Biochar: How to Turn Your Brush Piles into a Beneficial Product

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Solving the megafire crisis of the 21st Century is going to require coordination between the diverse groups of forest stakeholders in the Pacific Northwest. There are 10 million acres of forestland in eastern Washington, and 3 million of these forested areas are significantly overstocked, with an imminent risk of a high-severity fire or insect outbreak occurring. Climate change, and the probability of a dry summer and extended fire season, is increasing the risk of a major forest health disaster.

A traditional slash pile contains the non-merchantable waste of a forest health treatment in eastern Washington. (Photo by Sean Alexander, WSU Extension Forestry)

However, forest health treatments, including thinning suppressed trees and dense fuel loads, can be costly, as the material is often not commercially viable. It is essential that as land managers actively work to facilitate a resilient forest in the future, we implement diverse approaches, considering effectiveness, economic viability, and multiple uses.

One product that land managers can potentially use to offset operational costs is biochar, a carbon-sequestering product created with low-oxygen fires that provides a host of soil benefits, too.

The fires used to create biochar are different than the traditional slash piles burned on site to reduce fuel loads following a thinning project.

Although burning slash is cost-effective, it does have drawbacks – standard pile burning releases large amounts of carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), and particulate matter into the atmosphere. This leads to poor air quality in spring and fall months, and the net carbon emissions remain the same as if the material burned in a wildfire.

The piles, which burn and smolder for long periods of time and at high temperatures, can create hydrophobic soils that do not retain water well. With the complete consumption of woody and herbaceous fuels on the forest floor, important organic nutrient inputs that maintain a healthy soil composition are lost.

To understand what biochar is and how to create it, you need to look at the combustion process – the consumption of oxygen and organic fuels, which ignite under a heat source. These organic fuels typically consist of active carbon, which is a core component in many living cells. Very rarely does full combustion occur, which releases aerosolized smoke particulates and heavier solid particulates. In an oxygen-rich environment, the carbon in the fuel combines with oxygen in the atmosphere, leaving primarily as carbon dioxide, and ash is produced. Ash is mostly the remnants of the minerals present in the fuel that could not combust in the process.

Biochar is a similar solid byproduct of combustion. However, biochar occurs when oxygen is limited in the process, and the fuel materials transform into inactive carbon, which remains stable for an extended period. Although the exact length of storage is highly variable and not fully known, estimates range between 1,000 and 10,000 years.

Biochar has several properties that make it different than highly volatilized ash. In addition to its stored inactive carbon, biochar is highly porous, which gives it a high capacity to store water, inorganic nutrients, and organic matter such as fungi. Biochar is basic (high pH) and can be added to highly acidic soils to increase the pH. Finally, biochar has a negative charge. Much like a battery that attracts opposites, negatively charged materials will attract positively charged nutrients, which are called cations. This property is called its cation exchange capacity. These characteristics make biochar a potentially powerful tool as a soil amendment to restore a degraded site or additive to increase biomass production.

A biochar fire is burned as part of a demonstration with the Kalispel Tribe of Indians, The Lands Council, Resource Synergy, and WSU Extension Forestry. (Photo by Sean Alexander, WSU Extension Forestry)

The Lands Council, a nonprofit working to preserve and revitalize Inland Northwest landscapes, uses biochar as a remediation tool in partnership with several organizations. To help filter out toxic PCB compounds, from the Spokane watershed, they have worked to build stormwater gardens lined with biochar. The intention is to bind with and hold the PCBs as they infiltrate through the soil.

"We strive to create conversations about biochar and get people together to see the process, how biochar works, and how effective it can be," said Adam Gebauer, the council's public lands program director.

Recently, The Lands Council has partnered with the Kalispel Tribe of Indians to put on demonstrations on biochar production.

