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Reclamation is a Long-Term Prospect: Lessons Learned at Prince William Forest Park, Virginia

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Introduction

Prince William Forest Park, a unit of the National Park Service (NPS), is located in Triangle, Virginia, approximately 30 miles south of Washington, D.C. The park protects 15,000 acres of Piedmont forest and 70% of the Quantico Creek watershed. It is used primarily for passive recreation, including hiking, biking, and camping. One of the most heavily visited areas in the park is the Cabin Branch Pyrite Mine site. Waysides located at the site tell the story of the large pyrite mine that operated in the late 19th and early 20th centuries.

Pyrite was first discovered in Quantico Creek in 1890, and the Cabin Branch Pyrite Mine began operation in 1889 in the southeastern corner of what is today Prince William Forest Park. Pyrite (iron sulfide) was mined for its sulfur content, which was used in the production of sulfuric acid, gunpowder, and many other products. From 1908 to 1920, more than 200,000 tons of pyrite were excavated from the pyrite lens, which was estimated to be 1,000 feet long and up to 14 feet wide. There were eight shafts, a narrow-gauge railroad, and 70 buildings associated with the mine (Mountjoy 1978). After the mine closed in 1920, the site was abandoned, and aerial photographs taken of the site in 1937 and 1954 show it to be barren with a few small patches of vegetation.

Early studies and reclamation efforts

Prior to reclamation, the site contained approximately seven acres of primarily barren, acidic soils spanning both sides of Quantico Creek, and water quality at the site was very poor due to acid mine drainage and heavy metal contamination. Eight reclamation projects and/or studies were undertaken between 1971 and 1994 at the Cabin Branch Pyrite Mine site. Management efforts during that period were focused around stabilizing the stream bank and leaving the rest of the site barren for environmental studies and experimentation by park visitors, researchers, and youth groups.

The first documented soil samples were taken on site in 1971 by James Patterson, an agronomist working in the NPS National Capital Region's Professional Services Division. The pH was found to be around 2.8, and lime and fertilizer applications were recommended (Patterson 1971). No follow-up work was documented in park files. In 1980, superintendent Robert Harney requested additional assistance from Professional Services staff, stating that "In the last few years, the area has been subject to extensive erosion…. The pyrite ore is highly acidic and is continually exposed by precipitation and erosion."

Twenty-seven research plots were installed at the mine site in the summer of 1980. Nine different reclamation techniques involving varying concentrations of fertilizer, lime, compost, and a combination of lime and compost were evaluated. Grass seed was planted in each plot; the best results were observed in those plots treated only with compost. Soil samples

showed pH values ranging from 2.0 to 3.9, and concentrations of soluble salts ranging from 1,800 to 2,560 ppm (Patterson et al. 1984). As part of this three-year study, the researchers also measured the depth of overburden at the site and found depths ranging from 8 inches to more than 36 inches. Overburden is defined as a mixture of pyrite, sulfur compounds, soil, stone, and rock fragment. They noted that the soil had been moved often during the life of the mine and that the spoils had been used as fill for grading (Patterson et al. 1982).

Subsequent efforts included the development of a site rehabilitation plan by park staff; a stream bank stabilization project performed by a group of Eagle Scouts; a Virginia pine transplant study conducted by L.K. Thomas, research scientist in the National Capital Region; and an abandoned mineral lands field inspection and site reconnaissance visit conducted by Bob Higgins, chief of the Mineral Resources Section of the NPS Mining and Minerals Branch, and Phil Cloues, a mining engineer. During the latter site visit, several old mine shafts were identified by their concave appearance on the landscape, and erosion problems along the stream banks were noted. Higgins and Cloues recommended that all shafts be located and drilled to determine how they were capped, that soil and water samples be collected and analyzed for metals and pH, and that warning signs be posted at the site (Higgins 1989).

In the early 1990s, Prince William Forest Park began planning for a full-scale reclamation of the Cabin Branch Pyrite Mine site. This period marked a shift in management focus from stream bank stabilization to total site remediation. The impetus for this shift was a change in Environmental Protection Agency (EPA) regulations, which now included acid drainage from abandoned mines as nonpoint source pollution. Assistance was requested from the NPS Water Resources Division, which funded a project that collected and analyzed groundwater, surface water, stream sediments, and soils. Several metals were found at concentrations that exceeded EPA standards, pH values ranged from 6 to less than 3.5, and the mine site was found to be impacting the local aquatic ecosystem (Resource International Ltd. 1993, 1994).

