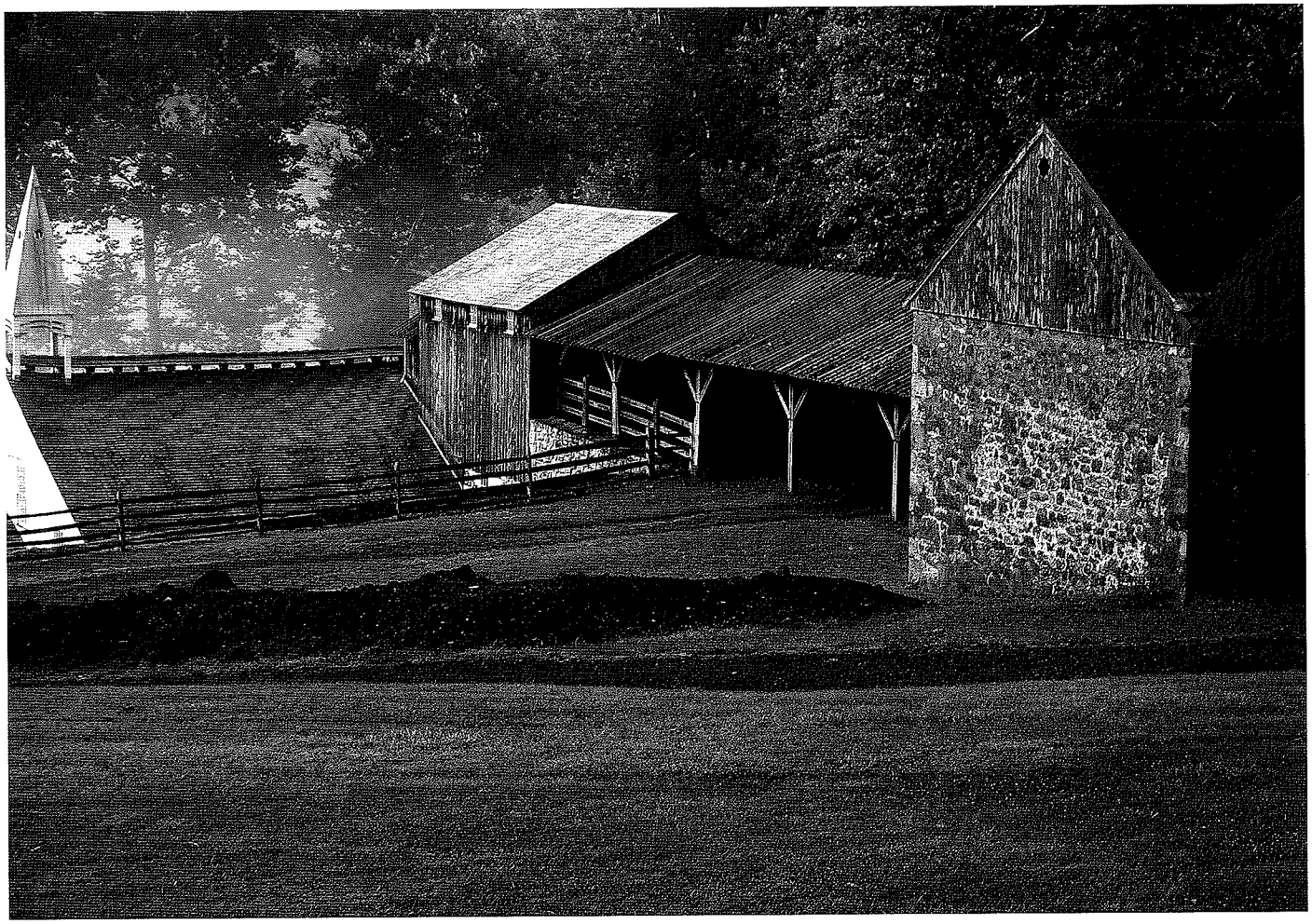
HISTORY ON THE ROAD

HOPEWELL FURNACE NATIONAL HISTORIC SITE

By Thomas J. Straka and Wayne C. Ramer

Charcoal production played a significant role in early American forestry. Charcoal, made from wood, provided the fuel for the early eastern iron furnaces and the western gold and silver smelters in the United States. Although lumbering is widely recognized as the major cause of forest devastation in the nineteenth century, the demand for charcoal likewise affected American forests. The demand for a sustained (as opposed to a sustainable) wood supply in iron-producing areas led to some of the nation's first attempts at forest regulation.

