Ecosystem Service Restoration Handbook

Howard EcoWorks
9770 Patuxent Woods Drive
Columbia, MD 21046

06/25/2024

Introduction

This Handbook was made possible with funding from a Howard County Innovation grant. The work was led by Lori Lilly of Howard EcoWorks, and interim Environmental Sustainability Intern, Jazlyn Benitez, during October 2023 through June 2024. The purpose of this Handbook is intended to help educate Howard EcoWorks crew members and the public on relevant topics concerning ecosystem service restoration. Many of these topics covered are utilized on a daily basis at Howard EcoWorks, and this Handbook helps serve as a ground level introduction to many of these concepts.

Table of Contents

Acknowledgements **2**

Table of Contents **3**

Management for Ecosystem Service Benefits: Overview **4**

What are Ecosystem Services? 4

Examples of Ecosystem Services 5

Why link stormwater management and climate mitigation? 7

Management for Ecosystem Service Benefits: Soil **8**

Determining Healthy VS. Unhealthy Soil Indicators 8

Implications of Stripping Topsoil During Development 9

Implications of Soil Compaction 9

Problems with Utilizing Grass 9

Management for Ecosystem Service Benefits: Biochar **10**

What is Biochar? 10

Commercial vs. Kiln-Produced Biochar 11

Management for EcoSystem Services: Biochar Applications (Cloverly, 2024) **13**

Biochar Applications for Howard EcoWorks: Gardens 13

Biochar Applications for Howard EcoWorks: Composting 14

Biochar Applications for Howard EcoWorks: Urban Landscapes 14

Additional Biochar Applications: Agriculture and Water Treatment 15

The Business of Biochar 15

Management for Ecosystem Benefits: Forests/Woodlands **16**

Impact of Invasive Species 17

Creating Biochar Production from Local Invasive Species 17

Invasive Species suitable for Biochar in the Mid-Atlantic Region 18

Management for Ecosystem Benefits: Streams **19**

Identifying Healthy VS Unhealthy Streams 19

Logistics to Stream Enhancement and Restoration 20

Management of Headwaters - First Order Streams 20

Appendix A: Educational Fliers **22**

Management for Ecosystem Service Benefits: Overview

What are Ecosystem Services?

Ecosystem services are the natural resources provided by Earth that serve a purpose to all forms of life. These natural resources are also heavily relied on for other basic necessities of modern human society, otherwise known as benefits. All aspects of life link back to one or more ecosystem services, and are the cause of human overall health, food and water, security, and the source of driving commodities in our economy.

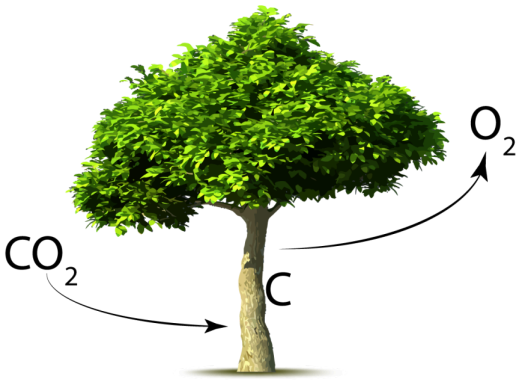
Many ecosystems services are invisible and humans often don't take notice and may take it all for granted. Nonetheless, how we take care of our community and manage the land surrounding, i.e. the water, land, soil, and air, has a direct impact on the ability of our ecosystem services to thrive and the benefits humans reap every day. Climate change in recent years has altered these ecosystem services with intense weather events, higher pollution levels, and an increasing human population requiring more land development.

The benefits received by ecosystem services are threatened by climate change. Advancing the resiliency of our ecosystem services is imperative in mitigating the effects of climate change and retaining the ecosystem benefits that are heavily relied on. The chart below illustrates the factors of an ecosystem service: the natural resources, the benefits to humans, and the drivers of change for our natural resources (EPA, 2024).

(EPA, 2024)

