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Forging Ahead in the Somerset Hills: Archaeological Documentation of an 18th-Century Bloomery Forge in Bernardsville, New Jersey

Richard Veit and Michael J. Gall

This paper describes the results of a program of salvage archaeology at the Leddell Forge in Bernardsville, Somerset County, New Jersey. The site, which dates from the late-18th century, was discovered during landscaping activities on private property. Small-scale ironworks, such as this forge, were once a ubiquitous part of the cultural landscape in northern New Jersey, but today they are largely forgotten. With support from the Historical Society of the Somerset Hills and private donors, the forge remains were recorded. The Leddell Forge site contained exceptionally well-preserved wooden remains which provide new information about bloomery forge layout and construction. As seen at this site, archaeology can provide considerable new data about these fascinating early American industries and serve as a touchstone for learning about the entrepreneurs who owned them and the people who labored in them.

Cet article décrit les résultats d'un programme d'archéologie de sauvetage à la forge de Leddell à Bernardsville dans le comté de Somerset de l'état du New Jersey. Ce site, datant de la fin du XVIII^e siècle, a été découvert lors de l'aménagement paysager sur une propriété privée. Des sites de petites forges telles que celle-ci, ayant déjà été un élément omniprésent du paysage culturel du nord de l'état du New Jersey, ont presque entièrement été oubliés. Grâce à l'appui de la société historique de Somerset Hills ainsi que des donateurs privés, un relevé des vestiges de la forge a pu être effectué. On retrouve au site de la forge de Leddell des vestiges en bois exceptionnellement bien préservés fournissant de nouvelles informations sur l'aménagement et la construction des forges catalanes. Ce site démontre que l'archéologie peut fournir de nouvelles données importantes sur ces fascinantes industries américaines et qu'elle fournit un point de référence dans l'étude des entrepreneurs qui possédaient ces industries ainsi que des ouvriers qui y travaillaient.

Introduction

A modern visitor to northern New Jersey's Somerset Hills finds a serene wooded landscape traversed by steep winding roads and studded with impressive houses. The area's Revolutionary War heritage is well known; however, in addition to playing host to George Washington and his troops, these hills and valleys were once home to men who worked iron and participated in the nation's equally important industrial revolution. Recent excavations at the Leddell Forge Site in Bernardsville, Somerset County, have the potential to provide new information about this formative period in our nation's past and illuminate the role of rural industries in early America. The Leddell Forge dates from the end of the 18th century. Small-scale ironworks, such as this forge, were once a ubiquitous part of the cultural landscape in northern New Jersey, but today they are largely forgotten.

The Leddell Forge was investigated during the summer of 2006 in the course of

landscaping activities on private property in Bernardsville, Somerset County (FIGS. 1 and 2). It is located on a tract of land once owned by Dr. William Leddell though it appears to have been operated and managed by a series of tenant ironworkers, including James Frost and Benajah Sanders. Historical evidence indicates that there was a forge on or near this location from the 1780s through at least the first decade of the 19th century. Although the forge's metal elements were salvaged or scavenged after its abandonment, extensive, well-preserved, wooden elements of the forge structure were present. These included substantial elements of the hurst frame, anvil base, cribbing, an anvil base, and a section of waterwheel. Despite landscaping activities, which reduced the site's integrity and made interpretation of the organization of the forge challenging, the site retains considerable significance as the only known 18th-century bloomery forge in New Jersey where extensive wooden elements have survived in a good state of preservation.



Figure 1. Site locator map showing the approximate location of the site.

Forges and Furnaces

Ironworking in North America began in the 17th century with small bloomery operations in Tidewater, Virginia (Markell 1994: 56-58). In 1621, a blast furnace was constructed at Falling Creek, near Richmond Virginia. However, it was attacked in the Indian uprising of 1621, its workers killed, and the project abandoned (Gordon 1996: 55). Later, in the mid-17th century, first at Braintree and later at Saugus, Massachusetts, blast furnaces were constructed (Hartley 1957). By the late 17th century, bloomeries had been established in the New England and Middle Atlantic states.

New Jersey's first ironworks was established at Tinton Falls, then part of Shrewsbury, in Monmouth County, by James Grover in 1673 or 1674, and acquired by Lewis Morris shortly thereafter (Smith 1983: 69-70). This ironworks is believed to have consisted of a forge and

blast furnace. It employed bog iron (limonite) from the nearby Hockhockeson Swamp. Iron production in northern New Jersey began three decades later. Rich deposits of iron in the form of magnetite and hematite ore present in Morris County were recognized by the beginning of the 18th century. By 1710 a forge had been established in Whippany, in central Morris County (Munsell 1882: 40). Pennsylvania's first bloomery was established shortly thereafter in 1716 near Pottstown, and Delaware's first was constructed in 1722 (Gordon 1996: 60-61). Furnaces followed quickly and Pennsylvania rose to preeminence in the field of iron manufacture.

In his 1783 report about the iron mines of the United States, Samuel Gustaf Hermelin stated that "the majority of the iron ore fields hitherto exploited are situated in the following three states: New Jersey, where there are rock ores with sweeping veins; Pennsylvania, where some fields contain rock ore, but most of them contain stratum ores in regular beds...[and] Maryland..." (Johnson 1931: 21). Morris County and the surrounding area were well known for their rich iron deposits. The Leddell Forge exploited those rich deposits. As another 18th-century commentator, W. Winterbotham wrote:

The mountains in the county of Morris give rise to a number of streams necessary and convenient for these works, and at the same time furnish a copious supply of wood and ore of a superior quality. In this county alone are no less than seven rich iron mines, from which might be taken ore sufficient to supply the United States; and to work it into iron are two furnaces, two rolling and slitting mills, and about thirty forges, containing from two to four fires each. These works produce annually about five hundred and forty tons of bar iron, eight hundred tons of pig, besides large quantities of hollow ware, sheet iron, and nail rods (1796: 381-382).

In 1750, Great Britain passed an act to encourage the manufacture of pig and bar iron, while at the same time, preventing the construction of slitting, rolling or plating mills, as well as steel works (Munsell 1882: 41). Essentially, Britain hoped to transform raw materials supplied by the colonies into finished products.

Iron was produced through three basic methods in colonial America: blast furnaces, finery forges, and bloomery forges. Blast

furnaces were often the focal points of complete industrial communities. Industrial archaeologist Ed Rutsch (1974: 10-23) characterized them as iron plantations. Other scholars have called these self-contained iron-working communities *Bruks*, roughly the equivalent of industrial manors (Hudson 1976: 42). The typical iron plantation included a furnace, casting house, coal house, charcoal kilns, workers' houses, an iron master's house, school, church, and other ancillary structures.