Opportunities to observe authentic demonstrations of traditional charcoal making are rare. But the Hopewell Furnace National Historic Site, located a short drive northwest of Philadelphia in Elverson, Pennsylvania, offers several lessons in forest history. In operation from 1771 to 1883, Hopewell served as a foundry for cannon during the American Revolution and then turned out cast-iron stoves in the nineteenth century before losing business after the Civil War to the new integrated iron and Bessemer steel industries.[1] The furnace was purchased by the federal government in 1935 and designated a national historic site in 1938. Restoration began soon thereafter. Today it is a living history village, with costumed molders, blacksmiths, storekeepers, cooks, and maids portraying life on an iron plantation in the 1820s to 1840s, when iron production and charcoal making were at their peak at Hopewell. The complete process of charcoal making is demonstrated several times a year by a group of dedicated volunteer colliers, or charcoal makers, who have learned the trade from those who once made their living by producing charcoal in these same woods. As anthropologist Cathy Stanton has noted in her study of Hopewell, "Americans have long cele-



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Hopewell Village was an iron plantation and a self-contained community. The charcoal house is the large building to the right.

brated and learned from their past by performing it."[2]

ABOUT CHARCOAL

Charcoal is made by partially burning (carbonizing) wood to remove water vapor and volatile gases, leaving a carbon residue. Wood is stacked above ground in what is called a charcoal pit, then covered with soil and leaves to keep out the air, and ignited. Combustion is controlled by regulating the flow of air to the burning wood. The dry wood begins to break down at just over 500°F, and the heating process peaks at about 750°F. Oak and hickory were strongly preferred for making "hard" coal; gum and poplar, which made "soft" coal, were of less value.[3] The specific gravity (higher density) of the dry wood is the controlling factor; that is why oak was worth twice that of pine in charcoal production.[4]

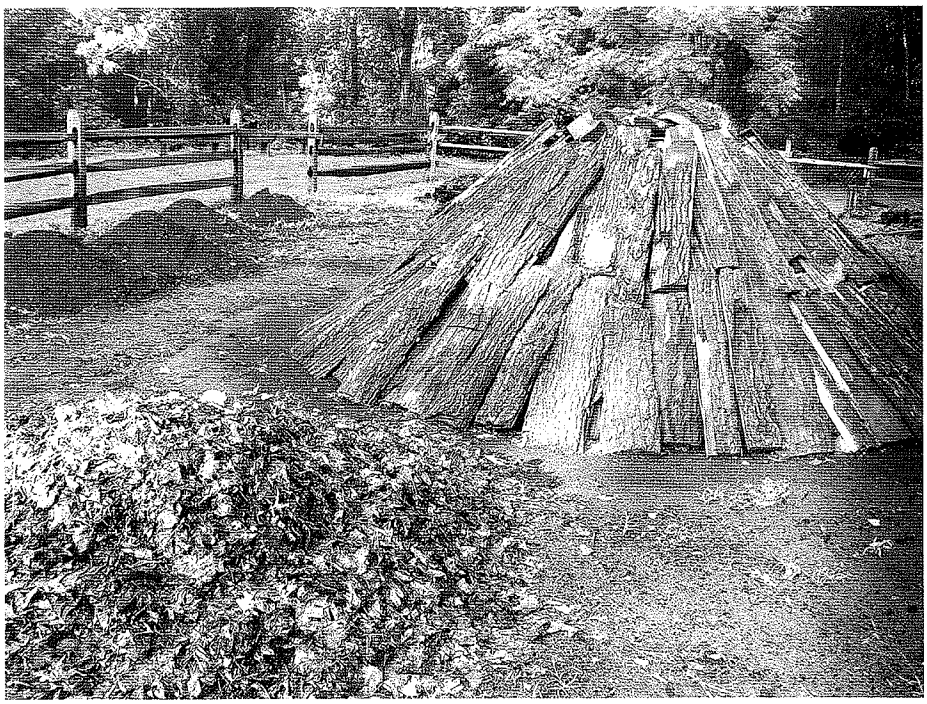
A charcoal furnace might require half the capital of a coke furnace, but the cost of transporting fuel, as measured by weight and distance, played a large role in determining the profitability of an iron furnace.[5] Charcoal reduced the volume of wood by about half and its weight by a quarter and was thus easier to transport, though the conversion to charcoal took half the energy value of the wood and considerable time—up to several weeks for a large pit.[6] Coal, however, was even less costly to transport than charcoal because it was less bulky and came from established mines, rather than scattered timber sources.

