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Changes in the Land: Indians, Colonists, and the Ecology of New England

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TAKING THE FOREST

The furbearers of colonial New England had been destroyed in two ways: by having a price placed on their heads and by losing their ecological habitats to new human uses of the land. As we have seen, the edge habitats once maintained by Indian fires tended to return to forest as Indian populations declined. But edge environments were also modified or reduced—and on a much larger scale—by clearing, an activity to which English settlers, with their fixed property boundaries, devoted far more concentrated attention than had the Indians. Whether edges became forests or fields, the eventual consequences were the same: to reduce—or sometimes, as with European livestock, to replace—the animal populations that had once inhabited them. The disappearance of deer, turkey, and other animals thus betokened not merely a new hunting economy but a new forest ecology as well.

Colonists cut down trees for many reasons. Some of these—like clearing fields for agriculture—were a necessary adjunct of a European rural economy, and often bore only an indirect relationship to production for market. Others, such as lumbering, were much more immediately involved with mercantile activity and trade. Like furs, timber products were among the earliest "merchantable commodities" colonists sent back to Europe to repay their debts to financial backers. In 1621, when the Pilgrims made their first shipment home in the 55-ton vessel *Fortune,* they sent only two barrels of furs; the rest of the ship's hold was, as Bradford reported, "laden with good clapboard as full as she could stow." Even more than furs, whose acquisition required an exchange of trade goods with their Indian hunters, timber was free for the taking. One

had theoretically to own the land on which it stood, but this was an easy rule to evade. Much of the value inhering in timber appeared to be a gift of nature, requiring only a modest investment of labor and capital to be turned into profit. To "improve" timber, and so acquire sure property rights to it, one had merely to cut it down, saw or split it into manageable sizes, and—the most costly single step—ship it to market. In some areas, this was done in conjunction with clearing for agricultural settlement; in others, the cutting of timber was a chief economic activity in its own right.[1]

Colonists sought different species of trees for different purposes, and so, when lumbering as opposed to clearing, cut forests selectively. White oak was the chief wood used for the timbers and planking of ships, and proved to be ideal for barrel staves as well. Black oak, which was less suitable than white for most maritime uses, was appropriate for the underwater portions of a ship's timbers because of its resistance to boring by tropical worms. Cedars and chestnuts were also relatively immune to rot and well suited to use in exposed outdoor sites. Pitch pine furnished a wide range of naval stores, including pitch, turpentine, and rosin. Most dramatic of all, the white pine, towering above all other trees in New England forests, was a perfect source of ship's masts. The wide range of uses these trees served in a maritime trade economy meant that the demand for each varied, and that each to some extent was traded in a different market. It also meant that the habitats in which they grew were subject to different stresses by colonial lumbering activities.[2]

From the 1630s onward, the largest concentration of commercial lumbering for export was located in Maine and New Hampshire along the major rivers north of the Merrimac. There, on the sites of old forest fires, stood tracts of white pine containing trees as much as four to six feet in diameter, and 120 to 200 feet in height. Trees of such size and straightness were unknown in Europe; no European trees were large enough to serve for masts without several being spliced together. Up until the development of lumbering in America, England had been forced to rely for its ships on the pieced-together masts of Scotch fir

which it received in trade from Baltic forests. With the closing of Baltic trade during the Dutch war of 1654, the Royal Navy commissioners began to look to the white pines of New England for an alternate mast supply. The first sawmills in Maine had been established in the early 1630s, but it was not until after mid-century that the northern lumbering industry came into its own. By 1682, there were twenty-four sawmills operating at the sites of present-day Kittery, Wells, and Portland, shipping principally softwood lumber which, unlike hardwood, would float on the navigable streams flowing down to the coast. The mouth of the Piscataqua rapidly became the chief lumber port of the northern colonies: as Samuel Maverick remarked in 1660, "Most of the Masts which have come for England" had been gotten on that river. Some of these were transported in special mast ships of a length and tonnage suited to carrying two or three dozen whole pine trees for use by the Royal Navy as masts. New England forests thus became a key resource for maintaining English naval power.[3]