Examples of Ecosystem Services

I. Carbon Dioxide Storage

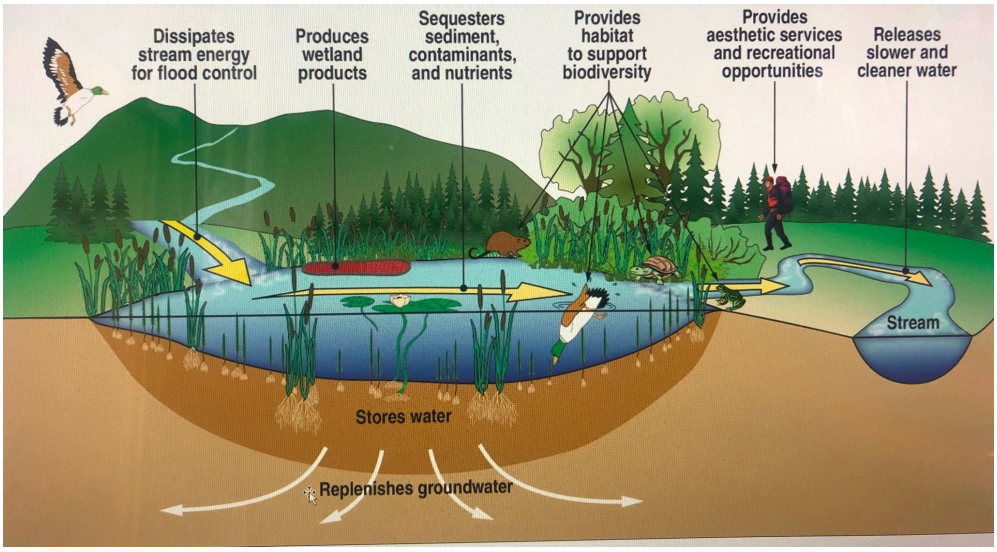


(Replant.ca, n.d)

By sequestering greenhouse gas emissions, our ecosystem services are able to regulate the global climate. For example, as trees and plants need CO2 to grow, in doing so, they remove carbon dioxide from the atmosphere and lock it away into their tissue (National Park Service, n.d). Trees and plants then emit clean oxygen in the atmosphere. Trees and plants are considered the best natural carbon sequestration method, and have become an increasingly popular method in environmental restoration practices.

Oceans are also considered a carbon sink and ecosystem service, and naturally sequesters up to 31% of CO2 emissions every year (NOAA, 2022). However this can cause ocean acidification over time, which harms our marine ecosystem and fisheries industry.

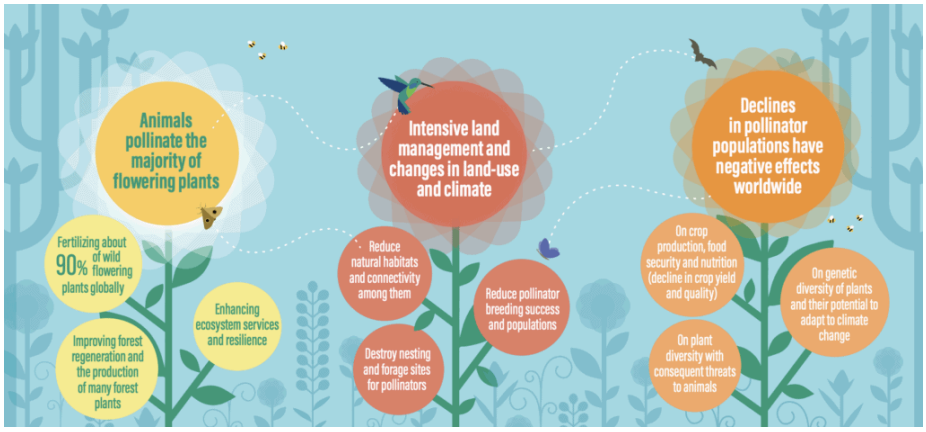
II. Improving Water Quality



(Rozelle, 2019)

Ecosystem services, such as Wetlands, filter effluents and decompose the waste though microorganisms. This eliminates any harmful pathogens for both humans, animals, and plants. In this process, habitats for life are created, groundwater is replenished, and recreational activities for humans are nurtured. Ensuring that restoration efforts assist these ecosystem services is vital in the success of natural freshwater filtration systems (NOAA, n.d).

III. Pollination

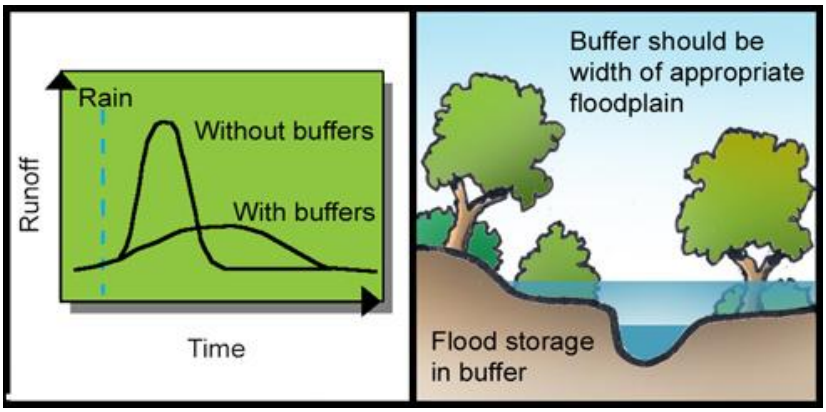


(CIAT, 2021)

Did you know that bees, birds, and bats account for 35% of the world's food production? Pollinators are responsible for about 75% of output for the leading food crops worldwide. Insects and pollinators are a natural way to plant and spread trees and plants, which is essential to the development of fruits and vegetables. Pollinators are also responsible for orchard, horticultural, and forage productions as well (Porto, et al. 2020).