Iron furnace technology developed in Continental Europe during the Late Medieval period (Rolando 1992: 6-8; Hildebrand 1994; Gordon 1996). The furnace was typically built into a hillside allowing it to be charged from the top. In this process, iron ore, charcoal, and limestone were placed in a high furnace and an air blast was introduced. Molten iron collected at the bottom of the furnace and was run out onto the casting room floor. This iron flowed into channels on the sand-covered floor of the casting house, a pattern that resembled a sow and her piglets, hence the term pig iron. Pig iron was cast iron and therefore quite brittle. It could not be used by blacksmiths but could be cast into firebacks, hollowware, cannons, and many other useful items. Most blast furnaces had associated finery forges. These reheated the pig iron, introduced carbon into the iron, and made it more malleable. The reworked pig iron was formed into an ancony, or bar, of wrought iron with a knob at either end. In turn, these anconies might be reworked to form smaller pieces of bar iron which were more easily used by craftsmen.

In contrast to furnaces and finery forges, bloomery forges allowed wrought iron to be produced directly from ore. Bloomery forges resembled a blacksmith's forge but were much

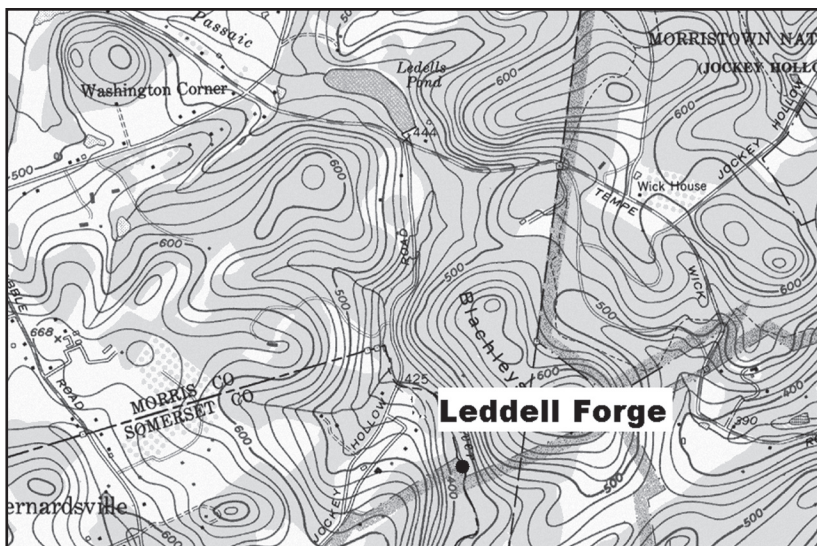


Figure 2. USGS Mendham Quad showing the approximate location of the site. Scale 1"=2000'

larger. Air was introduced into a bed of hot charcoal, using a bellows or air tubs generally pumped by a waterwheel. The iron ore was mixed with charcoal in a small hearth. The carbon and oxygen combined to form carbon monoxide, which removed the oxygen and left metallic iron in the form of unconsolidated metal particles (Harvey 1988: 19; Chard 1995: 2). The unconsolidated mass of iron contained considerable quantities of slag. Slag is a glassy waste product consisting of accumulated ore impurities that forms around 1150° C (Harvey 1988: 21). At this temperature, the iron is not quite hot enough to melt. Instead, it forms a pasty mass called a bloom. Most blooms were small. According to historian Jack Chard (1995: 2), "It was a cause for celebration in about 1775 when a 28-pound bloom was produced in North Jersey." Slag and gas holes were driven out of the bloom through repeated episodes of heating and hammering (Harvey 1988: 21). The result was a wrought-iron bar known as merchant bar or common bar (Rutsch 1999: 15).

Most bloomeries were small-scale enterprises with a single hammer and one or two fires. The Leddell Forge is believed to have had a single hammer and a single fire. A small forge could produce approximately one ton of bar iron in a week (Wacker 1968: 112). A handful of receipts from the Leddell Forge indicates that at this smaller operation, a few

hundred pounds of iron might be on hand at a time. A bloomery or bloomery forge allowed individuals of modest means to produce iron with a more-limited investment of funds, less expertise, and less manpower. Geographer Peter Wacker notes that "the bloomeries [were] located, for the most part, in relatively rugged, glaciated areas, where large-scale economic production of pig and bar iron was impossible, but where there was a good supply of wood available, and where a sufficient demand existed" (Wacker 1968: 112). The Highlands of northern New Jersey were particularly well suited to the establishment of bloomeries because of the presence of iron ore, the availability of water power afforded by steep narrow valleys, and the presence of large stands of woodlands used for charcoal. Charcoal is a bulky fuel, which, in the 18th century, could not easily be transported long distances (Muntz 1960: 316). The Leddell Forge is located in a well-wooded, narrow and falling valley, adjacent to the Passaic River and near the base of Mine Mountain. It is very well sited.

In comparison to furnaces, bloomery forges were once considerably more common. However, they are less well known today as, unlike furnaces, their archaeological traces (e.g. foundations, slag piles, mill dams, and races) are much more subtle than the massive masonry stacks associated with furnaces.

The number of ironworks in New Jersey fluctuated with economic conditions, declining during the Revolution, but rising again in the early 19th century. A 1784 census listed eight blast furnaces and 79 forges and bloomeries in the state (Swank 1892: 161). Forty years later, in 1834, Thomas Gordon noted 12 blast furnaces and 108 forge fires (Gordon, T. 1834). However, Morris County's forges were already in decline. Munsell notes that "all of the forges near Morristown were extinct in 1823" (1882: 40). This appears to be true of the forge examined here. As Gordon wrote:

The forge was uniformly the precursor of the farm. ...As the country was cleared, the makers of iron gradually retired to the remote, rough, and almost inaccessible regions, where the cost of transportation of ores, and of the metal to market, rendered their operations very unprofitable (Gordon, T. 1834: 185).

Though not noted by Gordon, deforestation was also a problem. When the forests which had provided the raw material for charcoal fuel were cut, fuel became too expensive to continue iron manufacturing.

Discovering and Documenting the Forge

The Leddell Forge was a small bloomery, unearthed by landscapers attempting to drain a swampy section of a property near the Passaic River in Bernardsville Township, Somerset County. The property owners were aware that a forge had stood near the site, but neither they nor their landscapers were prepared for what they discovered. Shortly after beginning excavation, large wooden timbers were encountered. At first, it was not clear what they represented. A landscape architect retained by the property owners to design a new garden carefully sketched and then removed these timbers. More timbers were found, some quite massive. One measured over 20 ft in length and 2 ft in width and height. Fragments of a waterwheel and the wooden base of an anvil were also identified.