England's experiences with timber and fuel shortages, as well as its involvement in European wars that threatened to cut off its foreign supply of shipbuilding materials, led its rulers to adopt what seemed to many colonists an overly cautious attitude toward conserving New England's forests. When Massachusetts received its new charter in 1691, a clause was inserted that reserved for the Royal Navy "all [mast] trees of the diameter of twenty-four inches and upwards at twelve inches from the ground." A fine of £100 per tree was to be assessed against any person "Felling Cutting or Destroying" without royal license any such trees not already in private hands. The terms of the charter were eventually supplemented by additional restrictions. In 1704, royal surveyors were charged with marking all potential mast trees with a blaze shaped like a broad arrow to ensure the Crown's right to them. At the same time, pitch pines were protected to maintain the Navy's supply of pitch and turpentine. These regulations were repeatedly renewed until the American Revolution; if enforced, they might conceivably have slowed the cutting of

New England forests. Enforcement proved virtually impossible, however, and so the "broad-arrow laws" came to stand more than anything else for European anxieties about deforestation. The colonists violated the laws constantly.[4]

New England lumbering used forests as if they would last forever. Because prime mast trees were usually scattered among those of lesser value, many less-than-perfect trees were simply destroyed when larger ones were felled. Colonists were usually far more interested in conserving their own labor than in using available timber resources to the full. A favorite labor-saving device was the technique known as "driving a piece," in which lumberers cut notches in a row of small trees and then felled a larger tree on top of them, thus cushioning its fall so as to protect it from shattering. The method was ideal if an area was to be used for farming once lumber trees were removed, since it brought down many more trees with much less work. Any trees without market value could simply be burned where they fell. Waste was compounded by high colonial standards of what was and was not marketable lumber. Even purposes for which Europeans made do with low-quality wood were accomplished by New Englanders with the finest available lumber. A memoir written in the Androscoggin River country in 1800 recalled how

> The richest and straightest trees were reserved for the frames of the new houses; shingles were rived from the clearest pine; baskets, chair bottoms, cattle bows, etc., were made from brown ash butts; all the rest of the timber cleared was piled and burned on the spot.… All the pine went first. Nothing else was fit for building purposes in those days. Tables were made 2½ feet wide from a single board, without knot or blemish.

This was a pattern that would characterize American lumbering until the late nineteenth century.[5]

Not only the white pine suffered from these practices. Although New England white oak was shunned by English shipbuilders as "tender" and too easily prone to decay, colonial carpenters were not so fastidious. They used it heavily. Moreover, sugar plantations in the West Indies and wineries in the Madeiras needed barrels in which to ship their commodities to European

markets. Their voracious consumption of wood in burning fuel and clearing land left many of the Atlantic and Caribbean islands completely deforested, so that by the late seventeenth century they were dependent on New England for staves and hoops made of red as well as white oak. In New England, colonial tanners used increasing quantities of oak bark as their operations grew, and oak lumber was also favored for building construction. Because of their lightness and resistance to decay, white and red cedar were considered ideal woods for the manufacture of shingles, clapboards, and fence posts. Colonial architecture came to rely on thin-walled structures supporting relatively lightweight roofs, and so cities like Boston developed significant markets in cedar shingles. Even some Indians were drawn into the trade. Daniel Gookin told of one Indian village whose inhabitants earned "many a pound, by cutting and preparing cedar shingles and clapboards, which sell well at Boston and other English towns adjacent."[6]

Such uses of wood placed prices on certain New England trees just as the fur trade had placed prices on New England mammals: the forest itself came to have a value at market. Neither white pine nor white cedar—extensive stands of the one being limited to dry ridge tops and old burn sites, and of the other to stream-banks and wet swamps—had ever been abundant in New England. Timothy Dwight gave an indication of their relative numbers when he said that if the white pines south of Maine "were all collected into one spot," they "would scarcely cover the county of Hampshire" in England; the white cedars, still rarer, "would scarcely fill three townships." Neither tended to regrow when cut—pine was generally replaced by hardwoods, and cedar by red maple—so that the populations of both were easily reduced by lumbering activities.[7]