As the figure above shows, pollinators serve an important purpose in enhancing ecosystem services and resiliency, and ineffective land management combined with the effects of climate change will have a vast negative impact on food security.

IV. Flood attenuation



(USDA, n.d)

Many ecosystem services, as well as living organisms, are responsible for creating buffers of protection against natural disasters. Whenever natural disasters occur (floods, storms, tsunamis, avalanches, landslides, and droughts), there are natural ecosystem benefits to mitigate the damage by reducing peak flows and lessen downstream flooding. When human developments destroy these services, then the runoff and physical damage caused by any natural disaster increases. The width of the buffer should correspond to the width of the concerned floodplain, for more information visit the USDA's National Agroforestry Center.

V. Biodiversity

(Price, 2023)

Maintaining biodiversity directly helps protect our ecosystem services. For example, without beavers to create dams in lakes and rivers, and without bees and insects to pollinate the plants and trees that produce vital fruits and vegetables, then humans would be impacted with more flooding and less food to sustain themselves. Protecting our biodiversity is crucial and often requires the maintenance and a balance of our land, water, and atmosphere (FAO, 2024).

Why link stormwater management and climate mitigation?

Climate change and the warming of our planet is directly linked to more frequent and intense weather events. After extreme weather, storm water is produced, which is the melted snow or rainfall that runs off of streets, lawns, and other sites. The intensity of storm water runoff is important to mitigate for it can cause many more pollution problems.

Our current municipal stormwater management system is overwhelmed from the increased intensity and frequency of storms. Stormwater itself can also collect sediment, nutrients, and other pollutants, which can jeopardize the water quality for drinking and the general quality of the water. To aid, stormwater management is crucial in mitigating the impacts

of stormwater in our community. Finding solutions to assist our natural ecosystems in properly draining runoff from storms can minimize the amount of stormwater and flooding in our streets, lawns, and other public spaces.

Management for Ecosystem Service Benefits: Soil

Determining Healthy VS. Unhealthy Soil Indicators

Healthy Soil	**Unhealthy Soil**
	
Dark and Rich in Color, indicates presence of organic matter	Light and Pale in Color
Crumbly texture, allowing air and water movement	Compacted and hard texture
Earthy smell, indicator of organic matter decomposition	Sour and unpleasant smell
Teaming with life, such as earthworms, fungi, etc.	Lack of presence of life
Good water absorption, preventing erosion	Poor water retention
Resistant to pests and diseases, promotes biodiversity	Susceptible to pests and diseases

In addition to referencing the chart above on the basic characteristic differences of healthy vs. unhealthy soil, it is important to consider the main principles of soil health as well. Soil that is healthy is also productive, and able to provide basic ecosystem services to those dependent on it. In forest restoration management, it is important to ensure that the project is

helping to maximize living roots, maximize soil cover, maximize biodiversity, and minimize disturbance (USDA, n.d).

Implications of Stripping Topsoil During Development

Significant stripping of topsoil can cause negative consequences to the health of the remaining soil over time. Ultimately, damaging the topsoil can lead to negatively impacting the land's long-term sustainability and ecosystem-services function. In the short term, effects can lead to a loss of nutrients, increased amount of erosion, varied disruption of soil structure, and loss of beneficial soil organisms, which can all contribute to the decrease in soil fertility and quality. In the long-term, removing the top soil could reduce the land productivity and have an increased need for fertilizers and amendments — which has a higher cost and more susceptibility to challenges of ensuring fertility of the plants. In the long-term, removing the topsoil could also impact the associated ecosystem services for the region, including regulation of water flow, filtering pollutants, and mitigating climate change (Lewandowski, 2003).

Implications of Soil Compaction

When soil is compacted, meaning it has been pressed together where the amount of pore space is low, there can be significant negative consequences to the soil's overall health and ability to carry out basic functions. Compacted soil has fewer air pockets, so it is harder for the vital exchange of oxygen and carbon dioxide between the soil and the atmosphere to transpire. Soil compaction is essentially suffocating the plant's roots which can lead to impaired root growth over time. Compaction leads to decreased level of soil biodiversity, has an increased susceptibility to erosion, can lead to lower crop yields and agricultural productivity, and an overall negative impact on ecosystem services that soil typically contributes to (American Society of Agronomy, 2011).

Problems with Utilizing Grass

Although appreciated and often utilized in many public and private spaces, grass has significant environmental effects to its surrounding environment and the soil it lays on. For one, grass has a very high demand for water, and heavily demands fertilizers and pesticides in order to grow and prevent weeds. However, this heavily contributes to runoff pollution and has detrimental effects to some animals and soil quality. Having large areas of grass can also contribute to having limited biodiversity in the space, as well as contribute to the "heat island effect" where vast amounts of grass in a city can contribute to higher temperatures due to the reduced heat absorption by the natural landscape (EPA, n.d).