Site reclamation

The primary non-NPS partner for the reclamation project was the Virginia Department of Mines, Minerals, and Energy (DMME), which helped secure funding and develop reclamation project specifications based on previous work at abandoned pyrite mine sites. National Park Service staff from the Water Resources Division, Geologic Resources Division, National Capital Region Center for Urban Ecology, and Prince William Forest Park worked closely with the DMME to ensure that the project was in line with NPS policies and to review and update specifications. The goals of the project were to eliminate impacts on natural resources, ensure the safety and health of park visitors and staff, and bring the area into compliance with the Clean Water Act.

In 1995 the park began a $152,000 multi-agency reclamation project with funds from the EPA's Non-point Source Program, the NPS Geologic and Water Resources Divisions, the DMME, the Virginia Orphaned Mines Program, the NPS National Capital Region, and the Virginia Department of Conservation and Recreation. The reclamation included sealing eight mine shafts with reinforced cement caps, pulling back all tailings within 20 feet of the

stream banks and storing them against a high wall on site, leaving the other tailings piles in place, and treating all tailings with agricultural lime at a rate of 20 tons per acre and covering them with approximately one foot of clean topsoil. Stormwater conveyances were constructed to divert surface water away from the tailings piles, and 3,500 trees and 500 shrubs were planted.

Post-reclamation studies and follow-up efforts

Disturbed lands reclamation is a long-term process that requires numerous studies and efforts both before and after the main reclamation work. There is no quick fix and the Cabin Branch Pyrite Mine is a prime example of this. The reclamation project is considered to be a success and has been highlighted as such by the Environmental Protection Agency (EPA 2002) and the DMME. Post-reclamation, ten studies have been conducted by universities, federal agencies, and park staff; these have evaluated the success of different aspects of the reclamation project. Highlights from several of the studies are provided below.

During the period 1997–1999, a two-year post-reclamation water quality study was conducted by researchers from George Mason University. The data collected showed a decrease in heavy metals in Quantico Creek, an increase in the number of fish species and individual fish in the creek, and an increase in the pH of the creek to a level that is now capable of supporting aquatic life. Benthic macroinvertebrate data showed assemblages that varied from nonimpaired to moderately impaired (Hamblin-Katnik et al. 2000), and data collected at the site as part of Prince William Forest Park's in-house water quality monitoring program show that diversity is improving in this area.

The U.S. Geological Survey (USGS) has performed several studies on site. The first was a one-year (1997) surface water and groundwater study in which quarterly samples were taken and compared with those taken at a control site. The control site was located in an area with a large pyrite belt that had never been mined, thus providing a reference for what would be natural background levels. All samples fell within the field of those taken at the control site (Seal 1997). In 1999, the USGS performed a ground electromagnetic survey that used soil conductivity to map the distribution of sulfides. They found that the highest conductivity zones were associated with the tailings piles and that the creek and stream banks were low-conductivity areas (Wynn 2000). Finally, the park worked with the USGS on a three-year project during the period 1999–2001, which demonstrated that the stormwater conveyance and associated ponds were effectively capturing runoff, and several of the ponds were providing suitable habitat for amphibians (Pollio 2001).

In September 2004, over 100 soil samples were collected by park staff with assistance from Greg Eckert, an NPS restoration ecologist, in response to a trip report written after a 2002 site visit. Eckert noted that "[t]he site is stable today; however, a nonnative species of lespedeza is the primary ground cover. A 'hot spot' also remains on the east side of the creek. This area is devoid of vegetation and water samples taken from the storm water runoff channels show high concentrations of metals.... Virginia pine is colonizing the site from one side, while other tree plantings appear to have had total failure" (Eckert 2002). The purposes of this project were to evaluate the integrity of the lime cap, determine the soil conditions where the site is barren and compare them with the vegetated areas, and provide data to determine

what soil amendments may be needed. Preliminary results indicate that soil on the west side of the creek is intact and functioning, and remaining bare areas may be evidence of erosion from surface runoff. These need to be addressed, but will not require major application of lime and soil. Soil sample pH in the samples from the west side ranged close to neutral. The east side of the creek may need additional reclamation efforts, as numerous acidic hotspots were identified in that area. The data are currently being analyzed by Ken Gerow, statistician with the Statistical Consulting Center at the University of Wyoming. Additional studies, including mycorrizhal fungal assessment of abundance, morphotype identification, and innocula increases, are being conducted through the Rutgers University Pinelands Research Station.

Conclusions

Ten years after reclamation, follow-up efforts to treat barren sites and continued monitoring are still required. Conditions at the Cabin Branch Pyrite Mine have improved dramatically, but the site is still far from being fully restored. Prince William Forest Park staff remain in contact with NPS Natural Resources Program Center staff, and with the DMME, and are encouraging additional research on this unique site.

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