Unlike wood, charcoal was not attacked by insects or fungi and could be stored indefinitely. It was also easier to burn, produced less smoke, and was a more concentrated heat source (producing about one and a half times more heat than an equivalent weight of dry wood). Compared with coal, it produced a higher quality of iron, leaving a "fine grain" that kept a tougher, or "fine," cutting edge.

In 1859 about three-quarters of American iron furnaces still used charcoal; these were concentrated in southern Ohio, northeast of Pittsburgh, in south-central Pennsylvania, and on New York's border with Massachusetts and Connecticut. The transition to mined coal and coke began around 1840, but charcoal iron works persisted until 1945. The abundance of wood, especially in new settlement areas in the upper Midwest, contributed to the long reliance on charcoal in iron production.

CHARCOAL AND EARLY FORESTRY

Franklin Hough, a pioneer of American forestry, was closely allied with the Pennsylvania iron industry. Charcoal's fundamental role in iron production made forest management critical to maintaining the long term wood supply for a furnace. Many of the earliest American forestry papers were published in the journals of the iron industry. Hough reported that the woodlands used for charcoal production were "being 'wasted' and used at a much more rapid rate than they are reproduced by natural growth," and that soon "scarcity and high prices" would exhaust the supplies.[7]



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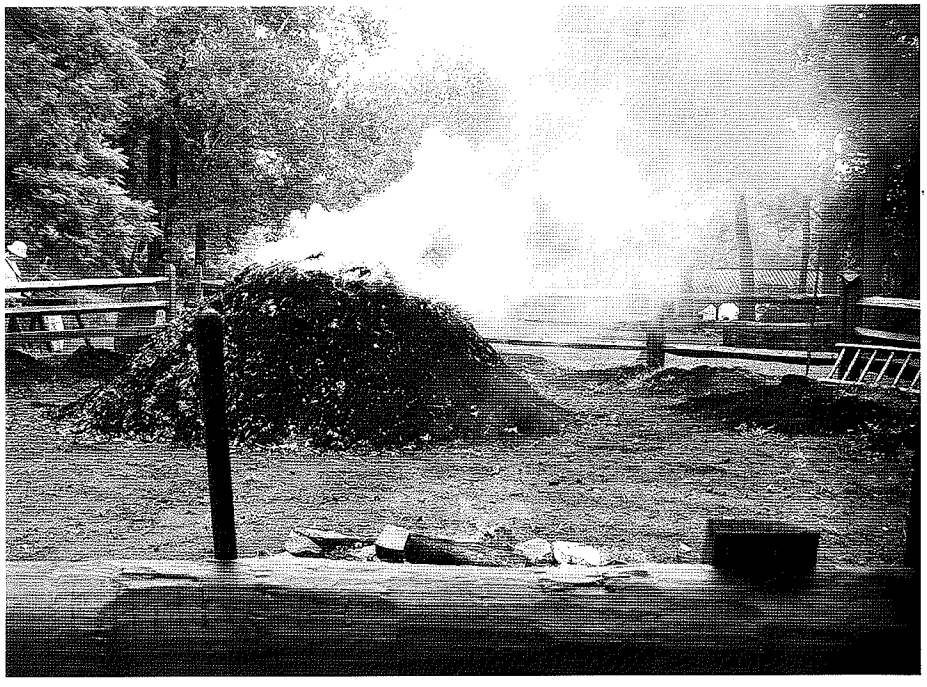
Charcoal pits usually had three tiers and might contain 25 to 50 cords of wood. The demonstration pit at Hopewell is smaller at about 5 to 6 cords. Note the piles of leaves and charcoal dust ready to cover the pit.