Speaking of the white pines he had once seen near Lebanon, New Hampshire, Dwight wrote that "a great part of them have since been cut down." To show that this was not merely a local effect, he added, "There is reason to fear that this noblest of all vegetable productions will be unknown in

its proper size and splendor to the future inhabitants of New England." His prophecy soon came true, but full removal of the original northern pines did not come until the lumbering boom of the nineteenth century. In coastal regions and in southern New England, they disappeared from many areas much earlier. When the West Indian merchant James Birket visited the Piscataqua country in 1750, he found its inhabitants complaining that their lumber was "far to fetch out of the Country and Stand[s] them very dear"—this in the region which a century before had been the center of northern lumbering. All along the main coastal road, Birket noted, the land was "generally Cleared." Even at Dover, miles upstream, he learned that lumber was "very dear to them the Cartage out of the woods to the mills being now a long way." Lumbering continued, but moved relentlessly upstream, extending the local areas from which trees had been removed. When Dwight visited the region half a century later, he reported that "the forests are not only cut down, but there appears little reason to hope that they will ever grow again." Although the soil seemed productive where crops were planted, he said, "From the extensive nakedness which meets the eye, it is difficult for the imagination not to pronounce it barren."[8]

Although colonial writers tended to notice the disappearance of pine first, probably because of its high value and visibility, other species also suffered from wasteful cutting. One of these was cedar. What the Swedish naturalist Peter Kalm wrote of the New York region in the middle of the eighteenth century was equally true of New England: "Many swamps are already quite destitute of cedars, having only young shoots left." Heavy use was "not only lessening the number of these trees, but … even extirpating them entirely." As in the case of beaver, what remained behind were place-names that no longer made much sense. The historian Peter Whitney mentioned a stream in Worcester, Massachusetts, which "was formerly called Cedar Brook," although cedars no longer existed in the town through which it flowed; a similar fate awaited many of New England's various Cedar Swamps. White oaks, which did not share the reproductive problems of pines and cedars, were

in no danger of disappearing from New England forests. But their usefulness in all facets of construction meant that larger trees, which furnished the best lumber, were becoming relatively more scarce in many areas by the end of the colonial period. Hickories, which colonists preferred for fuel, also became less abundant. Colonial cutting reduced not only the numbers but the sizes of these trees. Dwight reported that many Europeans who visited New England in the late eighteenth century were surprised at the small girth of its trees, a fact which many of them attributed to "sterility of soil." In fact, Dwight said, "the real cause was the age of the trees, almost all of which are young." Older trees were gone, and most of those remaining were of second growth.[9]

As early as the 1790s, proposals began to be aired suggesting that forest preserves be created to protect their timber. The Revolutionary War general Benjamin Lincoln even suggested that programs be instituted to promote the planting of acorns. This was necessary, he said, because

> our timber trees are greatly reduced, and quite gone in many parts. In towns near and bordering on the sea shore, little can now be found within the distance of twenty miles; and it is not uncommon for the builder to send at this day from thirty to forty miles for timber and planks, and the stock fast decreasing, not only from the demand of timber and planks, but from scarcity of other fuel.

In a time when all heavy goods had to move either by boat on navigable streams or by horsecart on bad dirt roads, the economic cost of transporting lumber thirty or forty miles was not trivial. That it could be gotten at all, however, demonstrates the local extent of the deforestation produced by colonial lumbering.[10]

Perhaps surprisingly, the lumberer was not the chief agent in destroying New England's forests; the farmer was. The earliest settlements had tended to be established on land that was already cleared, whether by Indians, by the departed beavers, or by annual river floods. (Flooded lands, among the richest sites for agriculture, were the *intervals* so favored by colonial farmers.) The first mowing grounds were salt marshes and sedge meadows, likewise cleared of trees. Nevertheless, it was not long before settlement pressed out into the

forest itself, and here farmers encountered the problem of removing trees—not just selected species, but all of them.

As with lumbering, some habitats were more subject to such clearing than others. Colonial farmers quickly learned that certain tree species were associated with certain kinds of soil, some of which were better than others for agricultural crops. As Jedidiah Morse explained in his *American Geography,*

> Each tract of different soil is distinguished by its peculiar vegetation, and is pronounced good, middling, or bad, from the species of trees which it produces; and one species generally predominating in each soil, has originated the descriptive names of oak land—birch, beach, and chesnut lands—pine barren—maple, ash, and cedar swamps, as each species happen to predominate.