Although biochar may sound like a silver-bullet tool, biochar production does have challenges, too. The resulting product and yield can be highly variable and depends upon five factors in the combustion process: temperature, air flow (oxygen), time, parent material, and post-treatment, according to Gloria Flora, co-author on the biochar report "Biomass to Biochar" and founder of the U.S. Biochar Initiative.

The optimal temperature for biochar to develop is between 400-700 degrees Fahrenheit. Too low of a temperature and the biochar won't form its unique structure. Too high of a temperature and the yield of biochar will decrease or turn to ash. To achieve this, the pile is lit from the top and burns downward, allowing convective heat to rise above the fuel, only breaking down the material underneath through radiative heat. When looking at time of combustion, yield increased with the length of time.

"It's important to understand that not all biochar is created equal," Flora said. "Different parent materials will produce different forms and amounts of biochar. It is important that the parent material is dry and clean, without any soil particulates, municipal waste, treated wood products, or plastics."

One major challenge when producing biochar is the limiting of oxygen to create the necessary anaerobic conditions. Although a traditional "conservation burning pile" can produce biochar, the yield is often low.

Flame-cap kilns have been produced to house the material. As the air rises from the flame at the top of the pile, oxygen is pulled across the top, but it cannot penetrate the lower portions of the kiln. One benefit of the flame-cap kiln is that gases pass through the flame after they are released from the fuel in the burning process, creating a second ignition point to further combust the aerosolized material, limiting the smoke production.

These metal burning containers can be simple to make. However, they are often large and cumbersome, meaning that it can be difficult to transport the kiln across the landscape to burn individual piles where harvests occurred. For high-yield industrial purposes, closed-loop systems that have an oxygen-controlled environment have been created, but these are costly and often large.

Ultimately, the total yield of biochar from the initial biomass is the largest factor in production. Estimates range from 10 to 15 percent in standard production, up to 20 to 25 percent in the most efficient pyrolysis kilns.

Although small-scale, or place-based, production can be beneficial for small forest landowners who will use the product on-site – whether for gardening, agricultural production, or carbon storage on the landscape – the inefficiency has several implications for scaling biochar production to larger treatment projects or commercial production. Large landowners, like the Kalispel Tribe of Indians, who manage several thousand acres of forestland, understand the need to minimize the costs of fuel treatments in dry forests and the need to find a solution to capture and store carbon, according to Ray Entz, the tribe's natural resources manager for the tribe.

"As a land manager, adaptive management to do better work is our goal, and if producing biochar is a better method of slash abatement through its beneficial uses in soil augmentation, water holding capacity, and carbon capture, then we will look into how to implement that," Entz said.

However, it is important that implementing biochar creation is not detrimental or costly to the Kalispel Tribe in the long term.

"Due to the sheer amount of acres that we need to thin, unless you have a fleet of volunteers, it was difficult to meet the extra cost of producing biochar commercially," Entz said.

This economic scaling issue is something that Erik Makinson, the founder and president of Resource Synergy, is attempting to tackle.

"We know that there are plenty of acres of forestland that need to be thinned, and we know there are plenty of market opportunities where biochar can be applied, it's solving the issues in the middle, such as barriers to entry, labor demands, production efficiency, and transportation logistics, that need to be met," Makinson said.

Given the carbon offset benefit of producing biochar and storing it in the soil, one idea that Makinson hopes to see come to light is the introduction of carbon credits.

"I could imagine a scenario in the future where a small forest landowner borrowed a flame-cap kiln, produced biochar from their thinning, and documented the amount of biochar they generated," Makinson said. "We can then monetize the carbon sequestration value and provide a rebate back to the small forest landowner."

This will then provide an incentive to both thin forests to reduce overstocked stands and to manage the residual slash in a way that has a benefit to the environment and climate impact, while providing a beneficial resource to other market applications.

Regardless of the benefits or drawbacks to producing biochar, slash management will remain an ongoing management concern for the foreseeable future. Once we can crack the scaling issue for production, then we will begin to see a returnable offset for landowners who are actively working to make their forests more resilient to future fires and climate change.