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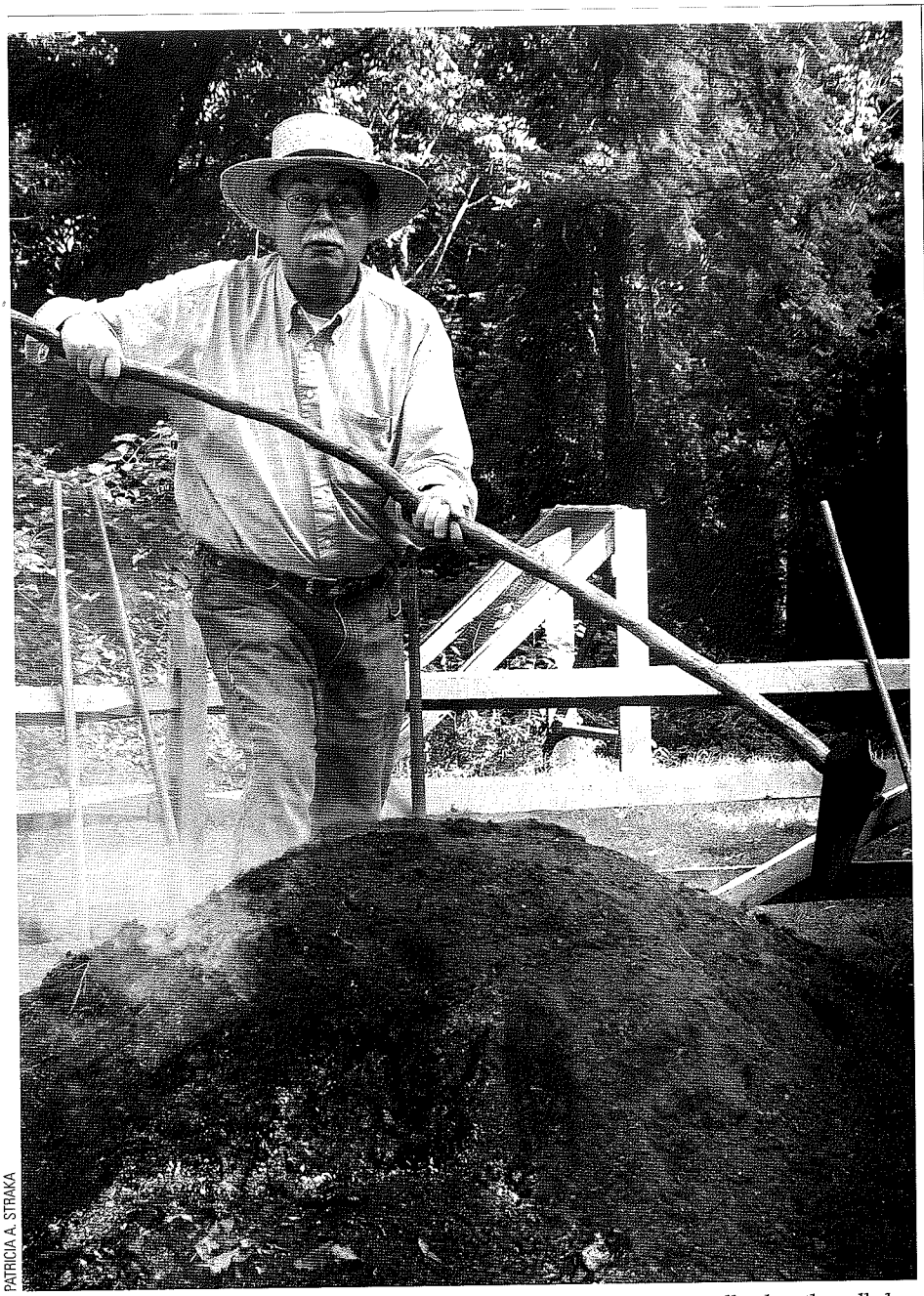
A charcoal pit. The white smoke indicates proper charring.



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As the charring process continues, pockets develop in the pit; the collier walks the pile, called "jumping the pit" to locate them. Any soft spots are filled in with more wood. This is the senior author jumping the pit during a recent demonstration.