Trees that required and maintained moist forest conditions, such as hickories, maples, ashes, and beeches, generally produced a rich black humus beneath their fallen leaves, and settlers interpreted them as indicators of prime agricultural land. Oaks and chestnuts, with their denser undergrowth and more frequent groundfires, had thinner soils which required more work before they would produce favorable European crops. Still less desirable were the acidic and often sandy soils beneath various conifers—moist under hemlocks and spruces, dry under pitch and white pines—and colonial farmers avoided these wherever they could. Worst of all were areas where thorny bushes had taken over abandoned Indian fields, or where dense tangles of scrub vegetation covered lowland swamps. Farming in these places was rarely worth the bother.[11]

Colonial observers like Morse were at least partially misled when they attributed the tree species of a district to its preexisting soils: forests caused soils as much as soils caused forests. The relative fertilities of various lands in part resulted from inherent physical properties of the soil, but also from processes maintained over long periods of time by the forest itself. Trees affected soil through a multitude of mechanisms: the spread of their root systems, the amount of light they allowed to reach the forest floor, the quantity

of water which they lost by evaporation from their leaves, their susceptibility to fire, the chemistry and quantity of their annual leaf fall, and so on. The net effect of these mechanisms was to make the forest an astonishingly efficient system for capturing, concentrating, and retaining nutrients from rainwater and other sources. Most soil in a forest was there because the forest kept it there. This being the case, soils changed when their parent forests were removed. As Dwight noted, newly cleared lands were "uniformly valued beyond their real worth" because their soils were blessed with a temporary gift of fertility from a forest which was no more. It was just this fact that had led Indians to practice a shifting agriculture, and as the next chapter will show, it was one that had important consequences for colonial farmers as well.[12]

At least two different methods were used in colonial times to clear forests for agriculture. Which was chosen depended on the nature of the forest, the amount of labor available, the wealth of the farmer, and the local market demand for wood. Once trees had been cut for such immediate needs as fencing and house building, early settlers tended to use the simplest and least labor-intensive technique for destroying the rest: *girdling*. Bark was stripped in an encircling band from each of the larger trees, and grain, generally maize, was planted Indian-style in mounds beneath them. Removing their bark prevented trees from leafing and eventually killed them, thus allowing enough light to reach the ground for crops to grow. Undergrowth was burned in early spring to suppress the original vegetation, and trees were removed as they eventually rotted. At the end of several years, a cleared field was the final result.[13]

Girdling had advantages and disadvantages. It wasted large amounts of wood, but by allowing trees to stand for several years before they were removed, it returned at least some of their nutrients to the soil. Letting trees rot thus helped make soil nutrients available for a relatively extended period of time. When the dead trees finally fell, however, they tore up large amounts of soil with their roots, creating pits in fields and sometimes leaving the pitted

areas soilless. Worse still, rotting trees had a disconcerting tendency to drop branches and fall over at unpredictable times, often damaging crops and fences and occasionally killing livestock and people. The job of clearing was left unfinished for a number of years, since the living roots had to be grubbed out before European-style plowing was possible. At a minimum, rotting trees eventually became a serious nuisance and were regarded by European travelers as having what Dwight called "an uncouth and disgusting" appearance. Girdling thus had the virtues of saving labor and conserving soil nutrients, but these were purchased by wasting wood, running risks of accident, and devoting long years to the incomplete removal of trees and roots.[14]

For all these reasons, an alternative method of clearing gradually became almost universal by the second half of the eighteenth century. Under this system, trees were felled with an ax sometime during the summer months, late enough in the season to discourage sprouting from stumps. They were allowed to lie until the following spring. Then, during the driest part of May, fire was put to the scattered heaps of wood and leaves. All but the trunks would burn, and the charred remnants of these could be sawed in half, piled together, and set afire once more. Such burning had several advantages over simple girdling. Although it destroyed much of the forest humus, it also killed the green roots of trees, preventing sprouting and enabling plowing to be done at an earlier date. With their roots dead, those stumps which were not turned to ashes rotted more quickly, and so could be removed sooner. Moreover, ashes returned much of the trees' nutrients to the soil, providing an effective fertilizer for the first year and substituting—at least in the short term—for any destruction of the humus layer. Unlike girdling, which returned nutrients to the soil over an extended period of time, burning did so in a single concentrated pulse, sacrificing longer-term conservation for shorter-term gain. Maize could be planted at once in the blackened field, without any need for plowing, hoeing, or manuring, and yielded a good crop in the first year. The second year, winter rye could be planted; thereafter, the field could be used for European grains, or, if seeded

with grass, for pasture or mowing lands.[15]