In an attempt to preserve and document what they had found, the property owners reached out to the archaeological community. Working with the Historical Society of the Somerset Hills and architectural historian Dennis Bertland, archaeologists Richard Veit and Michael Gall developed a program of basic archaeological recordation. This consisted of mapping the site, drawing and photographing the timbers, collecting samples of ore and slag, and monitoring the property owner's effort to repaint and reconstruct the forge foundation walls. A more formal program of archaeological study would have been preferable; however, the site was located on private property and was not subject to any state or local preservation ordinances that would have required the property owners to conduct a more extensive survey. Although archaeologists have documented several forges contemporary with the Leddell Forge in New Jersey, the site is unique for the outstanding preservation of its wooden components. The property owners are continuing to work with the Historical Society of the Somerset Hills to preserve these materials and interpret the remains found on their property. The material remains in stable condition in private ownership.

The History of the Leddell Forge

The forge site is believed to be the remains of the Leddell Forge. Known to local historians and archaeologists, it was first identified as the Leddell Forge by historian Fred Bartenstein in the 1960s (Bartenstein 1967). Ed Rutsch toured the site and commented on its features in the 1970s. More recently, industrial archaeologists Ed Lenik and Joe Macasek have visited the site.

There are a few early references to the Leddell Forge as well. Writing in 1783, mine surveyor Samuel Gustaf Hermelin noted:

For bar iron production are: Bloomery hammers, located at the Suckasunny mines, the Franklin, Neacky and Schangom at Danbrok River, Memen, Mendum and Flanders near Suckasunny; two hammers at the Black River, one at Pesdich River near Morristown, and Husbound Bloomery at the Hibernian Mines. Considering the quantity of ore [these works] should produce [a total of] 700 tons (Johnson 1931: 69).

It is possible that the hammer on the “Pesdich [presumably Passaic] River near Morristown” may be the Leddell Forge. Munsell (1882: 42) mentions “Leddle’s Forge” on a branch of the Passaic in his list of Morris County Ironworks. However, William Bayley’s (1910: 2-10) lengthy list of defunct ironworks in New Jersey fails to reference the forge. Charles Boyer’s (1931: 260) encyclopedic *Early Forges and Furnaces in New Jersey* notes a William Liddle’s forge in Mendham, but states that it was on the Raritan River a few miles below the village of Ralston. Other sources simply note that there was a Leddell Forge near the headwater of the Passaic River (Thayer 1975: 55).

Despite the rather garbled references to Leddell’s forges in the secondary literature, a fair bit of primary documentation exists from which a more complete history of the forge may be derived. The property on which the Leddell Forge is located was purchased by William Leddell (alternatively spelled Leddel, Leddle, Liddel, and Liddle) from his father, William Leddell, Sr. on April 6, 1756 (Colonial Conveyances 1756). It consisted of a 30-acre parcel including William, Sr.’s home. This transaction also included a 75-acre tract located one mile south of the former parcel. All told, William, Sr. sold his son 105 acres of land and a dwelling, but the forge property was on the 30-acre parcel. William, Sr. was a French naval

surgeon who settled in Elizabethtown. His son, William, Jr., moved to Mendham in 1766, when he was 19, and apprenticed himself to the local physician Dr. Ebenezer Blachley (a.k.a. Blackly and Blachy) (New Jersey Historical Society 2001). Leddell and Blachley continued their relationship for a number of years, and in 1773 together purchased a tract of land in Mendham along the Passaic River (Morris County Deeds). This tract, which later became known as Blachley’s Hill, was situated on a nearby upland landform known as Mine Mountain. During the Revolution, William Leddell, Jr. served as a lieutenant in the Morris County Troop of Light Horse. Promoted to major, he also served with the forces sent to quash the Whisky Rebellion in 1794 and had risen to the rank of Captain by the War of 1812. He was also Morris County’s Sheriff from circa 1783 to 1785 and a Justice of the Peace (New Jersey Historical Society 2001).

These medical, military, and civic accomplishments aside, Leddell also found time to construct, lease, and/or manage several small manufacturing enterprises in Mendham and Bernardsville, including a sawmill, gristmill, and two forges. Leddell’s sawmill was located north of the study area in Mendham near a mill pond on the Passaic River known as Leddell’s Pond. His homestead and farm were situated on the same side of the road, east of the mill pond. Leddell owned forges in both Mendham, Morris County, and neighboring Bernardsville, Somerset County. It is not clear where Leddell’s Mendham forge was located, but it was probably situated along the North Branch of the Raritan River. Leddell only operated and/or paid taxes on his forge in Mendham from 1782 to 1786. In fact, in 1783 he only paid half the taxes on his Mendham forge, suggesting that he co-managed it with a partner who paid the remainder of the taxes.

Information provided in the tax ratables and other historic documents about Leddell’s forge in Bernardsville is more complicated and suggests that Leddell likely leased his forge to tenant operators during the late-18th and early-19th centuries. Based on historic documents alone, the construction date for the forge is not clear. A pair of forges are depicted on the ca. 1780-1781 Millidge/Skinner map and 1781 Hills map along the Passaic River below Mendham near the location of the Leddell

forge. It is possible that one of these is the Leddell Forge in Bernardsville. An 1827 Map of the Line of the Morris Canal, New Jersey shows "Liddle's" forge in ruins (FIG. 3). This evidence fits with the historical and archaeological data.

Curiously, Leddell was first taxed for owning/operating a forge in Bernardsville in 1797. Given Leddell's occupation as a doctor, sheriff, and lawyer during the late-18th century, it is unlikely that he ever operated the forge himself. Rather, like most wealthy entrepreneurs of his day, William probably leased the forge to a series of tenants who managed its operation from the late-18th through the early-19th centuries.

The earliest tenants at the site appear to have paid the tax on the forge's operation prior to 1797. The first tenant was Samuel Thomson, who, in 1784 and 1785, paid tax on the forge [the only forge in operation in Bernardsville during those years], as well as on 100 acres of land, which may have been on part of Leddell's 105 acres on Mine Mountain. Forges were not listed as a taxable item on the 1786 through 1789 tax ratables in the township, and, therefore, the tenant operator(s), if any, is unknown. Later tenants appear to have included John Wright (1790-1792), Steven Whitaker (1793-1794), and perhaps Jesse Upson (1796). The latter two owned vast tracts of land in Mine Mountain, where they mined ore for the forge they leased. Interestingly, in 1794, William Leddell [listed as William Little] was taxed on the 105 acres he received from his father in 1756, but not the forge on his property (Bernardsville Township, Somerset County Tax Ratables 1778, 1782, 1784-1794, 1796).



Figure 3. Map of the Line of the Morris Canal, New Jersey by Prosper Desobry (1827), showing "Liddle's" forge as abandoned (New York Public Library Collections). Note that this map incorrectly shows the forge on the east side of the river.

