive approach required to check the blister rust fungus. Finally, the history of ownership by industrial land owners affected pine regeneration. Forest products companies increased their holdings on the reservation during the twentieth century from 1 percent in 1905 to 26 percent in 1988. Thus, pulpwood management practices were applied to a growing proportion of the reservation, which probably discouraged white pine regeneration.

Throughout the Lakes States region, forest managers promoted pulpwood species in the mid-twentieth century, as they had at Bad River. The combination of forest clearance and slash fires during the lumber era, sometimes followed by abandonment of failed farmsteads, created ideal conditions for aspen. Open, sunny sites, denuded of competing vegetation, encouraged the fast-growing species to become established across much of the region. Estimates of aspen-birch forest in northern Wisconsin prior to Euro-American settlement range from 315,000 acres to over 650,000 acres. By 1936, aspen-birch stands covered 5.2 million acres throughout Wisconsin, as well as 5 million acres in Michigan and over 6.5 million acres in Minnesota.[88] Aspen had boomed.

Toward the end of the lumber era, many forest resource companies had begun to integrate papermaking into their operations, when paper served as a good way to use otherwise worthless small trees cut during logging operations.[89] Although many foresters perceived aspen as an inferior forest species, called a "weed tree" by some, as the pulp industry took hold, many foresters pragmatically promoted the species. By the late 1940s, paper manufacturing was Wisconsin's third largest industry. The large extent of aspen-birch cover in the Great Lake states today attests to the history of industrial aspen management. Aspen-birch is the second most prevalent forest type in the Great Lake states (26 percent of timber land area).[90] In the absence of intentional practices to maintain aspen, this forest type would have shifted to other more shade tolerant species, especially in the mid- to late-twentieth century, when fires were usually suppressed.

Archival documents provided insight into an aspect of forest history that many studies of forest change have overlooked: the story of white pine regeneration. Forest inventories and surveys at Bad River frequently obscured the young pines that grew on the reservation in the twentieth century because of their focus on marketable resources in the forest canopy. Thus many inventories underrepresented the potential for future stands of pine to develop. This archival investigation enables us to tell a different forest history than we could tell if we relied on information about canopy composition alone.

While the ecological, cultural, and political conditions that drove forest change on the Bad River Reservation are specific to this one particular place, similar decisions took place across the Great Lakes region, with similar consequences. Throughout the region, the white pine was the first to be logged during the lumber era, and throughout the region, white pine no longer forms a dominant component of most forests.[91] While the intensive logging, removal of seed trees, and slash fires of the lumber era all affected the decline of white pine, decisions made throughout the mid-twentieth century were also influential.

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NOTES

We would like to thank two anonymous reviewers for their helpful comments and Mark Cioc for his editorial direction. Ted Sickley, Paul Weum, Sam Schultz, Cathy Yanger, David Templar, and the Forest Landscape Ecology Lab provided invaluable technical assistance. We appreciate the Chequamegon Bay Office of The Nature Conservancy, the Bad River Natural Resources Department, the Ashland Field Office of the Bureau of Indian Affairs, Ulf Gafvert, and Kevin Hopp for their encouragement and assistance to this research. We also appreciate the time that several oral history interviewees generously shared. Support for this research was provided by a USDA McIntire-Stennis research grant WIS04781/0198100, "The History of Adaptive Management in Wisconsin Forestry," and the National Science Foundation IGERT Grant 9870703, Human Dimensions of Social and Aquatic Systems Interactions at the University of Wisconsin-Madison.

1. For an overview of ecological and social change in the Great Lakes forests, see Susan Flader, *The Great Lakes Forest: An Environmental and Social History* (Minneapolis: University of Minnesota Press, 1983). See, also, Michael Williams, *Americans and Their Forests: A Historical Geography* (Cambridge: Cambridge University Press, 1989); and Gordon G. Whitney, *From Coastal Wilderness to Fruited Plain: A History of Environmental Change in Temperate North America from 1500 to the Present* (Cambridge: Cambridge University Press, 1994).
2. For a comprehensive review of white pine history and ecology, see Marc D. Abrams, "Eastern White Pine Versatility in the Presettlement Forest," *Bioscience* 51 (November 2001): 967-79. For a review of forest composition in relation to soil type and disturbance regime, see Forest W. Stearns, "History of the Great Lakes Forests: Natural and Human Impacts," in *Lake States Regional Forest Resources Assessment: Technical Papers*, ed. J. Michael Vasievich and Henry H. Webster, USDA Forest Service Gen. Tech. Report NC- 189 (Washington, DC: U.S. Government Printing Office: 1997), 8-29; Gordon G. Whitney, "Relation of Michigan's Presettlement Pine Forests to Substrate and Disturbance History," *Ecology* 67 (1986): 1548-59; and Gordon G. Whitney, "An Ecological History of the Great Lakes Forest of Michigan," *Journal of Ecology* 75 (1987): 667-84; Forest Stearns, "The Composition of the Sugar Maple-Hemlock-Yellow Birch Association in Northern Wisconsin," *Ecology* 32 (April 1951): 245-65.
3. Forest Stearns, "The Composition of a Remnant White Pine Forest in the Lake States," *Ecology* 31 (April 1950): 290-92; Stearns, "Sugar Maple-Hemlock-Yellow Birch Association," 245-65. Although fire and wind both introduce ecological disturbances, these two processes create different kinds of stands. Fire, which opens up a large area, promotes pine stands of a common age: an even-aged stand. Blowdowns, which create a small gap opening for sunlight, encourage pines to establish in scattered places amidst older, existing trees: an uneven-aged stand.
4. When characterizing the composition of the Great Lakes forests, one should bear in mind that the pre-Euro-American settlement forest communities were diverse and thus not easy to generalize. In northern Wisconsin and Michigan's upper peninsula, communities of hemlock and northern hardwoods, especially yellow birch, sugar maple, and basswood, were the predominant vegetative type. Studies of pre-Euro-American settlement composition typically employ the Public Land Survey notes as the baseline to their descriptions. See Stearns, "Remnant of White Pine Forest"; John T. Curtis, *The Vegetation of Wisconsin* (Madison: University of Wisconsin Press, 1959); David J. Mladenoff and John T. Pastor, "Sustainable Forest Ecosystems in the Northern Hardwood and Conifer Forest Region: Concepts and Management," in *Defining Sustainable Forestry* , ed. Gregroy H. Aplet et al., (Washington DC: Island Press, 1993), 145-80; Mark A. White and David J. Mladenoff, "Old-growth Forest Landscape Transitions from Pre-European Settlement to Present," *Landscape Ecology* 9 (1994): 191-205; and Lisa A. Schulte, David J. Mladenoff, and Erik V. Nordheim, "Quantitative Classification of a Historic Northern Wisconsin (U.S.A.) Landscape: Mapping Forests at Regional Scales," *Canadian Journal of Forest Research* 32 (2002): 1616-38. For discussions of the primacy of white pine in the midwestern lumber trade, see Robert F. Fries, *Empire in Pine: The Story of Lumbering in Wisconsin, 1830-1900* (1951; reprint, Madison: State Historical Society of Wisconsin,1989).
5. Whitney, *From Coastal Wilderness to Fruited Plain,* 182. Details of timber production history are available by species and at state, regional, and national scales for the years 1869 to 1944 in Henry B. Steer, *Lumber Production in the United States, 1799-1948*, USDA Forest Service Misc. Publication 669, (Washington, DC: U.S. Government Printing Office, October 1948). Our investigation of Steer's compilation of national lumber statistics attests to the economic importance of white pine in the Great Lakes region. We examined these records to estimate white pine as a proportion of total