Market conditions might change this procedure in important ways. If local demand were great enough, cut trees could be sold for lumber and a profit made from clearing itself. Where this was done, many of the fertilizing benefits of ashes were lost, and plowing had to be undertaken if the soil was to yield crops at all. Generally, only the well-to-do, who could purchase tools and labor, could afford such techniques, even though less timber was wasted when they were applied. If, on the other hand, a nearby market for potash or charcoal existed, even settlers who burned their lands could profit by selling ashes. Potash, which was used to manufacture soap and gunpowder, was a major New England export and in some regions furnished the sole cash crop during the initial year of settlement: it was claimed in 1717 that a farm laborer could, during the odd moments of a year, burn and process four acres of forest to produce eight tons of potash worth £40 to £60 per ton. Since the "improved" and newly fertilized land which resulted from such clearing could itself be sold for a profit, one understands why Jeremy Belknap could argue that it was "accounted more profitable for a young man to go upon new, than to remain on the old lands. In the early part of life, every day's labor employed in subduing the wilderness, lays a foundation for future profit." Destroying the forest thus became an end in itself, and clearing techniques designed to extract quick profits from forest resources encouraged movement onto new lands.[16]

The use of fire to aid in clearing land was something English settlers borrowed from their Indian predecessors, but they applied it for different purposes and on a much more extensive scale. Instead of burning the forest to remove undergrowth, they burned it to remove the forest itself. Doing so was not only profligate, consuming huge quantities of increasingly valuable timber, but dangerous as well. Within a year of settlement at Massachusetts Bay, John Winthrop reported that several haystacks and houses had been destroyed by the careless burning of fields. In an effort to avert such losses, the General Court in 1631 forbade colonists to fire ground before the first of March; Plymouth

passed a similar law in 1633. Toward the end of the 1630s, both colonies established fire regulations limiting burning to specified weeks during the dampest spring months. Anyone damaging another person's property by uncontrolled burning was liable for the full extent of damages, and users of fire were required to warn their neighbors whenever they planned to burn their fields. These restrictions set the general pattern for similar laws in other New England colonies.[17]

Colonists thus modified the Indians' practice of large-scale communal burning in order to accommodate it to European notions of fixed property boundaries; fire was not to trespass across such boundaries under penalty of law. Inevitably, the Indians themselves were affected by the change. In 1640, for instance, the Narragansetts agreed to be liable for any harm done by their fires to colonial lands, the damages to be determined in an English court under English law. Such restrictions, which were one of several ways colonists taught Indians how Europeans bounded the landscape, made earlier Indian uses of fire increasingly difficult to continue as colonial settlement advanced.[18]

New England towns required a regular supply of wood long after their fields were cleared, and their efforts to obtain it extended the process of deforestation. Sawmills frequently became the nuclei for new settlements in wooded areas, furnishing lumber for ships, churches, houses, barns, and all manner of farm outbuildings. A town's roads and highways often converged on its mills, which by cutting wood and grinding grain provided vital economic services for the whole community. Although many mills were initially simple sawpits in which two men cut planks by hand, the high costs of skilled labor led a number of New England mill operators to adopt water-power technology well in advance of their English counterparts. Milldams created artificial ponds, and mill activities cycled with the seasonal availability of water. Sawing charges varied depending on the species of tree being cut—oak, for instance, cost twice as much as pine—because the respective hardnesses of different woods required that different amounts of labor and water be used in

sawing them. Even when mills ran from sunrise to sunset during seasons, like winter, when water was plentiful, their output probably averaged no more than a few hundred feet of lumber per day. Such low productivity no doubt encouraged sawmills to use only the best timber and waste the rest.[19]

In the face of initially abundant timber supplies, colonists altered many Old World uses of wood which had originally been based on scarcity. Half-timbered construction of a building's walls rapidly gave way to full-timbered construction using clapboards; stone-walled construction became relatively rare. Thatch and slate roofs were replaced with wooden shingles. House size in general increased over English models, so that buildings not only required more lumber to build but more firewood to heat. Even where bricks replaced lumber in construction, great quantities of wood were needed for firing their clay. In short, most aspects of colonial house carpentry came to rely on the seemingly endless supply of timber.[20]