In 1878 the iron and steel works of the United States had a furnace capacity of nearly 6 million tons. Roughly one-third of these furnaces used charcoal for fuel, accounting for about one-sixth of iron production. A survey of 50 furnaces conducted in 1878 found that on average, charcoal from four cords of wood was needed to produce a ton of pig iron. Eighty percent of the charcoal consumed in the nation was produced in pits (as opposed to kilns), like those at Hopewell. Charcoal furnaces produced about one million tons for iron works and another 130,000 tons for forges and bloomaries (a type of furnace) annually. In all, that meant a total annual consumption of 4.4 million cords of wood. Timber in the vicinity typically produced one cord per acre per year. Thus, 147,000 acres, or 230 square miles, of forest was harvested annually to fuel the charcoal furnaces. Furnace operators preferred timber about 20 to 30 years old.[8]

As a result, forest depletion occurred in iron-producing areas. As early as the 1830s some furnaces hauled wood as far as 10 to 12 miles "with great vexation," and by the late 1850s some were idle because of a lack of charcoal as operators waited for second-growth timber to mature.[9] Hough's 1878 *Report upon Forestry* noted that many iron furnaces became unprofitable enterprises because of exhausted wood supplies.[10]

Bernhard E. Fernow, another pioneer of American forestry and a professional forester by training, managed the Lehigh Furnace and its 15,000-acre forest near Slatedale, Pennsylvania, from 1879 until 1883. He found the iron industry to be a strong early supporter of forestry. The iron industry needed to regenerate lands near a furnace, and it was one of the few exploitive industries to take the long view and plan for sustainability. In the years before professional forestry was established in the United States, Fernow and other members of the American Institute of Mining Engineers discussed the benefits of forest management in the pages of the organization's journal.

Having emigrated from Germany only three years before, Fernow looked at the American approach to forest reproduction and management from a new perspective.[11] He wrote to his fellow engineers about forest management problems and timber supply, predicting that "recklessness, wastefulness, and ignorance" would lead to timber "scarcity, high prices, and injurious influences on all industries using wood."[12] In Pennsylvania most of the hardwood used for charcoal production was regenerated via coppice; protecting young growth from fire and cattle grazing was the key to satisfactory reproduction. Fernow wrote that he effectively controlled cattle grazing on his lands by warning his neighbors that he had placed poison throughout his young forests.[13]

CHARCOAL PRODUCTION AT HOPEWELL FURNACE

Hopewell Furnace was an iron plantation and, like agricultural plantations in the American South, a self-contained community. It comprised an ironmaster's mansion ("the Big House"), tenant houses, the furnace, casting shop, office and store, blacksmith shop, cooling shed, charcoal house, and farm and forest lands. Today the site also includes a visitors center and museum. Land controlled by the furnace varied over time from about 4,000 to 8,000 acres, but some of that land was used for

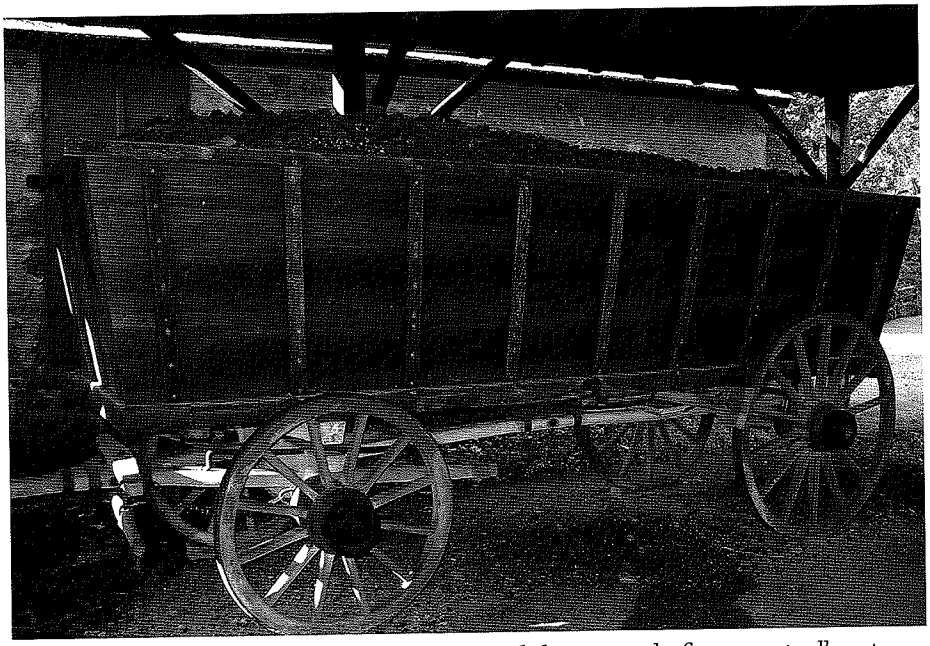
farming to support the plantation workers.