Lake States timber production. According to these records, the importance of white pine peaked in 1879 for the Lakes States region, when it accounted for 82.5 percent of the total timber production. Between the mid-1870s and the mid-1890s, annual white pine lumber production in the Lake States surged from less than four billion board feet to over nine billion board feet. Williams, *Americans and Their Forests*, 222-23.

6. William J. Cronon, *Nature's Metropolis: Chicago and the Great We*st (New York: W.W. Norton, 1991), 151-58, 169-206. The physiological characteristics of white pine help to explain its structural properties. Mature white pine trees grow tall because they are able to emerge above the forest canopy into the supercanopy. Travelers of pre-Euro-American settlement forests reported white pine trees growing to heights of 250 feet or more with diameters of six to seven feet. For details, see Whitney, *From Coastal Wilderness to Fruited Plain*, 179. Another desirable trait of pine as a building material is its clear, knot-free wood, which develops because trees drop their lower branches as they grow.
7. Abrams, "Eastern White Pine Versatility"; Whitney, *From Coastal Wilderness to Fruited Plain*; Forest W. Stearns, "Ecological Characteristics of White Pine," in *White Pine Symposium Proceedings: History, Ecology, Policy, and Management*, ed. Robert A. Stine and Melvin J. Baughman (St. Paul: Department of Forest Resources, College of Natural Resources and Minnesota Extension Service, 1992), 10-18; Lee E. Frelich, "Old Forest in the Lake States Today and Before European Settlement," *Natural Areas Journal* 15 (1995): 157-67.
8. G. J. Nowaki, Mark D. Abrams and Craig G. Lorimer, "Composition, Structure, and Historical Development of Northern Red Oak Stands along an Edaphic Gradient in Northcentral Wisconsin," *Forest Science* 36 (1990): 276-92.
9. For discussions of the vegetative communities that reforested cutover sites in the Great Lakes region, see Filibert Roth, *On the Forestry Conditions of Northern Wisconsin*, Wisconsin Geological and Natural History Survey Bulletin number 1, (Madison: State of Wisconsin, 1898), 12-20; Curtis, *The Vegetation of Wisconsin*, 469-71; White and Mladenoff, "Old-growth Forest Landscape Transitions"; Susan Snetsinger and Steve J. Ventura, "Land Cover Change In The Great Lakes Region From Mid-Nineteenth Century To Present," U.S. Forest Service Great Lakes Assessment, http://www.ncrs.fs.fed.us/gla/reports/LandCoverChange.htm, 2000; Forest Stearns and Gene Likens, "One Hundred Years of Recovery of a Pine Forest in Northern Wisconsin," *American Midland Naturalist* 148 (2002): 2-19; John Kotar, Joseph A. Kovach, and Tim L. Burger, *A Guide to Forest Communities and Habitat Types of Northern Wisconsin* (Madison: University of Wisconsin-Madison Department of Forest Ecology and Management, 2002).
10. Lisa A. Schulte et al., "Homogenization of Northern U.S. Great Lakes Forests as a Result of Land Use," in press, *Landscape Ecology*; David T. Cleland, Larry A. Leefers, and Donald I. Dickman, "Ecology and Management of Aspen: A Lake States Perspective," in *Sustaining Aspen in Western Landscapes, Symposium Proceedings*, comp. W. B. Shepperd et al., USDA Forest Service, Rocky Mountain Research Station RMRS-P-18 (Washington, DC: U.S. Government Printing Office, 2001), 81-99.
11. In his comprehensive report to the Wisconsin legislature, Filibert Roth, special agent to the U.S. Department of Agriculture observed, "[a]ll [white pine] logging is extremely close" typically including anything that would "make a 2 x 4." Roth, *Forestry Conditions*, 18. Roth reported of the areas that had been repeatedly burned: "Here are large tracts of bare wastes, 'stump prairies,' where the ground is sparsely covered with weeds and grass, sweet fern, and a few scattering runty bushes of scrub oak, aspen, and white birch." Roth, *Forestry Conditions*, 13.
12. Research on the loss of white pine typically highlights the logging era. Cleland, Leefers, and Dickman note, in Michigan "extensive areas were converted from pine to aspen"