Fences, which in England were usually made of stone or of living hedges, in New England were initially made entirely of wood. In part because they were designed to save as much labor as possible, they too consumed large sections of the forest. The first fences a farmer erected after clearing might simply consist of a row of stumps and large logs, or a worm fence of timbers stacked atop each other in a zigzag pattern. These were eventually replaced by rail or picket fences, which were used until repeated plowing turned up the rocks from which New England's famed stone walls were finally built. Most colonial wooden fences were poorly made, subject to rot, and wasteful of wood. As St. John de Crèvecœur remarked, "Our present modes of making fences are very bad.… They decay so fast, they are so subject to be hove up by the frost, it is inconceivable the cost and care which a large farm requires in that single article." To slow decay, colonists favored and selectively cut chestnut and cedar for fence construction, but frequently had to use oak. Where they did, a fence might last for no more than six to eight years before it had to be replaced. The final shift to stone walls was thus a way both of ending the

labor cost of repeated fence construction and of conserving disappearing timber resources—not to mention getting rid of the annoying rocks which were accumulating along the edges of fields. “For the last few years,” wrote one observer in Goshen, Connecticut, in the early nineteenth century, “there has been an increased attention to the building of stone fences; till which time chestnut rails were mostly used and the timber was fast decreasing.”[21]

The greatest use of the New England forest by far, however, beyond fences or buildings or exported ship’s masts, was for fuel. In addition to their love of large fires and warm houses, which had been apparent from the 1630s onward, New Englanders burned their wood in open fireplaces, which were four or five times less efficient than the closed cast-iron stoves of the Pennsylvania Germans. European travelers were frequently astonished by American consumption of firewood: the Swedish naturalist Peter Kalm remarked with some horror that “an incredible amount of wood is really squandered in this country for fuel; day and night all winter, or for nearly half of the year, in all rooms, a fire is kept going.” A typical New England household probably consumed as much as thirty or forty cords of firewood per year, which can best be visualized as a stack of wood four feet wide, four feet high, and three hundred feet long; obtaining such a woodpile meant cutting more than an acre of forest each year. In 1800, the region burned perhaps eighteen times more wood for fuel than it cut for lumber. When the effects of such burning are summed up for the whole colonial period, it is probable that New England consumed more than 260 million cords of firewood between 1630 and 1800.[22]

This enormous demand could only be supplied by the forests. Farmers usually tried to maintain a woodlot on a hillside above their houses so that fuel could easily be dragged downhill for burning. Just as with lumber, certain species in such lots—especially hickory and oak—were preferred for firewood, so that these were depleted sooner than others. Be this as it may, not everyone had woodlots, and not all woodlots lasted forever. Local firewood scarcities often became a cause for concern within ten or fifteen years of a

town's establishment. Boston, whose admittedly peculiar situation forced it from the start to gather fuel from the islands of Massachusetts Bay, experienced shortages as early as 1638, but other communities eventually did too. Private cutting of wood on common lands became a perennial source of dispute, and towns and colonies alike attempted to regulate it to prevent deforestation. In the long run, however, especially along the coast and near larger towns, timber for fuel became scarce and had to be obtained from greater and greater distances. Dwight wrote of one Vermont town whose inhabitants had "cut down their forest with an improvident hand: an evil but too common in most parts of this country. Unhappily it is an increasing evil, and may hereafter put a final stop to the progress of population." Elsewhere, he could report that in the 240-mile journey from Boston to New York a traveler passed through no more than twenty miles of wooded land, in fifty or sixty parcels. One result was a rise in fuel prices: the English traveler William Strickland was told in 1794 that timber and wood had "doubled in price, in every part of New England, within ten years." Most major cities of the East Coast shared this problem, which was a key reason for their eventual shift to coal in the nineteenth century.[23]

Timber scarcities and fuel shortages were of course local, as much a function of transportation costs as of absolute ecological changes. Great forests continued to exist in areas remote from rivers and population centers, but they were located at increasing distances from the regions undergoing deforestation. There, rising wood prices were a direct result of the prodigious consumption entailed by American clearing, lumbering, and heating practices. For observers accustomed to a world of scarcer resources, such uses of the forest seemed reckless in the extreme. Peter Kalm's judgment in 1749 retains much of its original force: "We can hardly be more hostile toward our woods in Sweden and Finland," he said, "than they are here: their eyes are fixed upon the present gain, and they are blind to the future."[24]