About half of the 200 to 250 furnace employees were woodcutters. Most cutting was done in winter, and many of the woodcutters worked part time. In 1830 the furnace required about 5,000 cords of wood (at a cost of $1.20 per cord). With the Hopewell forest rarely able to produce more than 4,000 cords annually, another 2,000 or 3,000 cords of wood was purchased from neighbors. The hardwood forest around Hopewell was mainly chestnut, oak, hickory, and elm, and yielded about 30 to 35 cords per acre every 30 years. Clearcutting on a 30-year cycle was used. Short-rotation coppice forestry was used, and around 200 acres of forest was cut each year (producing 6,000 to 7,000 cords annually). For a rotation age of 30 years, a forest of about 6,000 acres would be required to support the annual cutting cycle.

Woodcutters were paid by the cord but also for hauling distance and quality.[14] Two sizes of wood were cut: lap-wood that was 1½ to 4 inches in diameter and billets that ranged from 4 to 7 inches in diameter. Both were cut in 4-foot lengths with a bias in the end so that they would slant inward and the woodpile would form a heap. Most billets came from tree trunks, and most lap-wood from branches.

A good team of men working the whole season, from October to April, could cut and rank 1,500 cords.[15] Cutters ranked their own wood and were paid when the rank was measured by the collier (master charcoal burner). A deceitful woodcutter might rank his wood over boulders or a tree stump or pile it loosely. Wood volume might be reduced by as much as 30 percent through such tricks. Woodcutting tended to occur within four to five miles from the furnace. Charcoal pits required constant monitoring in case of venting, as the wood could burn to ash; so the collier might build a small shelter and have food delivered from home.

There was no argument at Hopewell over which wood produced the best charcoal, as every acre was cut clean and all wood ended up in the charcoal pit.[16] Hopewell Furnace would consume as much as 800 bushels of charcoal per day when it was "in blast." This equates to as much as an acre of forest cut to produce one day's worth of charcoal. It took about 200 acres of forest to produce a year's worth of charcoal for a furnace.[17]