because of slash fires of the logging era; Cleland, Leefers, and Dickman, "Ecology and Management of Aspen," 81-99. Other related studies include T. J. Karamanski, *Deep Woods Frontier: A History of Logging in Northern Michigan* (Detroit, Michigan: Wayne State University Press, 1989); Q. Zhang, K. S. Pregitzer, and D. D. Reed, "Historical Changes in the Forests of the Luce District of the Upper Peninsula of Michigan," *American Midland Naturalist* 143 (2000): 94-110; Abrams, "Eastern White Pine Versatility"; Steven K. Friedman and Peter B. Reich, "Regional Legacies of Logging: Departures from Presettlement Forest Conditions in Northern Minnesota," *Ecological Applications* 15 (2005): 726-44; Michael J. Leahy and Kurt S. Pregitzer, "A Comparison of Presettlement and Present-day Forests in Northeastern Michigan, *American Midland Naturalist* 149 (2003): 71-89; and I. D. Thompson, J. H. Simard, and R. D. Titman, "Historical Changes in White Pine (*Pinus strobus* L.) Density in Algonquin Park, Ontario, During the 19th Century," *Natural Areas Journal* 26 (January 2006): 61-71. For details on the adverse effects of blister rust on white pine reforestation, see S. A. Katovich et al., "Restoration and Management of Eastern White Pine within High Blister Rust Hazard Zones in the Lake States," USDA Forest Service Proceedings RMRS-P-34 (Washington, DC: U.S. Government Printing Office, 2004). For details on the adverse effects of fire suppression, see Brian J. Palik and Kurt S. Pregitzer, "A Comparison of Presettlement and Present Day Forests on Two Bigtooth Aspen-dominated Landscapes in Northern Lower Michigan," *American Midland Naturalist* 127 (April 1992): 327-38; Abrams "Eastern White Pine Versatility"; and Thompson, Simard, and Titman, "Historical Changes in White Pine," 61-71. For details on the adverse effects of herbivore browsing, see William S. Alverson et al., "Forests Too Deer: Edge Effects in Northern Wisconsin," *Conservation Biology* 2 (December 1988): 348-58; and Chel E. Anderson et al., "Effects of Browsing Control on Establishment and Recruitment of Eastern White Pine (*Pinus Strobus* L.) at Cathedral Grove, Lake Superior Highlands, Minnesota, USA," *Natural Areas Journal* 22 (2002): 202-10.

13. We restricted our study area to a subportion of a single Land Type Association (LTA) to meet our research criteria for uniform soil and landform characteristics and thereby control for sources of ecological variation. Because of this research design specification, we limited the study area to 72 percent of the reservation and excluded an ecologically dissimilar part. Scientists consider an LTA to be an ecological unit because of its ecological uniformity. Details available at Wisconsin Department of Natural Resources (hereafter WDNR), *Wisconsin Land Type Associations (LTAs)* (Madison, Wisconsin: Department of Natural Resources, 1999).
14. Lee Clayton, *Pleistocene Geology of the Superior Region, Wisconsin*. Geological and Natural History Survey, Information Circular, No. 46, (Madison: University of Wisconsin-Extension, 1985); W. G. Batten and S. M. Hindall, *Sediment Deposition in the White River Reservoir, Northwestern Wisconsin*, U.S. Geological Survey Water Supply Paper 2069 (Washington, DC: U.S. Government Printing Office, 1980), 8-9.
15. A comparison of the landscape histories of the reservation and off-reservation subregions can be found in Michelle M. Steen-Adams, "Change on a Northern Wisconsin Landscape: Legacies of Human History" (PhD diss., University of Wisconsin-Madison, 2005).
16. For a discussion of the impact of the La Pointe Treaty on the Ojibwe, see Edmund Danziger, Jr., *The Chippewas of Lake Superior* (Norman and London: University of Oklahoma Press, 1979), 89- 90.
17. Kotar, Kovach, and Burger, *A Guide to Forest Communities*. For details on soil conditions in other parts of the cutover region, see A. R. Whitson, T. J. Dunnewald, and Carl Thompson, *The Soils of Northern Wisconsin*, University of Wisconsin Agricultural Experiment Station Bulletin 306 (Madison: April 1919). For details on relationships

between vegetative communities and microclimate, see Curtis, *The Vegetation of Wisconsin,* 40-41.

18. Ashland Land Use Planning Committee, *Ashland County Intensive Land Use Planning Report* (Ashland, Wisconsin, May 1, 1940), 8, Steenbock Library Government Documents, University of Wisconsin-Madison. Bayfield Land Use Planning Committee, *Bayfield County Intensive Land Use Planning Report* (Washburn, Wisconsin, July 1941), 10, Steenbock Library Government Documents, University of Wisconsin-Madison. On average, thirty inches of precipitation fall per year. Hill and Smith cite a 110-160 day growing season: See George W. Hill and Ronald A. Smith, "Man in the 'Cut-over': A Study of Family-farm Resources in Northern Wisconsin," Research Bulletin 139. Agricultural Experiment Station (Madison: University of Wisconsin, 1941), 7. Other sources, for instance, the Bayfield County Land Use Planning Committee, cite a minimum 90-day growing season.
19. Helen H. Tanner, *Atlas of Great Lakes Indian History* (Norman, Oklahoma, and London: University of Oklahoma Press, 1987), 146; Thomas E. Pearson, "The Wild Rice Harvest at Bad River," in *Wisconsin Land and Life,* ed. Robert C. Ostergren and Thomas R. Vale (Madison: University of Wisconsin Press, 1997); Madeline Mathews, "The History of the Ojibwe Indians in the Chequamegon Bay Region to 1763," (History Thesis, University of Wisconsin-Madison, 1920). Wisconsin Department of Natural Resources, Bibon Marsh-White River Project Proposal, 1971.
20. A GIS is an especially powerful tool for historians because it enables investigators to systematically examine questions that rely on complex geographic data, especially of geographic change. Examples of integrative environmental history-landscape ecology research using a GIS include Lynne Heasley, *A Thousand Pieces of Paradise: Landscape and Property in the Kickapoo Valley* (Madison: University of Wisconsin Press, 2005); Brian Donahue, *The Great Meadow: Farmers and the Land in Colonial Concord* (New Haven: Yale University Press, 2005); and Gregory Cunfer, "Causes of the Dust Bowl," in *Past Time, Past Place: GIS for History*, ed., Anne Kelly Knowles (Redlands, CA: ESRI Press, 2002), 93-104. Ecologists also have used a GIS to develop histories of landscape change, including White and Mladenoff, "Old-growth Forest Landscape Transitions,"; Matthias Burgi and Monica G. Turner, "Factors and Processes Shaping Land Cover and Land Cover Changes along the Wisconsin River," *Ecosystems* 5 (2002): 184-201. For a discussion of methods and theories of integrating GIS into historical research, see Anne Kelly Knowles, "Introducing Historical GIS," in *Past Time, Past Place*; ed. Knowles, xi-xx; Ian N. Gregory, *A Place in History: Using GIS in Historical Research* (Oxford, Oxbow Books, 2003); and Lynne Heasley, "Shifting Boundaries on a Wisconsin Landscape: Can GIS Help Historians Tell a Complicated Story?," *Human Ecology* 31 (2003): 83-211. Many other investigators have carried out integrative historical-ecological work without the use of a GIS. For example, see Joan Iverson Nassauer, ed. *Placing Nature: Culture and Landscape Ecology* (Washington, DC: Island Press, 1997); Emily W. B. Russell, *People and the Land through Time: Linking Ecology and History* (New Haven: Yale University Press, 1997); David R. Foster, G. Motzkin and B. Slater, "Land Use History as Long-term Broad-Scale Disturbance: Regional Forest Dynamics in Central New England," *Ecosystems* 1 (1998): 96-119; Nancy Langston, *Where Land and Water Meet: A Western Landscape Transformed* (Seattle: University of Washington Press, 2003); and David R. Foster and John Aber, *Forest In Time: Ecosystem Structure and Function as a Consequence of 1000 Years of Change* (New Haven: Yale University Press, 2004).
21. For further details on the methods employed in this study and companion research, see Steen-Adams, "Change on a Northern Wisconsin Landscape." Limitations of the PLS records include data ambiguity and potential sample bias; these records are not an unbiased sample of pre-European vegetation. Recent research in northern