From 1797 through 1806 a William Liddle [presumably Leddell] was taxed for a forge. The next available and last tax ratable for the township was in 1818. During that year only one forge was in operation in the township. It was owned and/or operated by William Ludlow [not William Leddell] who had been taxed on this forge since 1802 (Bernardsville Township, Somerset County Tax Ratables 1797, 1802-1803, 1805-1806, 1818). Based on the 1818 tax ratable, the Leddell Forge went out of operation sometime between 1806 and 1818, and was certainly defunct when Silas Ward, the executor of William Leddell's estate, sold the forge property to Ezra Sanders on April 28, 1828 (Somerset County Clerk's Office 1828).

A collection of nearly 60 photocopied documents, donated to the current property owners by the late F. Crampton Frost of Morristown, is associated with the Leddell Forge and suggests that the forge continued to be operated by tenants from 1795 to at least 1800. During much of that time, Leddell paid taxes on the forge. The documents, primarily receipts and indentures, suggest that between 1794 and 1802, James Frost of Bernardsville operated the forge with partner Benajah, a.k.a. Benia, Benaiah, or Benjamin Sanders [presumably a relative of Ezra Sanders who later purchased the forge lot in 1828].

The following are typical examples of correspondence from the Frost Family Papers:

August 18, 1795
Mr. Benjamin Sanders or James Frost.
Sir Please to let the bearer Samuel have one bar of iron and charge the same to my account and in so doing you oblige your friend
Amos Dunham.

Sir, Please to send me by Cesar a bar of iron.
James Lunny
20th July 1796
Mr. J. Frost

Peapack, June 28th 1797
Mr. Sanders will let Samuel Todd have what iron he wants and charge the same to my Account in your Compliance you much Oblige me.
Mr. Benajah Sanders
David Nevius

Sir, I will thank you to send me by Cesar a bar of Iron. I also wish a mold for an English ploughshare. Please to send the weight.
22 August 1797
J. Lunny
Mr. James Frost

Sir I will thank you to draw me a pair of sleigh shoes. I wish to have them this week.
30th Nov. 1797
James Lunny
Mr. Frost

Mr. James Frost Please let Thomas Ward have iron to the amount of two pounds Eighteen Shillings and one penny and charge the same to my account and you will oblige for your humble servant.
William Steel
December 3, 1800

May 18th 1800
Dear Sir Please to draw my iron by 28th this Instant without fail.
Draw 20 foot square bars
8 foot small ax bar
Mr. James Frost
Abraham Van Arsdalen
By Pound 1:1:6

These receipts show the production of relatively small quantities of iron bars, and some additional work, such as forging sleigh shoes, or runners, and ploughshares. Many of the receipts reference production of bar iron, which was sold by the pound. Although too

few receipts survive to estimate yearly or even monthly production, several inferences can be made. First, the business appears to have been carried on with a minimum of cash transactions. Most of the receipts note that James Frost should charge the cost of the iron to an existing account. The purchasers were members of the local community living in Morris and Somerset Counties. Various intermediaries were sent to pick up and deliver the iron, including an individual named Cesar, most likely an African American. Personal relationships appear to have affected the business. One receipt dated April 26, 1800 from Samuel Van Arsdalen, a prominent Somerset County farmer, to James Frost, notes that Van Arsdalen borrowed iron and would like it deducted from his account (Frost family papers). Although they represent a fragmentary and incomplete record of the production of this forge, the receipts remain intriguing.

The forge may also have functioned as a blacksmith shop. Some of the work noted in the receipts, such as forging sleigh shoes suggests such a function. Although no clear physical evidence for blacksmithing was found within the structure documented here, field conditions were less than optimal.

During the period covered by the Frost documents, James Frost and his wife Elizabeth, residents of Bernardsville, rented land from a man named William Steel, who owned hundreds of acres of ore-rich land on Mine Mountain south of the Leddell Forge. In fact, a June 1796 receipt notes the payment of 15 pounds to William Steel by B. Sanders and James Frost for "1 years rent of mine" (Frost family papers). Frost likely exploited the mines on Steel's land to gather ore for the forge's operation. In December 1803, James Frost died intestate (Somerset County Surrogate's Office 1803). Benajah Sanders and Ezekial Frost were listed as his fellowbondsmen and Elizabeth Frost, his widow, served as his executrix (Somerset County Surrogate's Office 1803; Hutchinson 1946: 172). William Leddell, the property owner, acted as Frost's physician during his final illness. Elizabeth paid the bill for medicine, attendance, and two years interest after his death. Elizabeth Frost, with the help of Benajah Sanders, may have continued to manage or fund the forge's operation after her husband's death. Despite these

efforts, the tax records indicate that the Leddell forge likely stopped operation sometime between 1806 and 1818. In April, 1828, Ezra Sanders, probably a brother of forge operator Benajah Sanders, purchased the forge parcel from Leddell's executor, Silas Ward. About the same time, another Sanders, Lewis, purchased a parcel from William Leddell located one mile south of the forge (Somerset County Clerk's Office 1829). Clearly, a strong connection existed between the Leddell, Frost, and Sanders families, probably originating from ties with the Leddell Forge.

The Forge Remains

Working intermittently over a period of three months, from October to December 2006, the authors documented the remains of the Leddell Forge. The site lies in a narrow valley near the headwaters of the Passaic River. The forge remains are located on the western side of the river immediately adjacent to and below

or south of a broken earthen dam. The dam measures roughly 12 ft high at its highest point and has a stone core covered with earth. A small portion of the dam, located beneath a modern house, shows carefully-laid stone resembling the riprap on 19th-century canals. At its broadest point, the flat-topped dam is 25 ft wide. It appears that a freshet blew out the dam, though the date when this occurred is unknown. The river now flows roughly 60 to 75 ft east of the forge. The area between the forge and the river is littered with slag and occasional pieces of black magnetite ore. Approximately 14 ft south of the forge building a tailrace is evident. It runs directly south from the forge to the Passaic River. One hundred fifty ft of the race is still visible. It varies from 3 to 5 ft wide and measures roughly 1 ft deep.