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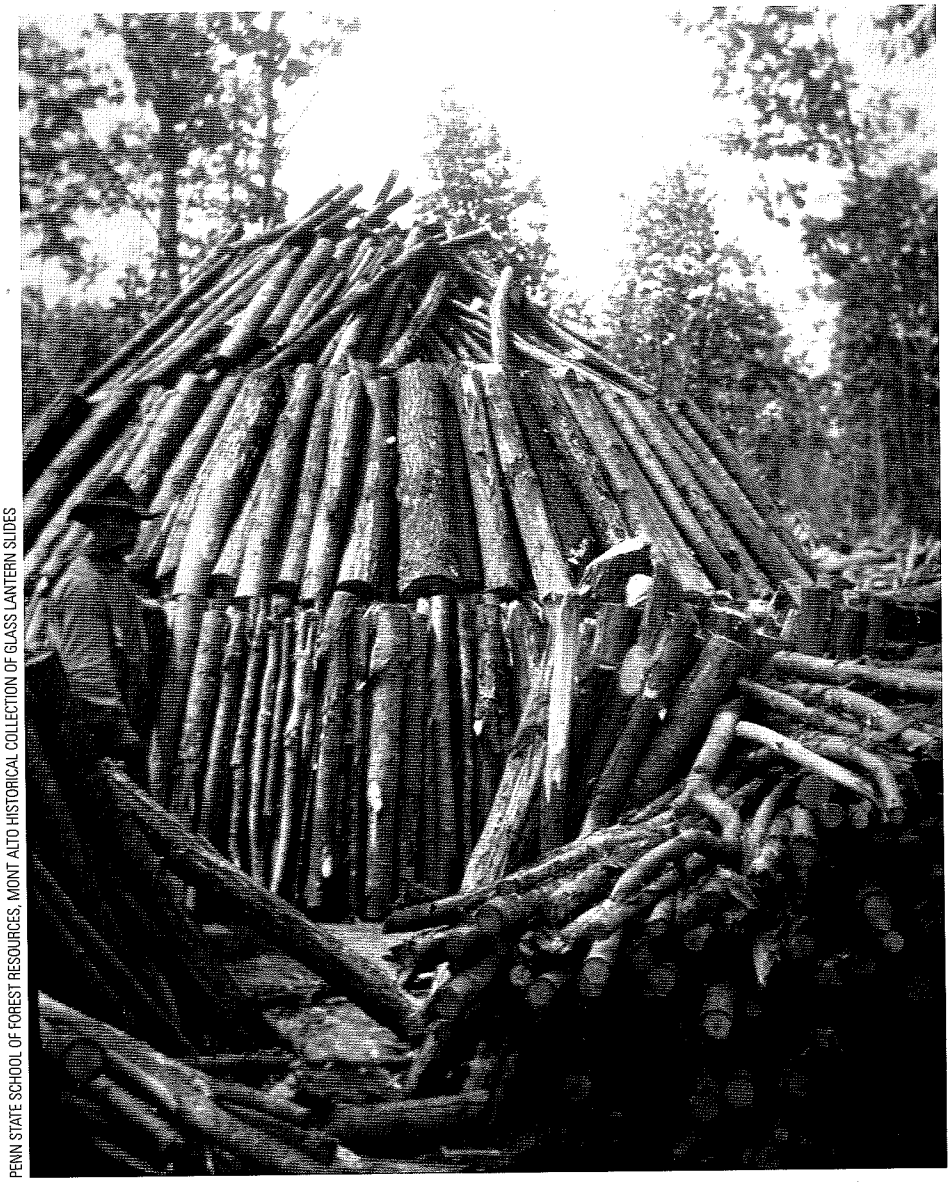
Once the charring process ended, great care was needed to ensure the fire was actually out. The charcoal was then transported by teamsters to the charcoal cooling shed. The charcoal wagon above sits in the cooling shed next to the charcoal house. Once the threat of reignition was past, the charcoal was moved into the charcoal house for storage.

The traditional charcoal-making process can be most easily understood if it is described in temporal steps:[18]

- Ground was cleared for the charcoal pit, usually a 30-to-40-foot circle on level ground. A flat, dry hearth also ensured even burning. The word "pit" is a misnomer; a charcoal pit is entirely above ground and includes the hearth and the wood pile.
- An 18-foot pole of green wood called a "fagan" is placed in the ground at the center of the hearth.
- A small triangular chimney or opening is built around the fagan with lap-wood.
- Three tiers of billets are carefully laid against this chimney; all slant slightly inward. Billets form the tiers and all small spaces are filled with lap-wood. Once the first tier (the "foot") was in place, the collier built the chimney up another 4 feet and completed a second tier (the "waist"). Finally a third tier (the "head") was added. A pit might contain 25 to 50 cords of wood. The demonstration pit at Hopewell holds about 5 to 6 cords.
- The pile is then covered first with an inch of leaves and then with about 4 inches of dirt, though old charcoal dust from a prior burn is preferred to dirt.
- The chimney is filled with kindling and the fagan is removed to provide draught. Red hot coals from the cooking fire are used to ignite the top of the central chimney and it is covered with bridging (flat wood pieces) and leaves/dirt when burning begins. The pit then "burns downward and outward." The rate of "burning" depends on the kind of wood, its size and dryness; the method of piling, temperature and weather; and the character of the ground. Two cords might take 2 to 3 days to burn and 30 to 50 cords might take several weeks.
- Once ignited, the chimney top is recharged (the void from kindling is filled with wood) and the pit is carefully watched and tended to by the collier to ensure uniform burning.
- For the 25-to-30-cord charcoal pits at Hopewell, the pit "came to foot," or was fully charred, in about two weeks. The pit was carefully raked out, starting at the foot. Great care was needed to ensure the fire was actually out. The charcoal was then transported by teamsters to the charcoal-cooling shed. Once the threat of reignition was past, it was moved to the charcoal house for storage (both structures are still at Hopewell).