Wisconsin, however, suggests that while surveyor variability may introduce some error, "variability within data sets representing larger areas are likely to be minimized": see K. L. Manies, D. J. Mladenoff, and E. V. Nordheim, "Surveyor Bias in Forest Data of the U. S. General Land Office Records for Northern Wisconsin," *Canadian Journal of Forest Research* 10 (2001): 1719-30. A much fuller discussion of potential bias is in Steen-Adams, "Change on a Northern Wisconsin Landscape." Several studies present guidelines to help users validly use the PLS data, including Hazel R. Delcourt and Paul A. Delcourt, "Presettlement Landscape Heterogeneity: Evaluating Grain of Resolution Using General Land Office Survey Data," *Landscape Ecology* 11 (1996): 363-81. Such research directed our methods, including scale of analysis. To make valid conclusions about landscape change, we applied the same scale of investigation to all datasets. Thus, all maps in our GIS represent land cover at the quarter-section scale. Using a classification scheme, we categorized land cover of all quarter-sections, then developed a land cover map for each of the three dates in this study. These maps enabled us to measure the proportion of various land covers in the Bad River Reservation and thus to quantify change in each vegetative class, including white pine.

22. Blister rust program documents have served as information sources for other historic studies of white pine. Some researchers consider blister rust records to be the foremost archival source on the twentieth-century history of this species, especially of management history, because of their accuracy and comprehensiveness. David B. King, Carl H. Stoltenberg, and R. J. Marty, *The Economics of White Pine Blister Rust Control in the Lake States*, USDA Forest Service Technical Report (Washington, DC: U.S. Government Printing Office, June 1960); Warren V. Benedict, *History of White Pine Blister Rust Control—A Personal Account,* USDA Forest Service Publication 355 (Washington, DC: U.S. Government Printing Office, March 1981).
23. Steen-Adams, "Change on a Northern Wisconsin Landscape."
24. Archival records show that some sites at Bad River supported dense stands of white pine. For example, a 1913 timber cruise estimated that an eighty-two-acre allotment contained thirty thousand feet of white pine which was "standing but dead about 3 or 4 years." Louis Schlecht. June 20, 1913. Scaler's Inventory of Section 7, SW, NE and SW, NW. T. 46, R.2. Estimates of Timber [for Bad River Agency], RG 75, National Archives and Records Administration—Great Lakes Region (Chicago) (hereafter NARA-GLR (Chicago)). Likewise, a 1925 study found that large volumes of pine grew on some Bad River parcels. The scale inspector, who made field measurements of stumps left over after logging operations, concluded that over 5.5 million board feet of white and red pine had been harvested from a single six hundred-acre section. The scaler calculated that the total harvest was "a total of 5,551,789 feet or an average of 346,987 feet to each forty which is a fair cut considering that four of the forties ... [are] mostly river bottom on which no white or red pine ever grew." Mark L. Burns, January 15, 1925. Report to Commissioner of Indian Affairs. File 339.5, Bad River Timber Sales Correspondence-General. Box 25, General Correspondence Files, Accession 65 A, 198, RG 75. NARA-GLR (Chicago).
25. For additional details on the landscape history of the Lake Superior clay plain, see Steen-Adams, "Change on a Northern Wisconsin Landscape."
26. Seventeen percent of the reservation study area comprised minor land cover classes or lacked available data for analysis.
27. Michael Williams describes the history of the white pine harvest, including its 1892 peak. Williams, *Americans and Their Forests*, 222. Godfrey presents annual data for harvest on the Wisconsin reservations. Anthony Godfrey, *A Forestry History of Ten Wisconsin Indian Reservations under the Great Lakes Agency: Precontact to Present* (Salt Lake City, UT: U.S. West Research, Inc., 1996). Although timber production rose to a high in 1907-1908, Danziger, *The Chippewas of Lake Superior,* 102, notes that the

pine harvest at Bad River skyrocketed to a yet higher volume (over 190 million board feet) in 1888, up from 31 million board feet in 1887-1888 (also, Godfrey, *A Forestry History of Ten Wisconsin Indian Reservations,* 33). The rapid, corrupt liquidation of tribal timber alarmed senators, leading to an 1888 Senate investigation (U.S. Congress. Senate. 1888. *Chippewa Allotment of Land and Timber Contracts.* 50th Cong., 2nd sess., S. Rep. 2710,) and a harvest moratorium at all reservations governed by the La Pointe Agency. In 1893, a new contracting system, known as the La Pointe Plan, allowed harvesting to recommence, this time under closer oversight and at a more measured pace.