The forge building is clearly evident as a nearly square foundation immediately below the dam (FIGS. 4 and 5). Its exterior dimensions are 39.5 ft wide from east to west and 42.6 ft long from north to south. The walls range from



Figure 4. Photograph showing the foundation of the forge site looking east. The dam is to the left and the tailrace is to the right.

approximately 2.0 to 2.5 ft wide. They stand from 1.6 to approximately 10 ft tall. The wall nearest the dam or north wall is much taller than the side walls. The southeastern corner of the structure is open and may represent a historic entranceway into the structure. This opening is 17 ft wide. The superstructure of the forge may have been wood or stone. The Bloomingdale Forge in Sussex County was built with stone walls (Ransom 1966), as was the Hay Creek Forge in Pennsylvania (Bining 1979: 72). Illustrations of contemporary French forges also show stone structures (Samson 1998). Although these dark stone buildings seem rather dismal by modern standards, the lack of light would have enabled forge men to better judge the temperature of the bloom, a critical and highly skilled aspect of a forge's operation. The stone walls would have also protected the building against fire. A vision of what the forge may have been like when in

operation is provided by an anonymous tourist quoted in Sellmer (1984: 3):

Those who are unaccustomed to places of this kind, feel strong sensations of horror at first entering. The clanking of chains, the dingy countenances of the workmen, the immense fires, and above all, the yellow glare thrown on everything by the flames shining through the dismal columns of smoke that continually fill the building, form altogether a very terrific picture.

All of the wooden framing elements had been removed from the interior of the forge before this project began. However, a map drawn in the fall of 2006 by landscape architect John Smith provides an indication of the locations of the major elements, as well as a possible configuration for the forge's floor plan (FIG. 6). This shows that the major framing elements formed an H-shaped structure set into the earth. The anvil base was present near the northwestern corner of the structure, though it was likely originally set near the hurst frame and anvil base cribbing, and the remains of the waterwheel were found immediately adjacent to the eastern wall of the building. The anvil base was plotted in Figure 6 in its suspected original location near cribbing timbers and the hurst frame. The waterwheel was found sitting within an approximately six-foot wide raceway. The depth of the raceway is unclear. Loose bricks in the northwestern corner of the structure near the anvil base may indicate the location of the forge itself. The interior of the forge building was full of very wet soil when the archaeologists visited the site and no evidence for internal features, other than those previously noted, could be seen. Moreover, the removal of the large timbers had badly disturbed the waterlogged soils within the foundation. Sadly, this also made it impossible to determine whether hammer scale, a good indicator of blacksmithing activity (Light and Unglik 1984: 40-42), was present near the anvil base. Observation of trenching done during the landscaping activities showed no well-defined cultural horizons, though some additional fragments of waterwheel were recovered from the eastern half of the structure. There was no clear evidence of a working floor, hammer scale, or any of the other traces that might be associated with the interior of the forge.

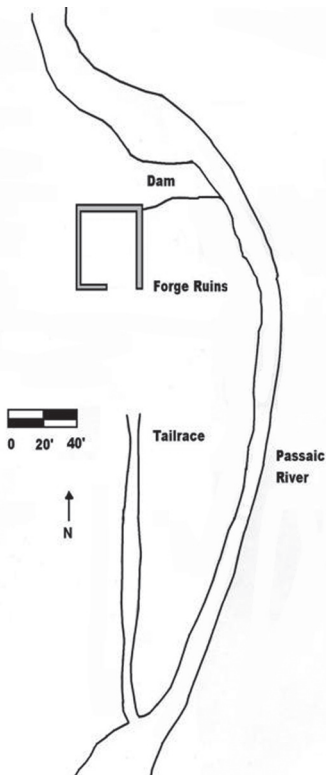


Figure 5. Plan view (2006) showing the relationship of major features on the Leddell Forge site. Portions of the tailrace are no longer visible. Nor is there any visible headrace. (Drawn by Richard F. Veit.)

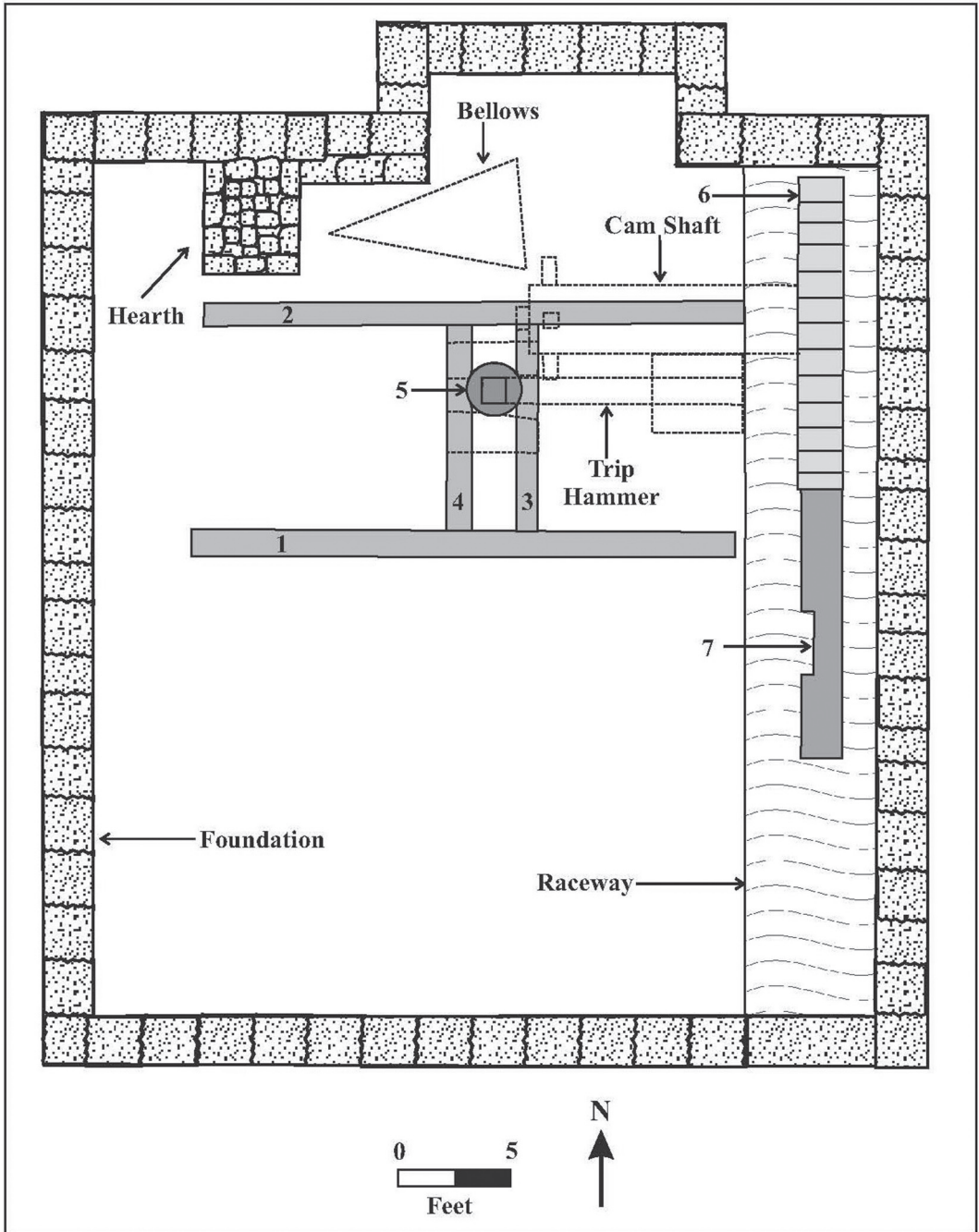


Figure 6. Interpretive plan of the Leddell Forge based on drawings by John Smith, Landscape Architect, showing the relationship of the major timbers recovered at the site to the forge foundation (1-4: wooden H-frame timbers; 5: wooden anvil base; 6: waterwheel; 7: miscellaneous timber). Location of timber eight was not recorded by Smith. Dotted lines indicate possible location of structural elements not present. Note, the wooden anvil base (5) was found in the northwest corner of the building. (Drawn by Michael J. Gall.)