The ecological effects of this regional deforestation were profound,

extending even to the climate itself. Although clearing changed little or nothing about the larger atmospheric movements of wind, clouds, or rain, it brought substantial changes at ground level in the way ecological communities experienced atmospheric phenomena. Microclimates, hydrology, and soil mechanics were all altered by the clearing process. It is difficult to quantify these changes with any precision, given the data that are available to us: as the cautious Dwight rightly pointed out, "Observation of this subject has been so loose, and the records are so few and imperfect, as to leave our real knowledge of it very limited." Broad trends nevertheless seem clear.[25]

Most New England naturalists agreed by the 1790s that deforestation and agricultural cultivation had the effect of warming and drying the soil, making the surface of the land hotter in summer and colder in winter. Temperatures in general fluctuated more widely without the moderating effects of the forest canopy to shade the ground and protect it from winds. Samuel Williams, in his 1809 *History of Vermont,* asserted that "the earth is no sooner laid open to the influence of the sun and winds, than the effects of cultivation begin to appear. The surface of the earth becomes more *warm* and *dry*." He went so far as to demonstrate these effects with a series of experiments. Measuring soil temperatures in adjacent woodlots and pastures, he found that "the earth and the air, in the cultivated parts of the country, are heated in consequence of their cultivation, ten or eleven degrees more, than they were in their uncultivated state." He found in addition that a bowl of water placed in an open pasture evaporated one and a half times as quickly as one placed in the shade of a forest. More recent research has generally confirmed Williams's findings: forests tend to keep the ground beneath them cooler on average than open areas, and to narrow the range between maximum and minimum temperatures to produce a steadier climate. They reduce wind speeds by 20 to 60 percent, and lower evaporation rates from soil. All these effects of course vary considerably, depending on the species and soil composition of the forest community, but all are interrupted by clearing. Cleared lands in colonial New

England were thus sunnier, windier, hotter, colder, and drier than they had been in their former state.[26]

In wintertime, the effects of clearing produced an even more complex set of changes in these relationships. Although cleared land tended to be colder in winter than forested land—because drier and more exposed to the effects of wind chill—it received enough radiant heat from the sun to melt snow more quickly. The result was to shorten the apparent length of winter. As Dwight explained:

> In many cases, the first considerable snow will in a forested country become the commencement of winter; when, if the same country were generally open, the same snow would be wholly dissolved by the immediate action of the sun, and the winter in the appropriate sense would commence at a later period. On forested ground, also, the snow will lie later in the spring for the same reason.… Thus the summer half of the year must in such a country be somewhat shorter than if the forests were removed.

It was not, as some thought, that the weather itself was changed by clearing, but rather the way landscapes responded to the weather. If seasons were defined as much by an ecosystem's cycle of biological rhythms as by the movement of winds and storms, then in one special but important sense destroying the forest changed the very seasons themselves.[27]

Two major consequences followed when snow melted on cleared lands. For one, the longer retention of snow in forested areas acted to keep fires from spreading in the early months of spring; cleared lands were thus more susceptible to the burning colonists used to remove woody vegetation from them. More importantly in the long run, because the snow acted as a blanket maintaining soil temperatures, snow removal meant that soil froze to depths that it rarely had when forested. The frozen ground was unable to retain the water of melting snowfalls as easily as it once had; this effect was further compounded by the absence of tree roots and forest litter which had previously allowed soil to hold back the flow of large quantities of water. For all these reasons, spring runoff in deforested regions began and peaked at an earlier

date; moreover, smaller rainstorms at other times of the year produced greater amounts of runoff. Watersheds emptied themselves more quickly, with the result that flooding became more common. Dwight described how the Connecticut River was "now often fuller than it probably ever was before the country above was cleared of its forests, the snows in open ground melting much more suddenly and forming much greater freshets than in forested ground." Negative evidence is always dangerous to use, but the most thorough history of New England storms records only one major flood in the region between 1635 and 1720; between 1720 and 1800, on the other hand, there were at least six that produced significant damage to life and property.[28]

Floods were a dramatic result of deforestation, but they were only the noisy heralds of a much subtler and more important change. In precolonial times, forests had not only held back the spring floodwaters with their roots and unfrozen ground; they had also staggered the runoff of that water over all the months of the year. Just as temperatures remained steadier in forested areas, so too did stream flows. When snowmelt and stormwater drained off cleared lands as floods, they left less water behind to keep streams and rivers running throughout the year. By the late eighteenth century, a number of naturalists were noticing how New England watersheds were responding to these changes. Noah Webster summarized them—using his own peculiar spelling system—as follows:

> The amazing difference in the state of a cultivated and uncultivated surface of erth, iz demonstrated by the number of small streems of water, which are dried up by cleering away forests. The quantity of water, falling upon the surface, may be the same; but when land iz cuvered with trees and leevs, it retains the water; when it iz cleered, the water runs off suddenly into the large streems. It iz for this reezon that freshes [floods] in rivers hav becume larger, more frequent, sudden and destructiv, than they were formerly.