28. Although federal officials directed that forest harvest should occur in a systematic way, in fact, Indian agents frequently flouted this directive in favor of local pressures and personal gain; for example, see the cases of agents James T. Gregory and of Samuel W. Campbell, discussed in Alan S. Newell, Richmond L. Clow, and Richard N. Ellis, *A Forest in Trust: Three-quarters of a Century of Indian Forestry* (Missoula, MT: Historical Research Associates, 1986), chap 1., 20-24; and in Patty Loew, "Newspapers and the Lake Superior Chippewa in the 'UnProgressive' Era," (PhD Diss., University of Wisconsin-Madison, 1998), 29-32. The goal to manage forests in a scientific manner emerged from the federal trust relationship with the tribes, which required the Indian Agency to manage forests responsibly for the benefit of present and future generations. Simultaneously, the treaty, which connoted the right of ownership, including the right to sell property, introduced a competing set of demands to Indian Agency officials. Many allottees ardently petitioned agents for permission to sell their timber in exchange for badly needed currency. Newell, Clow, and Ellis, *A Forest in Trust;* Danziger, *The Chippewas of Lake Superior.* For discussions of the devastating effects of the cutover across much of the American Midwest, see Williams, *Americans and Their Forests*, 233-37; and Whitney, *From Coastal Wilderness to Fruited* Plain, 156-64, 172-208; *Chippewa Allotment of Land and Timber Contracts,* S. Rep. 2710, i-vi, xiii-xxiii.
29. The Act of June 27, 1902, directed foresters to reserve timber on the tribal land that subsequently became the Chippewa National Forest (in Minnesota). The Act of May 23, 1908, increased the amount of "timber left standing for reforestation purposes" to 10 percent of total volume. W. M. Wooster, chairman, Chippewa Investigation Committee. Report to the Commissioner of Indian Affairs. November 14, 1922, 8; File 307.3 Part 1-A, Special Series A, Drawer 11. This report is located in Timber Report, Bad River Reservation, 1932, General Records, 1907-1939. E-126, PI 163, RG 75. National Archives and Records Administration Building, Washington, DC. For further description of contemporaneous understanding the Morris Act, see Jenks Cameron, *The Development of Governmental Forest Control in the United States* (Baltimore: The Johns Hopkins University Press, 1928), 228-32. The act required contractors to limit harvest to "no other timber except such as might be absolutely necessary in the economical conduct of logging operations ... [and] remove ... debris ... to minimize the fire hazard for the remaining and growing forest."; Raphael Zon, "Results of Cuttings on the Minnesota National Forest under the Morris Act of 1902," *Proceedings of the Society of American Foresters* 7 (1912): 100-105; Newell, Clow, and Ellis, *A Forest in Trust*, 2.1-2.11.
30. Newell, Clow, and Ellis, *A Forest in Trust*, 2.1-2.11.
31. J. C. Cavill, superintendent of Great Lakes Agency, to Walter V. Wolhlke, commissioner of Indian Affairs. December 17, 1943. Forest Management Plans. Field Office Records, Great Lakes Agency. Ashland, Wisconsin (hereafter FOR-GLA).
32. J. C. Cavill, superintendent of Great Lakes Agency, to Walter V. Wolhlke, commissioner of Indian Affairs. December 17, 1943, Forest Management Plans, FOR-GLA; R. W. Hayes to J. P. Kinney. October 7, 1915. Records of Forester, Correspondence, 1914-1917. Bureau of Indian Affairs Field Office Records, Red Cliff Agency, Bayfield, Wisconsin, Annual

Reports, Correspondence regarding accounts. RG 75. NARA-GLR (Chicago).

33. J. C. Cavill to Walter V. Wolhlke, December 17, 1943, Forest Management Plans, FOR-GLA. In addition, a 1907 letter reported this observation of a Bad River allotment: "some time ago the Forest Service marked forty-five white pine trees ... to be preserved for seed." C. F. Larrabee to S. W. Campbell, U.S. Indian Agent. December 21, 1907. "La Pointe" Box 98 (70842-08-339 to 3387-08-339), RG 75. National Archives and Records Administration Building, Washington, D.C. E. B. Meritt, assistant commissioner, to P. S. Everest, superintendent of Great Lakes Agency, January 22, 1917, NARA-GLR (Chicago).
34. In the last decade of the nineteenth century, expansive fires ignited repeatedly on the reservation. They broke out several times between 1890 and 1893, in 1896, and in 1900. Godfrey, *A Forestry History of Ten Wisconsin Indian Reservations.* Two major fires broke out during the decadelong interval when the seed tree retention policy was implemented (1908 and 1910). Indian Agency officials described the 1908 fire, which "swept over a considerable portion of the reservation damaging much timber," as especially severe. Consequently, loggers removed 163 million board feet of fire-damaged timber. J. C. Cavill to Walter V. Wolhlke, December 17, 1943. Forest Management Plans, FOR-GLA.
35. J. C. Cavill to Walter V. Wolhlke, December 17, 1943. Forest Management Plans, FOR-GLA. For a discussion of the susceptibility of white pine to fire, see Abrams, "Eastern White Pine Versatility."
36. Great Lakes Agency, Fire Control Plans, 1938 and 1942, FOR-GLA. The Marengo Burn of 1932, which encompassed about twenty-five square miles, greatly exceeded the size of the 1938-1942 fires, however; Great Lakes Agency, 1942.
37. Palik and Pregitzer, "A Comparison of Presettlement and Present Day"; Abrams, "Eastern White Pine Versatility," 977; Thompson, Simard, and Titman, "Historical Changes in White Pine," 61-71. See, also, the discussion of Stearns and Likens, "One Hundred Years of,": "Balsam fir ... sugar maple, and white spruce ... are now ... predominant in the understory ... In the absence of fire ... the pines would eventually give way to balsam fir, sugar maple, and white spruce."
38. Steen-Adams, "Change on a Northern Wisconsin Landscape."
39. Zon, "Results of Cuttings on the Minnesota National Forest," 100-105. Zon was the first director of the USDA Forest Service Lake States Forest Experiment Station (1923-1944). During the initial stage of his career, Zon was a protégé of Gifford Pinchot.
40. Zon, "Results of Cuttings on the Minnesota National Forest," 103.
41. William West Morris, 1934 (probable date), "Description of Timber on the Odanah Indian Reservation," File of Bad River Timber Cruise and Forestry Reports, FOR-GLA, 4. Morris reported that pine grew as an understory species on 48,000 acres of the 79,000 acres that supported aspen (about 50 percent of the 96,000 acres of timber species on the reservation at the time of the survey).
42. Theodore Young, scale inspector, to S. W. Campbell, U.S. Indian Agent, January 17, 1908, "La Pointe" Box 98 (0842-08-339 to 3387-08-339), RG 75, National Archives and Records Administration Building, Washington, DC. For details of pine resistance to fire, see Abrams, "Eastern White Pine Versatility," 977.
43. The difference in the density of pine seedlings at Bad River depended on soil type. Well-drained soils supported good reestablishment, whereas poorly drained soils often supported just one tree per acre. On average, just one white pine seedling (of the three- to six-inch diameter class) grew per acre, according to Morris' survey of eight plots. Morris, "Timber on the Odanah Indian Reservation."
44. King, Stoltenberg, and Marty, *Economics of White Pine Blister Rust Control.*
45. S. R. Gevorkiantz and R. Zon, *Second-growth White Pine in Wisconsin: Its Growth,*

Yield, and Commercial Possibilities, Wisconsin Agricultural Research Bulletin 98 (Madison: University of Wisconsin-Madison Agricultural Experiment Station, 1930), 6. See, also, E. L. Chambers and T. F. Kouba, *White Pine Blister Rust in Wisconsin*, Wisconsin Department of Agriculture Bulletin 222 (Madison, Wisconsin: June, 1941). Wisconsin forest scientists continued to investigate the feasibility of growing conifers, including white pine, into the 1960s. Systematic field studies led to them to cite the importance of management on forest growth: Highly productive soils "do not guarantee a rapid growth without meticulous management of plantations." S. A. Wilde et al., *Growth of Wisconsin Coniferous Plantations in Relation of Soils*, Wisconsin Agricultural Research Bulletin 262 (Madison: University of Wisconsin-Madison Agricultural Experiment Station, August 1965), 50.