Figure 7. The anvil base showing the large tenon.

Seven major structural timbers, roughly 20% of a waterwheel, and the base of an anvil were recovered. This is, to the authors' knowledge, the first time wooden elements of a bloomery forge have been recovered in New Jersey. However, wooden elements associated with the Martha and Hanover blast furnaces have been identified (Personal communications, Charles I. (Budd) Wilson, 2005 and Petar Glumack, 2006). In terms of preservation, the wooden remains of the Leddell Forge rival materials recovered from the Saugus Ironworks in Saugus, Massachusetts, where both a fragmentary waterwheel and an anvil base were found underground (Hartley 1957; Robbins and Jones 1959: 64-65; Linebaugh 2005: 69), wooden remains found at Clintonville's bloomery forges and ironworks in Clintonville, New York (Pollard and Klaus 2004: 33), and the materials unearthed by CCC excavators at Valley Forge in the 1930s (Schenck 1992). Similar wooden remains survived at the Windham Forge in northern

New Jersey and were recorded in a series of important photographs by Vernon Royle in 1893 (Ransom 1966: 96-99; Sellmer 1984).

The Anvil Base

The anvil base is an intriguing find. It consists of a minimally-shaped oak log measuring 2.5 ft in diameter (FIG. 7). Two of its sides are slightly flattened, probably the result of having been pressed in place by a large timber frame. It measures 3 ft tall. A square tenon projects 6 in from one end of the anvil base. When found this tenon was facing down. The opposite end contained a roughly 2-in diameter peg located in the center of its surface. The tenon may have locked the timber into the framework of the forge, or, alternatively, have served as a base for a large anvil. Anvils displayed at Ringwood Manor in Passaic County show mortises that would fit on similarly-shaped wooden tenons (FIG. 8). It seems likely that the

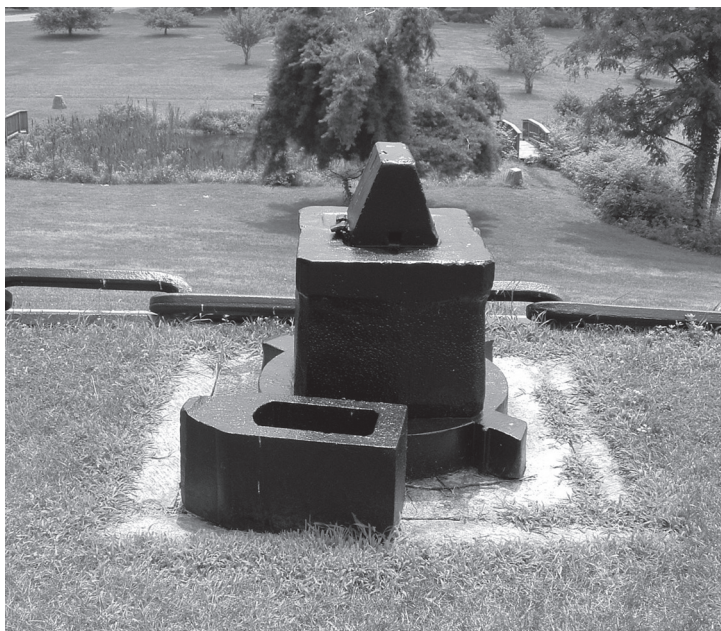


Figure 8. Anvil base, cam wheel, and hammer head displayed at Ringwood Manor State Park.



Figure 9. Accretion of iron and other material, possibly clay, that accumulated around or was placed around the anvil base.

anvil base supported the anvil under the trip hammer; alternatively, it may have supported a blacksmith's anvil. Found with the anvil base were two large metallic-looking objects, each of which had one concave surface. One of these objects had a wooden timber imbedded in it. At first, it appeared that these were fragments of iron worked in the forge; however, inspection with a simple magnet showed them to be much less magnetic than chunks of magnetite ore found at the site. Ultimately, it became clear that these were concretions of iron and perhaps clay and slag that had accreted around the bottom of the wooden anvil base (FIG. 9). In fact, they mirror the contours of the anvil base perfectly. It is worth noting that Roland Robbins in his excavations at the Saugus Ironworks found the wooden base of an anvil buried deep underground.

Packed around the anvil was a mixture of clay and slag (Robbins and Jones 1959: 65). Schenck (1992: 28) found that the anvil base at the Upper Forge at Valley Forge was supported by several spokes that braced the wooden base. There, the authors hypothesized that the anvil base was held in a cribwork of large timbers. At the Leddell Forge timbers 3 and 4 appear to have held the anvil in place.

The Waterwheel

A second extraordinary find was a section of a waterwheel. The portion recovered measures 9 ft long and 2 ft wide (FIG. 10). It was apparently preserved due to its location in waterlogged soils. Two of the spokes that would have formed the frame of the waterwheel, 12 loose fragments from the sides or shroud of the waterwheel, and numerous fragments of buckets were also found. Extrapolating from the surviving fragments it appears that the waterwheel measured 14 ft in diameter. Wood samples taken from the wheel and sent to the USDA Forest Products Laboratory in Wisconsin for analysis revealed that both the shroud and the buckets were made from *Quercus alba* (white oak) and that the pegs which held the major elements together were *Quercus rubrum* (red oak). Both species are locally available and due to their strength were widely employed in framing houses, barns, and other structures. The nails employed in the construction of the wheel include rose-head or hand-wrought nails and



Figure 10. Profile of the waterwheel.

hand-headed nails with machine-cut shanks (c. 1790-1820). The location of the waterwheel within the building is unusual in the Middle Atlantic (Personal communication Edward Lenik, 2006), however, it has been documented in Canadian forges (Samson 1998: 165). Based on the locations and form of the surviving buckets, it appears that the wheel was an over-shot wheel.