About 3.8 million acres, or 9.5% of the Chesapeake Bay Watershed, is filled by grass lawns and/or turf. For every acre of seagrass in the Bay, it equates to 50 acres of turf grass

around the watershed. Howard County stands in 11th place with Counties surrounding the Bay Watershed that have the most turf grass, with 41.2% of the 160,906 acres comprising the county line being turf grass. Its neighbor, Montgomery County, has the highest amount of turf gas with 44.2% of the 317,420 acres being covered.

About 19 million pounds of pesticide active ingredients are used each year on turf surrounding the Bay. These pesticides reach local streams and rivers and damage the water quality that is then unsuitable to protect aquatic life from the harmful chemicals. 99% of urban streams were detected to have at least 1 or more pesticide (Chesapeake Stormwater Network, 2009). In addition to turf grass itself, many lawn/garden equipment utilized for maintenance are gas powered, and are found to emit the third most CO2 emissions in Maryland during the summer—only falling behind just slightly from statewide car and truck emissions. To maintain the lawns around the Bay, $5 billion is spent every year on equipment and care (Chesapeake Stormwater Network, 2009).

Major improvements can be made to reduce the amount of nutrients and pesticides utilized, and also inherently contributing to runoff pollution, surrounding the Chesapeake Bay. To start off, spending less on the maintenance of homeowner and commercial grass lawns can significantly help the environment, and alternative lawn accessories that are native or not as harmful to the environment can be installed. The current landscaping workforce could shift focus on their missions and plant trees, incorporate soil compost amendments, install rain gardens, create meadows or butterfly gardens, or start new organic vegetable gardens instead. If enough people change their focus, the community impact of eliminating fertilizer use, pesticides, and unnecessary water use on lawns could have major improvements in our natural environment surrounding the Chesapeake Bay that encourage native plant and animal growth (Chesapeake Stormwater Network, 2009).

Management for Ecosystem Service Benefits: Biochar

What is Biochar?

First created and used by farmers in the Amazon Basin of South America more than 2,500 years ago, biochar is an ancient soil amendment. Biochar is charcoal produced from the burning of super-heating biomass in a low to no oxygen environment. Biochar became a useful tool for farmers living in areas where the soil had been previously poor and/or toxic. Biochar is often found naturally in environments where vegetation fires are common. Its manual creation for commercial or personal use has

become popular in recent years (US Biochar Initiative, n.d). Howard EcoWorks has been experimenting and adopting biochar burning practices with a kiln since 2019, based on the practice and teachings from Kelpie Wilson of Wilson Biochar in Oregon.

Biochar is a sustainable soil amendment made from the char remains of burning dried out plants, in particular for Howard EcoWorks, invasive species. Applying biochar to areas of lower soil health quality, low pH levels, high compaction problems, and poor infiltration is often the most beneficial (US Biochar Initiative, n.d). Biochar has a number of benefits, including:

1. Improvement to the soil's organic carbon and overall health
2. Increases crop yield and soil moisture over time
3. Increases nutrient retention levels
4. Increases microbial activity
5. Alleviates compaction troubles
6. Reduces soil acidity over time
7. Sequesters CO2 back into the ground for hundreds of years to come

Commercial vs. Kiln-Produced Biochar

Commercially produced Biochar, or Biomass pyrolysis offers a sustainable way to convert organic waste into valuable resources. In the absence of oxygen, heating biomass like wood chips or agricultural residue at high temperatures (350-700°C) triggers a decomposition process. This breakdown transforms the material into three main products: biochar, bio-oil, and syngas. Biochar, the focus of our interest, remains in the reactor as a charcoal-like solid rich in carbon. Its stable structure makes it ideal for soil improvement and filtration applications (USDA, 2021).

Biochar is commercially available for purchase if you're interested in its benefits. Online retailers, landscaping suppliers, and even biochar producers themselves might sell biochar suitable for gardening, soil enhancement, or water filtration. When choosing biochar, consider the source material (ideally sustainable and non-polluting), its properties (like pH level and surface area), and any certifications that ensure quality and responsible production practices. With this knowledge, you can find the right biochar product to meet your specific needs of the given project.