46. Otis C. Maloy, "White Pine Blister Rust Control in North America: A Case Study," *Annual Review of Phytopathology* 35 (1997): 87-109.
47. Benedict, *History of White Pine Blister Rust Control*.
48. Charles S. Hodges, "Diseases of Eastern White Pine," in *Eastern White Pine Today and Tomorrow Symposium Proceedings*, ed. David T. Funk, USDA Forest Service General Technical Report WO-51 (Washington, DC: U.S. Government Printing Office, 1986), 93-98.
49. Maloy, "White Pine Blister Rust Control in North America," 88; Benedict, *History of White Pine Blister Rust Control*, 43. From 1909 to 1967 the USDA directed the Blister Rust Control (BRC) program, which strove to protect white pine from this fungal disease. The BRC program primarily strove to control blister rust by eradicating *Ribes*, either through mechanical or chemical means. Nevertheless, blister rust continued to cause substantial timber losses. In 1952, for example, over 650 million board feet were lost to blister rust infection. Alan C. Jones, "The Problem with White Pine," in *White Pine Symposium Proceedings,* ed. Stine and Baughman, 64-72. For review of foundational plant pathological research to the blister rust control program, see E. P. Van Arsdel, "Climatic Factors Affecting the Distribution of White Pine Blister Rust in Wisconsin," (PhD Diss., University of Wisconsin-Madison, 1954); E. P. Van Arsdel et al., *The Climatic Distribution of Blister Rust on White Pine in Wisconsin,* Lake States Experiment Station Paper Number 87 (Madison, Wisconsin: 1961); Richard C. Staples, "Research on the Rust Fungi During the Twentieth Century, *Annual Review of Phytopathology* 38 (2000): 49-69.
50. For details of the administrative structure for blister rust control work in Wisconsin, see T. F. Kouba, "Annual Report of Blister Rust Control in Wisconsin," 1948, Blister Rust Control Files (hereafter BRC Files), FOR-GLA, 5.
51. Statewide, whereas an average of eighty-three *Ribes* per acre grew on initial treatment sites, an average of just twenty-four bushes grew on follow-up treatment sites. Blister rust control workers made substantial progress, eradicating an average of 243 bushes per day. Annual Report of White Pine Blister Rust Control in Wisconsin, 1944, BRC Files, FOR-GLA.
52. Earl R. Nielson, "Blister Rust Control on the Bad River Indian Reservation of Wisconsin," 1935, BRC Files, FOR-GLA," 18.
53. "Annual Report of White Pine Blister Rust Control in Wisconsin," 1944, BRC Files, FOR-GLA.
54. Kouba, "Annual Report," 1948.
55. Benedict, *History of White Pine Blister Rust Control*, 18.
56. The 1935 Blister Rust Control survey map shows that a sizeable proportion of the Bad River white pine stands were scattered, although stands were "well-stocked" on some sites. Much of the second-growth white pine grew along ravine slopes or required traversing an undulating landscape, which increased labor demands. The abundance of *Ribes* also contributed to the cost of the program. The 1935 preeradication survey

found that this secondary host shrub grew in most of the white pine stands on the reservation. Nielson, "Blister Rust Control on the Bad River Indian Reservation of Wisconsin;" A 1934 survey of Bad River timber resources, conducted in association with the Wisconsin Land Economic Inventory, also known as the Bordner Survey, reported that three-quarters of the second-growth pine that grew under aspen stands were scattered (36,000 acres of 48,000 acres). Morris, "Timber on the Odanah Indian Reservation." *Ribes* density was especially high near lowland, marshy sites. One blister rust leader reported that "[t]he swampy areas with real tall grass are mostly *Ribes* free, but other swampy or marshy areas ... are heavily infested with *Ribes.* Many of these areas are with Pine Stands and require slow and thorough work to remove the *Ribes.* In order to get satisfactory results ..., a larger man power (sic) is necessary ..., since the crews must work in close formation, pulling thousands of bushes. ... For a small crew, the job is a long and difficult one." Paul D. Plowman, Spotter, Civilian Conservation Corps-Indian Division, "White Pine Blister Rust Control, Bad River Indian Reservation," October 21, 1938, BRC Files, FOR-GLA. Likewise, *Ribes* density was higher in the ravines and creek banks than in the uplands. At such thickly infested sites, men and women had to work in close formation, six to twelve feet apart. Gordon P. Mitchell, Indian Emergency Conservation Service spotter to J. C. Cavill, Great Lakes Indian Agency superintendent, October 31, 1939, BRC Files, Bad River Reservation. FOR-GLA.

57. Kouba, "Annual Report," 1948.
58. Work at one site, located eighteen miles from the Bad River settlement of Odanah, exemplifies cofidence that ample labor resources were available for this trade-off: "truck travel and walking to and from work consumed from two to three hours per day, thus cutting down the actual productive working day to five or six hours." Despite the inefficiency of reaching this remote site, the quality of the white pine resource merited the project. In this treatment area, "white pine [was] very good, averaging from 15-25 feet in height and at least 200 trees per acre ... [with as much as] 500 trees per acre [in some areas]." Gordon P. Mitchell to J. C. Cavill, superintendent of Great Lakes Indian Agency, Blister Rust Control Report, October 31, 1939, FOR-GLA.
59. Benedict, *History of White Pine Blister Rust Control*; Theodore F. Kouba, "Blister Rust Control [on the] Bad River Reservation," 1943, 1. Kouba's sub-report is located within E. W. Cleasby, Assistant Pathologist, Bureau of Pathology and Plant Quarantine, "Annual Report of Blister Rust Control on the Bad River Indian Reservation," BRC Files, FOR-GLA.
60. Nielson, "Blister Rust Control on the Bad River Indian Reservation of Wisconsin;" Warren L. Smith, BRC supervisor, and E. J. Riley, Great Lakes Consolidated Agency chief clerk, "Annual Report of White Pine Blister Rust Control on the Bad River ... Indian Reservations," 1951, BRC Files, FOR-GLA.
61. Definition of a "control area" in Chambers and Kouba, *White Pine Blister Rust in Wisconsin*, 9. Many stands were well stocked, averaging two hundred to five hundred trees per acre, with an average height of twenty to twenty-five feet. Gordon P. Mitchell, Indian Emergency Conservation Service spotter, to J. C. Cavill, Great Lakes Indian Agency superintendent, October 11, 1937, BRC Files, Bad River Reservation. FOR-GLA. See, also, Gordon P. Mitchell to J. C. Cavill, Superintendent of Great Lakes Indian Agency, Blister Rust Control Report, October 31, 1939, BRC Files, FOR-GLA; see Kouba, "Blister Rust Control."
62. E. J. Riley to Don C. Foster, Bureau of Indian Affairs, Minneapolis, Minnesota, Annual Forestry Report, January 24, 1952, Forest Management Plans File, Great Lakes Agency Field Office, Ashland, Wisconsin.
63. Warren L. Smith and E. J. Riley, "Annual Report of White Pine Blister Rust Control on the Bad River ... Indian Reservations," 1951, BRC Files, FOR-GLA; Marshall J. Hall, BRC