Floods, in other words, went hand in hand with dried-up streams and springs.[29]

Clearing also produced opposite results, ones that colonial observers rarely recorded. Forests lose an enormous amount of moisture through

transpiration from their leaves; leaves also catch rainfall, which evaporates before it reaches the ground. Water lost in these ways can make up a large share of the annual precipitation that falls on a forested area. Removing trees thus actually *increases* the total amount of water flowing off the land into streams and rivers. In low, poorly drained areas, colonial clearing sometimes had the effect of transforming a relatively dry area into a swamp. This may be one explanation for the widespread tendency among those who visited frontier settlements to link the process of clearing with disease. As Dwight observed, "While the country is entirely forested, it is ordinarily healthy. While it is passing from this state into that of general cultivation, it is usually less healthy." Colonists attributed their "fevers" and "agues" to bad air and miasma rising from newly exposed soil; in fact, the real culprit may have been anopheles mosquitoes carrying malaria, their populations temporarily swelled by newly swampy areas which had not been drained.[30]

In the long run, however, even though more water entered drainage systems as a result of deforestation, its irregular and more rapid runoff left the countryside drier at most seasons of the year than it had been before. "One of the first effects of cultivation," said Ira Allen in his *History of Vermont,* "is the dissipation of the waters." The drying up of streams and springs continued for decades after their forests were removed, and their eventual disappearance could mean economic crisis for the farms and towns which had depended on them. "In many parts of those States which have been cleared for above a generation or two," wrote the Vermont naturalist George Perkins Marsh in 1864, "the hill pastures now suffer severely from drought, and in dry seasons no longer afford either water or herbage for cattle." Peter Whitney mentioned a pond in Worcester, Massachusetts, whose size had been cut in half by more irregular drainage patterns, and there were undoubtedly other such cases elsewhere. Probably the colonial enterprise that suffered most from these changes was the one which relied most heavily on waterpower. Mills, which had depended on small streams and ponds to turn their wheels, frequently

found themselves first with not enough water to work in summer, and finally with little water at all save in periods of peak runoff—the very moment that they were threatened with damage by floods. As Samuel Williams described the phenomenon, "Mills, which at the first settlement of the country, were plentifully supplied with water from small rivers, have ceased to be useful."[31]

In summary, then, deforestation was one of the most sweeping transformations wrought by European settlement in New England. It aided in the reduction of edge-dwelling animal species. Where forests were not completely eliminated, their species composition changed: trees such as white pines, white cedars, and white oaks became less common. Where forests were entirely destroyed, the landscape became hotter in summer and colder in winter. Temperatures in general fluctuated more widely. Snow melted more readily than it had before, and the ground froze more deeply. The water-holding capacity of the soil was reduced, and runoff was thereby increased and made more erratic. Flooding became more common, and stream levels came to vary so greatly that some dried up altogether for extended seasons of the year. Water tables fell. But the list does not stop even here.[32]

Dramatic as these changes may be, their full effect remains invisible until they can be seen in relation to the ecological habitats with which Europeans replaced the vanished forests. It was no accident that the colonists cleared land so much more extensively than the Indians had done, nor was it mere chance that the English had such destructive effects on New England forests. The colonists themselves understood what they were doing almost wholly in positive terms, not as "deforestation," but as "the progress of cultivation." The two descriptions were in reality simply inverse ways of stating a single fact: the rural economies of Europe were adapted to a far different mosaic of ecological habitats than were precolonial Indian economies. Reducing the forest was an essential first step toward reproducing that Old World mosaic in an American environment. For the New England landscape, and for the Indians, what followed was undoubtedly a new ecological order; for the

colonists, on the other hand, it was an old and familiar way of life.