Framing Elements

In addition to the anvil base and waterwheel, six massive timbers comprising elements of the frame of the forge were recovered prior to the inception of the archaeological recording (FIG. 11). They range from 10 to 24 ft long and resemble the frame elements shown in illustrations of early forges, such as those in Diderot's *Encyclopedia* (Abrams 1978: 826-827) (FIG. 12). Timbers 1, 2, 3, 4, and 7 appear to have provided a support for the wooden anvil base and possibly the trip hammer. In fact, timbers 3 and 4 contain large semi-circular notches, with similar diameters as the wooden anvil base, strongly suggesting that they may have served to clamp the wooden anvil base in place (FIGS. 6 and 12). Three of the timbers, 2, 4, and 7, have worn areas. It is possible that the cam that turned the hammer, the hammer handle, or some other heavy item rested in these spots. Timbers 2 and 4 also show shims. It is unclear if these are repairs to strengthen or tighten the frame or if these represent original construction elements. The shims measure approximately 2 in thick and were attached with pegs. Possible evidence for burning is present on two of the timbers. It is not clear, however, if this is evidence that the forge building burned or is simply a byproduct of the work conducted inside the forge.

Tree-Ring Dating

In an effort to better date the structure, a tree-ring sample was cut from one timber (FIG. 13). The sample was processed at Columbia University's Lamont Dougherty Earth Observatory, where it was examined under a microscope. Although stained nearly black from immersion in water, it was clearly oak. The tree-rings were measured and entered into a computer program which allowed them to be cross-dated with five master chronologies

commonly employed in the Northeast. All five master chronologies yielded the same dates for the sample, an extremely rare occurrence that leaves little doubt about the accuracy of the date. The tree from which the beam was made began growing in 1552 and was cut 226 years later in 1788. It retains some sapwood or cambium, though it is possible that a few rings have been lost. If this timber was part of the support frame for the wooden anvil base and trip hammer, as suspected, it would have been prone to heavy wear and possible breakage. The shims present on Timber 4 may have been the result of attempts to better fit the timber into an existing frame. While the 1788 date does indicate that the forge was in operation during that time or slightly thereafter, the timber from which the date was obtained may have been part of a rebuilding or repair effort, and, therefore, does not rule out an earlier construction date for the forge itself.

Other Artifacts

Only a handful of other artifacts were recovered from the site. Contextual information for these artifacts is lacking. They include half a dozen hand-wrought nails and spikes, a fragment of transfer-printed pearlware ceramic (c. 1775-1840), and a stone bearing block. The bearing block would have supported the waterwheel's axle or the cam shaft (FIG. 14). It

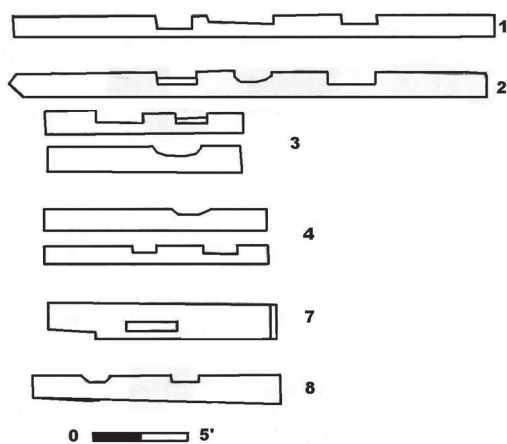


Figure 11. Profiles of the major frame elements recovered from the forge site. Numbers correspond with the interpretive plan map (Figure 6).

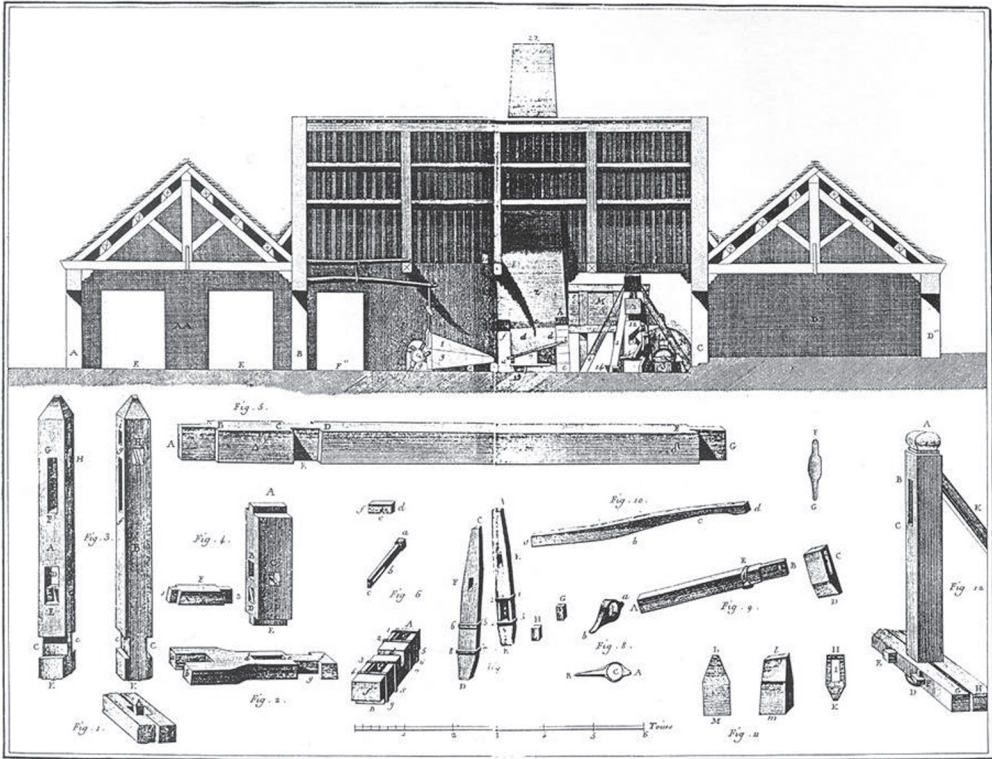


Figure 12. "Transversal Section of a Two-Fire Forge and Construction of the Hammer"
 Abrams (1978) *Diderot Encyclopedia: The Complete Illustrations*.



Figure 13. Timber 4. The sample for dating was cut from the end of this timber.

appears to be made from granite and is polished to a high sheen.

Numerous fragments of bloomery slag were noted in the field. Most of the slag was located between the forge's foundation and the Passaic River. The slag was ferrous and dark brown due to oxidization. According to Bachman (1982: 31), in the bloomery process,

As much as possible of the slag has to be removed from iron by liquation, and therefore the smelting process must take place at or above the temperature at which the slags become sufficiently fluid to drain away from the solid iron...The rest is removed by hammering while the slag is still in a fluid state.