Supervisor, and E. J. Riley, "Annual Report of White Pine Blister Rust Control on the Bad River ... Indian Reservations," 1952, BRC Files, FOR-GLA; "Annual Report," 1952; Andrew W. Depta, BRC Program, U.S. Forest Service, "Annual Report of White Pine Blister Rust Control on the Lac Courte Oreilles, Lac Du Flambeau, and Bad River Indian Reservations in Wisconsin," 1961, BRC Files, FOR-GLA; USDA Forest Service, "Annual Report [for] Blister Rust Control [in the] North Central Region," Reports for Calendar Years 1963 and 1964, BRC Files, FOR-GLA.

64. Andrew W. Depta and George F. Lehrer, Wisconsin Department of Agriculture. Annual Report of White Pine Blister Rust Control on the Lac Courte Oreilles, Bad River, and Lac Du Flambeau Indian Reservations, 1964, BRC Files, FOR-GLA. In 1965, Wisconsin Department of Agriculture area supervisors Andrew W. Depta and George F. Lehrer reported that just 3,101 acres of white pine and a control area of 4,678 acres existed at Bad River. This constitutes a 63.7 percent decrease in white pine (8,547 acres versus 3,101 acres) and 68.9 percent decreased control area (15,023 acres versus 4,678 acres). Andrew W. Depta and George F. Lehrer, area supervisors, Wisconsin Department of Agriculture. Annual Report of White Pine Blister Rust Control on the Lac Courte Oreilles, Bad River, and Lac Du Flambeau Indian Reservations, 1965, BRC Files, FOR-GLA. For details of the discontinuation of blister rust control at Bad River see, Andrew W. Depta and George F. Lehrer, area supervisors, Wisconsin Department of Agriculture. Annual Report of White Pine Blister Rust Control on the Lac Courte Oreilles, Bad River, and Lac Du Flambeau Indian Reservations [for the years] 1968 and 1969, BRC Files, FOR-GLA.
65. Depta and Lehrer, Annual Report, 1965.
66. Smith and Riley, Annual Report, 1951; Depta and Lehrer, Annual Report, 1964; Depta and Lehrer, Annual Report, 1965.
67. Depta and Lehrer, Annual Report, 1965.
68. Depta and Lehrer, Annual Report, 1964.
69. E. P. Van Arsdel, A. J. Riker, and R. F. Patton, demonstrated that climate influenced the likelihood of blister rust infestation: see "The Effects of Temperature and Moisture on the Spread of White Pine Blister Rust," *Phytopathology* 46 (1956): 307-18. Blister rust fungus is more likely to survive on sites that remain wet (100 percent humidity) and cold (less than 68 degrees Fahrenheit) over a two-day period. Van Arsdel's map of blister rust risk categorizes the Great Lakes states in moderate to high-risk zones (Regions 3 and 4).
70. In northern Wisconsin pole stands, blister rust incidence varies from 0 percent to 28 percent; S. E. Dahir and J. E. Cummings-Carlson, "Incidence of White Pine Blister Rust in a High-hazard Region of Wisconsin," *Northern Journal of Applied Forestry* 18 (2001): 81-86; Mark A. White, Terry N. Brown, and George E. Host, "Landscape Analysis of Risk Factors for White Pine Blister Rust in the Mixed Forest Province of Minnesota, USA," *Canadian Journal of Forest Research* 32 (2002): 1639-50. Katovich et al., "Restoration and Management of Eastern White Pine."
71. Forest scientist Raphael Zon discussed management practices consistent with the Morris Act's goal to promote second-growth pine. Zon, "Results of Cuttings on the Minnesota National Forest." For a review of the history of aspen in the Great Lakes region, including the effects of management to promote aspen on other species, see Cleland, Leefers, and Dickman, "Ecology and Management of Aspen."
72. Morris, "Timber on the Odanah Indian Reservation." Morris observed that aspen growing on the reservation was "of much greater value than popple [aspen] found on sandy lands [in Wisconsin] being much taller, cleaner and straighter with much less defect."
73. The 1944 Bad River Reservation forest plan forecasted, "after 1955, it is quite certain that the annual increment will increase considerably as second-growth pine and young

aspen stands become more mature."