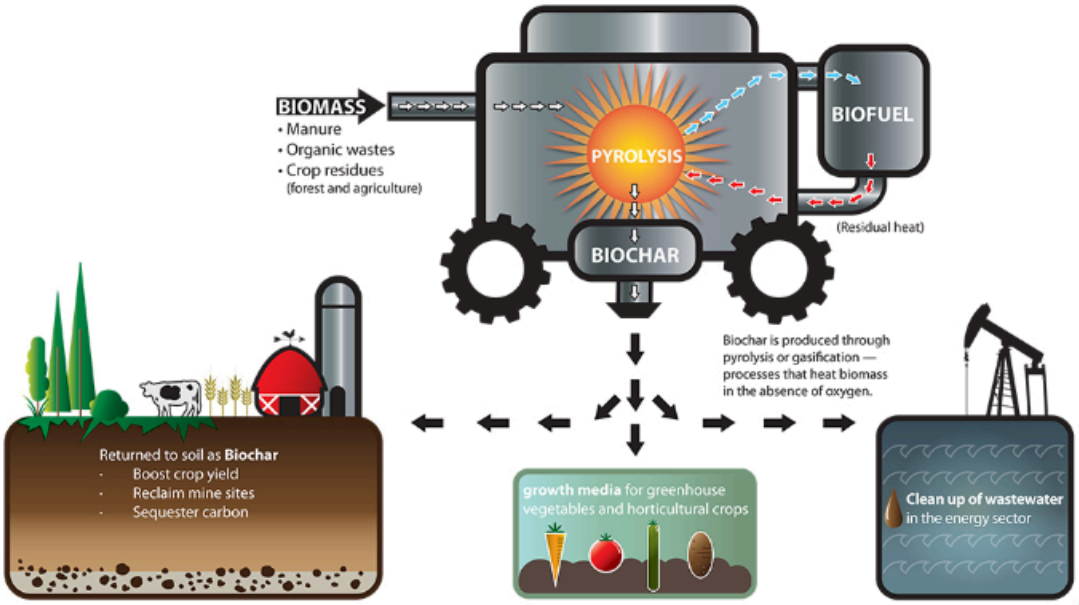
Kiln-produced biochar or a "flame cap kiln" or "conservation burn" biochar, is the simplest and most accessible way to produce biochar on a larger scale. The process includes organizing and stacking approximately uniform pieces of wood that is at least moderately dry and stocked into a cone-like shape. The pile is then burned and needs to reach a temperature point where the organic matter is volatilized and

the biomass converges to charcoal. Once ready to extinguish the fire, lots of water in a short time period during the cooling process is vital in this method to prevent any ash formation.

A flame cap kiln is a metal cylinder or box with either an open or closed bottom. Old metal drums are commonly converted to flame kilns by either cutting out their circular end or cutting them in half lengthwise. However, there are many other ways to DIY a kiln to your own specifications and resources. A taller and narrow kiln in size is more efficient at converting biomass to biochar. If possible, it is advised to avoid a kiln that is large in diameter but very short in height, this results in a cooler burn and is therefore less efficient at producing biochar. A general guideline of an ideal sized Kiln is a 1:5:1 ratio of height to diameter. Successful feedstocks in a conservation burn are 4 inches or less in diameter, with a depth of about 1-4 feet deep. Dry material is imperative, as moisture would result in a slower fire development and higher chance to produce ash. May depend on the size of the fire, but the goal is to move the burning processes quickly, from the top to bottom of the kiln taking about 20 minutes in duration once at maximum temperature (Hoffman-Krull, n.d). Immense amounts of water must be poured onto the biochar in order to cool down and prevent ash formation immediately following the end of the burning process. For more specific details on producing biochar, visit the Standard Operating Procedure.

In the kiln-produced process, feedstock material is loaded continuously throughout the burn process, the burn would then end with a Kiln full of biochar. The metal cylinder also prevents oxygen from entering the fire from the side-ends of the burn, instead, the active flame rises as new woody feedstock is added to the top of the pile within the kiln. This process prevents the oxygen from further burning the charcoal that has been produced in the lower layers of the kiln, and therefore prevents the possibility of over burning and ash formation. There is an average conversion rate of about 21% of total biomass to biochar by the end of a flame kiln biochar process (Hoffman-Krull, n.d).

Management for Ecosystem Services: Biochar Applications



(Cloverly, 2024)

The infographic above illustrates the scientific combustion process of how biochar is made, and then trickles into three different methods of how biochar can be applied to assist various industries.

Biochar Applications for Howard EcoWorks: Gardens

Studies show that biochar appears to benefit soils where turf grasses and trees are planted. Additionally, lawns with compacted, poorly drained soil benefit from the increased aeration and drainage that biochar can provide. Coniferous and broad-leaved trees have also shown improved growth and disease resistance in soils amended with biochar. Biochar also is light in weight, and can reduce the overall weight of planting mixed in container plants as well as green roof gardens. Biochar can either be mixed in by tilling or hand mixing.

However, it is advisable to use caution when applying biochar to your home garden, as "too much" biochar can occur. Too much biochar can hinder the presence of soil organisms like earthworms, and reduce the effectiveness of soil-applied pesticides. Monitoring your plants during the first few months of biochar application is a good practice to ensure the plant is not experiencing nitrogen deficiency. If so, adding nitrogen can solve this problem (Chalker-Scott, 2014). Below is a useful chart from Linda Chalker-Scott of Washington State University that details the benefits and drawbacks of biochar application, and what forms of soil are best suited for the amendment.

Table 1. How biochar application affects soils and plants.

