

Black to the Future: Biochar and Forests

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Soil Restoration with Biochar

Healthy soils play a critical role in supporting healthy forests, serving as the foundation for roots and essential ecosystem processes. Biochar is a useful land management tool for improving soil health. Soil health is a soil's ability to function as a living system, sustaining biological productivity, environmental quality, and the health of animals and humans. Healthy soils provide clean water, air, gaseous exchange, nutrient cycling, and hydrologic functioning.

Soil Health Basics

Soil organic matter (SOM), which is approximately 50% soil organic carbon (SOC), is critical to soil health. Generally, a SOM content of about 1-2% in the rooting zone is a critical threshold for soil aggregation, water holding capacity, aeration, and nutrient retention. When soils lose organic matter, they fail to function adequately, slowing down nutrient cycles and becoming prone to wind and water erosion. Such decline in soil health reduces ecosystem resilience, making the ecosystem more susceptible to increases in non-native or invasive species, drought, and tree mortality. In addition, soil health degrades when vehicles and machinery cause excessive soil compaction, vegetation is removed to increase erosion, salts accumulate when precipitation is insufficient to leach ions through the soil profile, or there is a loss of surface organic horizons. Such declines in soil health often ripple through forest ecosystems, increasing risk of tree and other vegetation mortality from larger disturbances such as drought, wildfire, disease, and insect outbreaks.

How Biochar Builds Soil Health

Biochar application is a land management tool that can restore soil function and health. Produced by burning woody biomass at relatively low



temperatures in an oxygen-limited environment, biochar is a charcoal-like material that has useful properties as a soil amendment. In forest soils, the addition of biochar can enhance water holding capacity and availability, foster a diverse microbial community, and increase soil organic matter, cation exchange capacity (nutrient retention) and soil pH. The impact of biochar on soil is influenced by its own properties, the characteristics of the soil, and their interaction with the local climate. The greatest benefits of biochar are observed when it is applied to low fertility or acidic soils.

Biochar amendments change soil health primarily through two mechanisms: (1) physiochemical processes, such as nutrient cycling, fertility, and soil structure, and (2) biological processes, including the activity of soil fauna, food webs, and microbial enzymes. These combined effects can promote vegetation growth. However, it is important to note that the initial addition of biochar to the soil may temporarily immobilize nutrients, potentially leading to a minor and short-term reduction in plant growth. Over time, biochar further enhances soil structure through sustained additions of dissolved organic carbon that can stabilize aggregates and increase microbial activity. Soil structure, characterized by the presence of macro- and micro-pore spaces, plays a crucial role in regulating the flow of water and nutrients in the soil solution that plants and microbes rely upon.

When forest soils experience disturbances such as harvest, wildfire, drought, or infestation and disease, the inputs of organic matter decrease, and

Pollinator Habitat in Log Landings



The Pollinator Habitat in Log Landings (PHiLL) project uses biochar to decrease soil compaction on log landings and promotes pollinator habitat. This project was initiated by Northern Research Station scientists in cooperation with the Hoosier, Shawnee, and Mark Twain National Forests. In 2021, log landings on all three forests measured about 29% bare ground cover, with 2022 showcasing only 5% bare ground cover post-biochar application. These forests also demonstrated increased plant available phosphorous, total carbon stocks, and higher biomass quantities. This work is being duplicated by Rocky Mountain Research Station researchers on the Siuslaw National Forest. Learn more about PHiLL [here](#).



Spreading biochar across a log landing on the Shawnee National Forest. Biochar amendments can improve soil health and increase vegetation growth. USDA Forest Service photo by Lauren Pile Knapp.

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the soil is exposed to warmer temperatures, which increases decomposition of surface and mineral soil organic matter. This loss of SOM can have negative effects on soil health and forest ecosystems. Biochar amendments can bolster soil health by improving soil physical, chemical, and biological processes which leads to additional water storage capacity and nutrient availability. For example, biochar may ameliorate soil compaction and improve the success of native plant species. In addition, biochar is carbon rich and slow to decompose, providing a robust, natural pathway for carbon sequestration within forest soils.

Soil Properties & Biochar

While microbes may be slow to decompose biochar, biochar fractures and disperses through forest soils. After entering the soil, water moving across and through the biochar further dissolves the organic and mineral compounds. These solutes increase dissolved organic carbon, cations and anions in the soil solution, and may subsequently increase electrical conductivity and pH. The extent of change depends on soil and biochar types, but generally occurs much faster in acidic soils. Over time, this dissolution spreads the physical and chemical effects of biochar through the soil, helping to improve soil structure and nutrient cycling. It is important to note that the potential effects of biochar may differ between soils, given that soils can have different physical and chemical properties, and so too can biochar. For instance, water storage and availability are governed by soil texture (finer textures hold more water), thus biochar additions to coarse-textured soils are likely to have greater effects on plant available water relative to fine-textured soils.

Restoration with Biochar

Restoration uses for biochar include enhancing native plant production or planting, riparian restoration, remediation of abandoned mine sites, restoring soil structure after road decommissioning, and decompacting skid trails and log landings to support pollinator plants and insects. When restoration sites are in proximity to harvest areas, producing biochar on-site can help mitigate the excess fuels that increase wildfire risk and facilitate its application to nearby sites. A variety of methods exist for creating biochar on-site, including the use of hand piles, kilns, and air curtain burners that reduce emissions and fire risk.