74. Morris, "Timber on the Odanah Indian Reservation."
75. Curtis, *The Vegetation of Wisconsin.* This succession model holds especially true on nutrient poor-mesic sites, such as the Lake Superior clay plain, where hardwoods and balsam fir are less likely to establish. See, also, John Kotar, "Managing White Pine: Finding the Proper Niche," in *White Pine Symposium Proceedings,* ed. Stine and Baughman, 150-56; Kotar, Kovach, and Burger, *A Guide to Forest Communities;* Lee E. Frelich, "The Relationship of Natural Disturbances to White Pine Stand Development," in *White Pine Symposium Proceedings,* ed. Stine and Baughman, 27-37; Abrams, "Eastern White Pine Versatility"; and Stearns, "Ecological Characteristics of White Pine."
76. The 1951 Forestry Annual Report noted, "We shall try to sell as large a proportion of aspen as possible." Based on new inventory data, the 1967 forest management plan called for aspen to comprise 89 percent of the annual allowable cut, aspen accounted for 62 percent of the timber land. In the 1960s, the Indian Agency attempted to push the subdominant hardwoods and pines into the canopy through an overstory harvest. For example, the 1967 Timber Operating Plan aimed for a conversion to hardwoods and pines through removal of the aspen overstory. Godfrey, *A Forestry History of Ten Wisconsin Indian Reservations*, 229. A review of a detailed forest history of the Bad River Reservation indicates that this objective never again appeared in management plans after 1967, suggesting a lack of management interest in promoting stands other than those comprising pulpwood species.
77. Godfrey, *A Forestry History of Ten Wisconsin Indian Reservation,* 162-71, 228.
78. Mastin G. White, secretary of the Interior, to Senator Herbert H. Lehman, November 9, 1951, Entry 749B, Central Classified Files, 1937-1953, GR 48, National Archives at College Park, MD.
79. Godfrey, *A Forestry History of Ten Wisconsin Indian Reservations*; Bad River Natural Resources Department, *Integrated Resources Management Plan* (Odanah, Wisconsin: 2001).
80. D. A. Perala, *Manager's Handbook for Aspen in the North Central States*, UDSA Forest Service General Technical Report NC-36 (Washington, DC: U.S. Government Printing Office, 1977); Cleland, Leefers, and Dickman, "Ecology and Management of Aspen."
81. An alternative hypothesis for the decrease of white pine in the understory is competitive exclusion: More shade tolerant species such as balsam fir or spruce that were present in the understory may have excluded pine over time. The Wisconsin Land Economic Inventory survey data, however, reported little spruce and fir present at Bad River in the 1930s. While factors other than pine and aspen management may have contributed to the loss of white pine, the absence of spruce and fir in the Wisconsin Land Economic Inventory data suggests that competitive exclusion was unlikely to have been the dominant factor.
82. In a companion study, we found that industrial ownership increased from 6 acres (1 percent of the reservation study area) to 15,340 acres (16 percent of the reservation study area) between 1905 and 1960; in 1988, forest products company ownership climbed to 26,469 acres (27 percent of reservation), mostly comprising paper company holdings. Steen-Adams, "Change on a Northern Wisconsin Landscape."
83. The Stearns Lumber Company held the primary logging contract at Bad River (logging occurred between 1886 and 1922). Godfrey, *A Forestry History of Ten Wisconsin Indian Reservations.* The Bell Lumber Company of Minneapolis, Minnesota, also held a timber contract, primarily to harvest cedar. "Cedar and Other Timber Cut During the Following Fiscal Years," No Date (internal evidence suggests ca. 1924), Sales of Logs: Bad River, RG 75, NARA-GLR (Chicago).
84. John J. Moran, interview with Michelle M. Steen-Adams, February 2, 2004, Ashland,

Wisconsin; Joe Timmerman, interview with Michelle M. Steen-Adams, February 19, 2004, Hayward, Wisconsin; Ralph Swanson, interview with Michelle M. Steen-Adams, June 11, 2004, Winchester, Wisconsin (tape recordings and notes of all interviews in possession of author).

85. Many ecological studies have examined why pines have declined, including Curtis, *The Vegetation of Wisconsin*, 469; Whitney, "An Ecological History of the Great Lakes Forest of Michigan;" and Abrams, "Eastern White Pine Versatility." For a related contemporaneous discussion on the effects of the cutover on the predicted future for white pine stands, see Roth, *Forestry Conditions,* 12-20. In his 1987 presentation at the Great Lakes Governors' Conference on Forestry, Forest Stearns noted the importance of post-cutover management practices on aspen, which in turn displace pines: "The extensive stands of aspen and aspen/ white birch, stimulated by the fires that followed early logging, are being perpetuated by clear-cutting." Forest W. Stearns, "The Changing Forests of the Lake States," in *The Lake States Forests: A Resources Renaissance, T*he Conservation Foundation and The Lake States Forestry Alliance*,* ed. W. E. Shands (St. Paul, MN: The Lake States Forestry Alliance, 1987), 28.
86. Of the total 1,345,745 acres in Minnesota, Michigan, and Wisconsin where blister rust control work was carried out, 691,567 acres were private land. Benedict, *History of White Pine Blister Rust Control,* 17.
87. The Wisconsin Department of Natural Resources reports an increase in the extent of white pine in Wisconsin. WDNR, *Wisconsin Forests at the Millennium: An Assessment* (Madison, Wisconsin: 2000). For a discussion of advancements in our knowledge of the microsite factors that control white pine blister rust, see Dahir and Cummings-Carlson, "Incidence of White Pine Blister Rust," 81-86; and White, Brown, and Host, "Landscape Analysis of Risk Factors for White Pine Blister Rust," 1639-50.
88. For details of estimates of presettlement and post-cutover (ca. 1935) aspen-birch forest, see Jeanine M. Rhemtulla, David J. Mladenoff, and Murray K. Clayton, "Regional Land-cover Conversion in the U.S. Upper Midwest: Magnitude of Change and Limited Recovery (1850-1935-1993)," in press, *Landscape Ecology;* WDNR, *Wisconsin Forests at the Millennium;* WDNR, *Northern Forest Communities, Ecological Landscapes of Wisconsin-Ecosystem Management Planning Handbook*, 2004, HB1805.1; Lisa A. Schulte, David J. Mladenoff, and Erik V. Nordheim, "Quantitative Classification of a Historic Northern Wisconsin (USA) Landscape: Mapping Regional Forest Types and Their Spatial Uncertainty," *Canadian Journal of Forest Research 32* (September 2002): 1616-38*;* Cleland, Leefers, and Dickman, "Ecology and Management of Aspen." The Public Land Survey (PLS) notes also attest to the infrequent and ephemeral presence of aspen prior to Euro-American settlement; aspen frequently represented less than 5 percent of PLS witness trees. Whitney, *From Coastal Wilderness to Fruited Plain*, 202, 204.
89. Paper mills had been built as early as the 1860s, when six existed in Minnesota. In Wisconsin, a mill was built in the Fox River Valley in 1872 and at Wisconsin Rapids in 1887. Stearns, "History of the Great Lakes Forests." For details on the importance of the pulp industry in Wisconsin, see "Paper Industry in Wisconsin," *Dictionary of Wisconsin History*, Wisconsin State Historical Society web page. http://www.wisconsinhistory.org/dictionary. Page accessed July 21, 2006.
90. Cleland, Leefers, and Dickman, "Ecology and Management of Aspen."
91. WDNR, *Wisconsin Forests at the Millennium.*