Benefits	Drawbacks	Best Use
Decreases soil bulk density	None	Compacted soils
Improves aeration	None	Heavy or compacted soils
Increases soil aggregation	None	Fine-textured soils
Improves water-holding capacity	Can cause waterlogging in heavy clay soils	Excessively drained, sandy soils
Increases soil sequestration of carbon	Can be washed out of saturated soils	All soils
Increases soil alkalinity	May injure acid-loving plants and earthworms	Soils used for alkaline-tolerant species, such as turf grasses
Increases cation exchange capacity (CEC)	None	Low nutrient and sandy soils
Binds salt	None	Soils contaminated with de-icing salts or exposed to tidal floods, or naturally salty soils
Binds nutrients, such as nitrogen and phosphorus, reducing their leaching	Not as effective on silty soils	Sandy and acidic soils
Binds organic material (OM)	None	Soils subjected to erosion or runoff
Binds and/or detoxifies heavy metals, such as lead, mercury, and chromium	None	Acidic soils
Binds and sequesters organic contaminants, such as polycyclic aromatic hydrocarbons	None	Application rates greater than 2% of soil volume
Binds and degrades pesticides	Soil-applied pesticides will be less effective	All soils
Reduces greenhouse gas emissions (CO_2, CH_4, and N_2O) from wet soils	None	Waterlogged soils, especially sandy types
Enhances fungal biodiversity, including mycorrhizal species	None	All soils
Increases availability of plant nutrients (N, P, K)	Levels of sodium can increase depending on biochar source	All soils
Decreases need for nitrogen fertilizers	None	All soils
Increases plant nutrient uptake and enhances plant growth	Less effective in OM-rich soils; use of excessive biochar in OM-rich soils can reduce growth	OM-poor soils and dry soils
Increases plant drought resistance	None when used appropriately	
Increases plant disease resistance	None when used appropriately	

Biochar Applications for Howard EcoWorks: Composting

Combining compost and biochar can allow a synergistic production and utilization of the two tools. Adding biochar to the composting process has been found to reduce the composting time, reduce GHG emissions, and reduce ammonia losses. It also allows the ability to serve a bulking agent for compost and reduces the odor as well. For the biochar itself, having compost mixed in allows the biochar to charge up with nutrients without breaking down the biochar substance in the process. 5-10% to even 50% application of biochar to compost has been done and tested with great successes as mentioned above (International Biochar Initiative, 2022).

Biochar Applications for Howard EcoWorks: Urban Landscapes

Biochar has made a name for itself in urban landscaping by being able to provide an improvement in soil structure, moisture retention, and nutrient supply. Biochar has also been linked to help reduce the effects of urban heat islands since it is very porous and allows easy air circulation and water retention for cooler outdoor spaces. Biochar is also very effective in removing greenhouse gasses and sequestering the carbon for hundreds of years to come—an attribute that many eco-conscious landscapers may find beneficial (Cloverly, 2024).

Additional Biochar Applications: Agriculture and Water Treatment

One of the most popular biochar applications is in agriculture. By adding biochar, farmers have been able to enhance soil fertility, improve water retention, and increase both microbial activity and nutrient availability. Over time, biochar has been linked to healthier soils that provide higher crop yields, and reduce dependence on chemical fertilizers and irrigation water. Biochar is also effective at carbon sequestration, providing a method of reducing greenhouse gas emissions and reducing nutrient runoff pollution into local bodies of water (Cloverly, 2024).

Another biochar application that has become increasingly popular is in water treatment and environmental remediation. Since biochar has a very porous structure and high absorption capacity, biochar has proven to be an effective tool in water purification and filtration. Businesses involved in water treatment have utilized biochar to remove any heavy metals, pesticides, or organic pollutants. Biochar has also been used to help restore degraded land, old mine site rehabilitation, and brownfield reclamation as well (Cloverly, 2024).

The Business of Biochar

If interested in utilizing biochar, it's possible to either purchase or make your own. If purchasing biochar, it's a bit more expensive, with average U.S. prices falling around $1.29/pound or $2,580/ton (Farm Energy, 2019). However, the biochar is registered and has been properly broken down for direct application use, offering a peace of mind. Making your own biochar is also a viable option that often comes a lot more affordable. However, it is important that proper materials and caution is used, as the process requires a lot of attention. Once the biochar is produced, it cannot be directly used for applications. The biochar must be further broken down into applicable pieces but must be done so carefully, or else it may be broken in a manner where it is too small to properly contain the sequestered carbon.

When assessing how much biochar to apply to your project, it is important to assess the volume of your project, and ensure that you only mix up to 10% of biochar into your soil. For example, 1 cubic foot of biochar would be needed for a 8x4 foot garden. You may also use the biochar as top-dress on your lawn or field at a rate of 1 cubic foot of biochar per 375 sq/ft. For a bulkier application of biochar, a single acre of land can support 10% of biochar by volume for the top 4-6 inches of soil (Cloverly, 2024).

