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Living in a Ghost Town: Iron-Cycling Bacteria in the New Jersey Pine Barrens

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The New Jersey Pine Barrens is the largest remaining example of the Atlantic coastal pine barrens ecosystem and a distinguishing feature of the coastal plain of southern New Jersey. The region is characterized by its nutrient-poor, sandy soil and iron-rich, acidic waterways. The delivery of reduced iron from underlying anoxic aquifers to the oxygenated surface leads to the precipitation of iron(III) oxyhydroxide or “bog iron” deposits, which supported a thriving ironworks industry throughout the 18th and early 19th centuries. While bog iron formation in the Pine Barrens is a well-documented phenomenon, the biogeochemical processes driving iron cycling in this environment are not well-understood. Previous experiments demonstrated that the formation of iron oxyhydroxide ore is driven by the activity of iron-oxidizing bacteria; however, these studies were performed prior to the advent of next-generation DNA sequencing and relied on microscopy to identify bacteria of interest. Microbial iron-cycling mechanisms and community dynamics in Pine Barrens waterways remain poorly characterized.

We collected iron oxyhydroxide microbial mat samples from three historic iron forges within three watersheds in the New Jersey Pinelands National Reserve: Martha’s Furnace (Oswego/Wading River), Batsto Village (Mullica River), and Weymouth Furnace (Great Egg Harbor River). Microbial mat samples and accompanying geochemical data were taken at multiple locations at each site. DNA was extracted from each sample and subjected to third-generation sequencing using nanopore technology for metagenomic analysis. Metagenomic data revealed a diverse community of iron-oxidizing and iron-reducing bacteria coexisting within the fluctuating redox conditions that characterize bog iron seeps. Multiple iron-oxidizing species and strategies were identified that were not detected by previous studies, including microaerophilic (*Sideroxydans*, *Ferriphaselus*, *Sphaerotilus*), nitrate-reducing (*Acidovorax*, *Bradyrhizobium*), and phototrophic (*Thiodictyon*, *Rhizobiales*) iron-oxidizers. We also found that microbial community structure and the relative abundance of microaerophilic, nitrate-reducing, and phototrophic iron-oxidizer clades varied greatly across sampling sites. The breadth of iron-cycling strategies displayed in our data suggests that the bog iron seeps host diverse microbial communities based on iron redox cycling. Our results demonstrate that the Pine Barrens offers a historically significant and understudied habitat to explore the biogeochemical relationships between iron-cycling bacteria and their environment.