Charcoal was the fuel of the early iron-making industry, and its production had a huge effect on American forests. Nearly



PENN STATE SCHOOL OF FOREST RESOURCES, MONT ALTO HISTORICAL COLLECTION OF GLASS LANTERN SLIDES

A charcoal pit on the Pennsylvania South Mountain Reserve—Snowy Mountain. Taken in 1905 by Charles R. Pancoast of Philadelphia.

that both Hough's and Fernow's comments were published in journals related to the charcoal iron industry. This industry did contribute to forest devastation in places that stirred public concern. At the same time, though, forestry pioneers were attracted to the problem of sustaining the forest production base for these furnaces. Many furnace owners practiced simple forest regulation to ensure a steady supply of charcoal. However, the charcoal iron-making industry literature contains some of the earliest American articles addressing silvicultural and forest management systems to establish sustained forest production to meet industry needs. If one looks closely at the roots of American forestry, charcoal production was one of the forces that led to expanded interest in developing a forestry profession to conserve and manage an important natural resource. □

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NOTES

1. Joseph J. Devanney, "The Hopewell Furnace National Historic Site of Berks County, Pennsylvania," *Anvil Magazine* (October 2000), http://www.anvilmag.com/smith/010f2.htm.
2. Cathy Stanton, *Cultures in Flux—New Approaches to "Traditional Association" at Hopewell Furnace National Historical Site: An Ethnographic Overview and Assessment* (Boston: National Park Service Northeast Region Ethnography Program, 2000), 160–180.
3. Franklin Benjamin Hough, *Report upon Forestry* (Washington, DC: Government Printing Office, 1878), 124–136.
4. Frederick Overman, *The Manufacture of Iron, in All of Its Various Branches* (Philadelphia: T. K. & P. G. Collins, 1854), 80–84.
5. Michael Williams, *Americans and Their Forests: A Historical Geography* (New York: Cambridge University Press, 1989), 147–151.
6. Forest Products Laboratory, *Charcoal Production, Marketing, and Use*, Report No. 2213 (Madison, WI: USDA Forest Service, Forest Products Laboratory, 1961).
7. Franklin B. Hough, "On the Importance of Giving Timely Attention to the Growth of Woodlands for the Supply of Charcoal for Metallurgical Uses," *Journal of the United States Association of Charcoal Iron Workers* 1 (November 1880): 67–80.
8. John Birkinbine, "The Production of Charcoal for Iron Works," *Transactions of the American Institute of Mining Engineers* 7 (1879): 149–154.
9. Williams, *Americans and Their Forests*, 149–151.
10. Hough, *Report upon Forestry*, 124.
11. Andrew Denny Rodgers III, *Bernhard Eduard Fernow: A Story of North American Forestry* (Princeton: Princeton University Press, 1951), 25–28.
12. Bernhard E. Fernow, "Should Our Charcoal in the Future Be Produced from Coppice or Timber Forest?" *Journal of the United States Association of Charcoal Iron Workers* 6 (October 1885): 272–281.
13. Ibid., 280.
14. National Park Service, *Hopewell Furnace: A Guide to Hopewell Furnace National Historic Site Pennsylvania*, National Park Handbook 124 (Washington, DC: Division of Publications, National Park Service, 1983), 53–56.
15. Edward M. Kirby, *Echoes of Iron in Connecticut's Northwest Corner* (Sharon, CT: Sharon Historical Society, 1998), 13–15.
16. Joseph E. Walker, *Hopewell Village: The Dynamics of a Nineteenth-Century Iron-Making Community* (Fort Washington, PA: Eastern National, 2000), 238–240.
17. Gerald G. Eggert, "The Iron Industry in Pennsylvania," *Pennsylvania History Studies* 25 (Mansfield, PA: The Pennsylvania Historical Society, 2008), 2–5.
18. Jackson Kemper III, *American Charcoal Making* (Fort Washington, PA: Eastern National, 1941 reprint). Lafayette Houck was one of the best charcoal burners who had ever worked the charcoal pits, and in 1936, he and his son, William, agreed to demonstrate the art of charcoal making. The entire process was photographed and documented for this booklet, which is sold at the historic site.