Although quite irregular in form, it appears that much of the slag from the Leddell site is tap slag. Quoting Bachman (1982: 31), "...distinguishing between these types [smith, forging] is difficult. The presence of ore and/or tap slag at a particular site is evidence of iron smelting." Unfortunately, funding was not available to subject the slag samples to more rigorous chemical analysis. Several strongly magnetic fragments of magnetite ore were also noted. One piece was as large as a soccer ball. This makes sense given that "Rich ore is needed for bloomery smelting" (Gordon and Killick 1992: 142). Moreover, northern New Jersey was known for its rich ores.

At the Leddell Forge most of the slag consists of fist-sized fragments. Without further investigation a more detailed analysis is not possible. In some cases, slag can be used as a proxy measure of a forge's productivity. Essentially the volume of slag produced by a forge was equivalent to the volume of iron. Therefore, slag may be used to estimate the forge's iron output (Gordon 1995: 71, 1996: 24). At the Leddell Forge, the slag was not neatly clustered in piles, making this sort of estimation impossible.

The Leddell Forge in Context

Bloomery forges were once the most common iron production sites in North America. Early examples were constructed in Tidewater Virginia in the 17th century. New Jersey's first ironworks dated from the late-17th and 18th century. However, compared to blast furnaces, which have a nearly iconic association with ironworking,

bloomeries are largely forgotten. New Jersey, with magnetite, limonite, and hematite ores, was home to a significant iron industry in the 18th and 19th centuries. Only a handful of the bloomery forges that once dotted the landscape of northern New Jersey have seen archaeological study. Others include the Canistear Bloomery (Lenik 1965), Lower Longwood Forge (Lenik 1970: 12-21); Charlotteburg Middle Forge (Lenik 1974); and Captain James Gray's Forge in Little Falls (Lenik and Gibbs 1993). More recently, archaeologists have investigated forge remains at Picatinny arsenal (Rutsch 1999), and on Mosele Road in Mendham (Richard Grubb and Associates, Inc. 2004, 2006). Though unpublished, a large number of local forge sites have also been documented by Bierce Riley and Joe Macasek. At most sites, iron elements of the forge survive. At the Leddell Forge, the ironwork seems to have been removed or scavenged but, thanks to a waterlogged environment, wooden elements survived. The most impressive pieces relate to the anvil base cribbing and the forge's trip hammer hurst frame. Both were constructed with massive beams



Figure 14. A granite bearing block to support a water-wheel axle or cam shaft.

and the latter would have resembled a giant sawhorse spanning the width of the building (Samson 1998: 174-175). Large legs supported a huge horizontal beam. The trip hammer would have been located beneath the main beam of the hurst frame, and the camshaft which drove the hammer would have been situated close by. The frame absorbed the pounding of the trip hammer while protecting the integrity of the forge building.

The Leddell Forge is similar in size to other local forges. It was a boxlike structure measuring 39.5 ft long and 42.6 ft wide. Other documented New Jersey forge sites have slightly smaller dimensions: a possible forge at Lower Longwood Forge measured 39.5 ft long by 27.5 ft wide while the Canistear Bloomery measured 32 ft by 17 ft (Lenik 1965: 273). The closest match is the Upper Forge at Valley Forge, which had approximately the same dimensions (Schenck 1992: 26). The Leddell Forge may have had only one fire, a reddened patch of soil was noted near the northwestern corner of the forge. What is possibly the base of the hearth or conceivably a support for machinery extends roughly 5 ft south into the structure near its northwestern corner. Most New Jersey forges during this period employed what was called the German

bloomery, in which crushed ore was smelted in an iron-bottomed, rectangular hearth (Gordon 1996: 95). A single fire operation of this type would have fit comfortably within the Leddell Forge.

The dam, at 12 ft in height, was just slightly taller than the ten-foot high dams of the Canistear Bloomery (Lenik 1965: 270) and the Lower Longwood Forges (Lenik 1970: 14). Like the dam at Lower Longwood Forge it measured 25 ft wide. The tailrace is quite informal and does not show the carefully laid cut and dressed stone associated with other forges (see Lenik 1970: 14). There is no evidence for a headrace. Presumably water was brought directly over the dam to the overshot-type waterwheel or wheels by a wooden flume. Although the presence of the well-preserved section of water wheel is surprising, the fact that there was no second waterwheel to power the bellows is curious. Very few other artifacts were recovered from the site. A handful of hand-wrought nails and spikes were found, as were fragments of hand-made bricks, one fragmentary socketed chisel, and a bent iron bar, possibly used to support work within the forge. One piece of pearlware (1775-1840) was found in the backdirt pile from the excavation. The anvil, hammer, and cam or cams were all



Figure 15. The stabilized forge site as it currently appears.

missing and could have been salvaged for reuse elsewhere. It seems quite likely that the usable metal was scavenged from the site, at or after its abandonment.

The Leddell Forge is an unusual and important archaeological site. Constructed in the 1770s or 1780s, it operated into the early-19th century. This was the heyday of the charcoal-fired iron industry in northern New Jersey. By the 1820s deforestation caused many small forges to close for want of fuel. The completion of the Morris Canal in 1831 only partially alleviated this situation. It carried anthracite coal from the mines of Pennsylvania to the industries of northern New Jersey and New York. Although some of northern New Jersey's iron mines were worked well into the 20th century, the once ubiquitous forges never returned to their former prominence. This contrasts with other areas which saw different industrial trajectories. In the Adirondacks, larger hearths and the adoption of hot blast technology greatly increased productivity and efficiency (Gordon 1996: 99). Bloomers there remained active into the late- 19th century (Allen, Dawson, Glenn, Gordon, Killick, and Ward 1990: 3-20).

Small scale industries, like the Leddell Forge, represent an important stage in American industrial development. In early America, enterprising local landowners, such as Dr. William Leddell, invested in local industries. This forge, operated by tenants, perhaps with the assistance of enslaved African Americans, took advantage of a fortuitous combination of ecological factors: accessible water power, woodlands for fuel, and iron ore deposits, and supplied a regional market for wrought iron. Although individual factors, such as the death of James Frost, likely contributed to the forge's demise, broader trends, including the development of larger more efficient ironworks employing coal for fuel and regional deforestation may have contributed to the decision to abandon the site. Scavenged after its abandonment, and largely forgotten, a surprising amount of the building and its internal elements have survived to the present day. Today, the site is stable. Its walls have been sympathetically reset and the wheel-pit and tailrace rewatered (FIG. 15). Despite considerable disturbance due to landscaping, the wooden remains recovered from the site retain

considerable potential to provide new information about forge construction and operation. The Leddell Forge serves as a reminder of the importance of small-scale rural industries and of the potential that sites associated with these industries hold.

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