Not only has biochar proven to be a vital tool in sustainable landscaping and forest management, it has also a lot of financial potential for biochar producers as well. In 2023 alone, the biochar producing market in the United States was valued at $600 million USD. The global biochar market is projected to grow to nearly $3.5 billion by 2025 (Cloverly, 2024).

Management for Ecosystem Benefits: Forests/Woodlands

Refer to the key indications that separate a healthy forest from an unhealthy one, information is provided by the US Fish and Wildlife Service and University of Florida:

Healthy Forest Indicators	Unhealthy Forest Indicators
	
Lots of biodiversity: animals, fungi, microorganisms, and plants from all kingdoms of life	Low level of biodiversity of animals, fungi, microorganisms, plants, etc.
More resilient to disease and large, high-severity wildfires	Signs of disease or damage from insects to the leaves, bark, etc.
Forests features and metrics of “healthy” demand on the elevation, climate, and access to water	Tress are all the same age, no young sprawlings apparent
Good mix of saplings and young trees among the old growth	Excessive Standing dead trees and dead logs, however a little is a good thing
Plenty of trees, shrubs, and grasses with robust root systems to control erosion. Access to clean water	Presence of invasive species
Access to clean water, Lichen on the trees	Poor water quality
Presence of keystone species: beavers, prairie dogs, wolves, grizzly bears, lions, etc.—presence depends on the type of forest	Lack of presence of keystone species: beavers, prairie dogs, wolves, grizzly bears,

	lions, etc.—presence depends on the type of forest

Impact of Invasive Species

There are over 200 invasive species that live in the Chesapeake Bay watershed, both animals and plants. Once exposed to a foreign area, invasive species can have a detrimental effect on the local ecosystem services and the health of the forest. Invasive species often lack the natural controls, like predators or disease, that otherwise would keep them in check from overgrowth.

Once established, it can be impossible to eradicate the invasive species (Chesapeake Bay Program, n.d). Invasive species are capable of causing extinctions of native plants and animals, reduce overall biodiversity, and often compete with native organisms for the already limited resources, forever altering the local established habitats (NOAA, 2024).

Invasive species are among the most serious problems affecting landscapes and communities across the U.S., often resulting in significant negative economic impacts and threatening the ecological integrity and biodiversity. The result of an invasive species entering a forest can be loss and destruction of forage and habitat for wildlife, loss of available grazing land, diminished land value, lost forest productivity, reduced groundwater levels, soil degradation, increased risk of devastating wildfires, and finished recreational enjoyment (U.S. Forest Service, n.d).

Climbing vines that are invasive add another layer of stress to a healthy forest. Climbing invasive vines reduce tree growth, particularly for larger/older trees, and vines in the crown of the forest reduce tree survivorship, particularly near forest edges in the Mid-Athletic region (Matthews, et al. 2016). Invasive species, especially vines, that entirely cover up trees often block out the sun and strangle the tree—causing even further damage to the local ecosystem (Monster Tree Service, n.d).

Creating Biochar Production from Local Invasive Species

Howard EcoWorks already heavily works on invasive species removal, so utilizing the biomass of removed invasive species into usable biochar can provide a method to convert the problematic plants into a valuable resource. Invasive species removals often end in the landfill, biochar production could offer an alternative disposal method that both reduces landfill burden and associated costs for Howard EcoWorks. In return, carbon is now stored in biochar for hundreds or even thousands of years to come, offering a beneficial environmental component of Howard EcoWork's forest management work. Some invasive species made into biochar can also improve soil fertility and water retention, however, it's important to do research to ensure

the plant does not contain allelopathic chemicals that could harm the soil health. Allelopathic chemicals are biochemical compounds produced by an organism that can influence germination, growth, survival, and reproduction of other organisms. The effects can vary depending on the specific compound and the target organism.

To start the process of invasive species removal and biochar production, the team must identify the target invasive species and ensure its removal aligns with local regulations and management plans. Permits may be required. It's important to minimize the risk of invasive species by hand pulling, so utilizing specialized equipment to avoid disturbing seeds or plant fragments is vital. Depending on the size of the plant, certain chunks may need to be cut smaller in order to ensure proper fit in the burning pile or kiln. Chunks of the invasive species must be twig to forearm width in size, in order to properly fit in the fire kiln and ensure thorough burning. Once initially removed, invasive plants must be thoroughly dried-out to ensure efficient biochar production. Air drying, mechanical or solar drying techniques are all fine.

Once the pieces of invasive species are fully dried out, prepare a portable kiln, or any other pyrolysis unit that is sufficient, in order to begin the burning process. The optimal temperature for biochar production is typically between 350-700*C. After the burn, the biochar should be assessed to characterize it into its quality level and potential applications. This could involve analyzing nutrient content, surface area, and potential presence of allelopathic chemicals. The possible end use of biochar varies on preference of the project, as it could be used as a soil amendment (be careful/caution to potential allelopathy), carbon sequestering projects, or as a filter media.

Invasive Species suitable for Biochar in the Mid-Atlantic Region

When assessing whether the removed invasive species is suitable for biochar production, it is important to consider whether the plant can easily dry out of any moisture, and can be either naturally or manually cut into a size no smaller than twig, and no bigger in diameter than a human forearm. As far as what plants are most suitable for biochar production, it may defer based on region. However, it is also more ecological and less wasteful to also try to utilize whatever invasive species that are already being removed from a project site. A few notable invasive species that are known in the Mid-Atlantic region and that Howard EcoWorks has worked with include English Ivy, Japanese Barberry, Japanese Knotweed, Callery Pear, Brush

Honeysuckle, and Privet. It is vital to remember that any one of these invasive species listed, or any others that may be utilized for biochar production, needs to be checked after production whether it is allelopathic or not. Utilizing tests for allelopathy can help save a native plant's life if ever coming into contact with biochar. To learn more about invasive plants please visit the page by the Maryland Department of Natural Resources to learn more, or visit the Maryland Invasive Species Council's website providing a full list of all plants classified as invasive in the State of Maryland.

Management for Ecosystem Benefits: Streams

Identifying Healthy VS Unhealthy Streams

Category	Healthy Streams	Unhealthy Streams
Example Image		
General	Have rifles, runs, and pools, they are dynamic and should have a variety of features, have a healthy amount of vegetated floodplain that is connected to the stream	Clear and fast flowing water, straight stream, no room to flood
Erosion	Typically has a stable bank cover that helps reduce erosion by reducing the amount of soil that is exposed to passing water as it rushes down the stream	Often has an unstable bank cover, exposing the soil to more erosion. Once the bank starts to collapse into the stream, the brushes, shrubs, and grasses do the same. Can introduce excess levels of Nitrogen and Phosphorus
Sedimentation	The amount of sediment being picked up and moved downstream should be equal to the amount being	Balance is lacking, either too much sediment being deposited or too much erosion is occurring, cascade

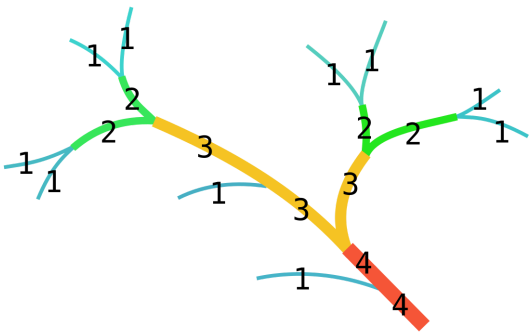
	deposited in the stream	of events from there
Buffers	Have trees, shrubs, and grasses of all varieties adjacent to the stream. Minimal human disturbance, the wider the buffer the more efficient the stream processes nutrients and slows sediment runoff before they enter the stream	Hardened shorelines, no signs of trees, shrubs, or grasses, or very minimal arrangement of each if so. Signs of human disturbance that has narrowed or eliminated the buffer, causing fast flowing water and high levels of runoff to enter the stream

Source: Ohio Watershed Network

Logistics to Stream Enhancement and Restoration

When considering projects that involve enhancing the flow of a stream or physical restoration efforts, it is crucial to consult with local regulators and relevant environmental agencies in the area to determine whether a permit is needed prior to breaking ground. Typical projects that require a permit include: physical alterations that modify the stream bed, channel realignment, stream bed excavation, habitat improvement structures, and/or impacting water quality by using heavy machinery or application of herbicides. Projects that do not typically require a permit include: minor maintenance activities to maintain existing stream health like removing invasive vegetation, planting native vegetation, or stream clean up.

Management of Headwaters - First Order Streams



The smallest streams in a network are often referred to as headwater streams. These can be further categorized as zero-order streams. Unlike higher-order streams that have already joined with others, zero-order streams are essentially channels where water first begins to collect and flow downhill. They typically appear as shallow, finger-like channels or even depressions in the ground where water accumulates after rainfall. These zero-order streams are often too small to be visible on topographical maps, but they play a crucial role in initiating the flow of water that eventually forms rivers.

Erosion in headwater streams has a domino effect downstream. Loose soil is washed away, filling rivers, lakes, and reservoirs with sediment. This reduces water storage, harms aquatic life, and increases flooding. The stream itself suffers too, with wider, shallower channels

and lost vegetation. Pollutants from the eroded land further degrade water quality. Protecting these vital beginnings of our waterways through erosion control is crucial for a healthy downstream ecosystem.

The solution to combat the amount of erosion at headwater streams is constructing a Beaver Dam Analogs (BDAs). A BDA is meant to mimic a beaver dam's capability to slow and hold water for longer periods of time on the landscape. Low-tech, cost-effective stream restoration tools that can help restore and maintain fish and wildlife habitat, improve connectivity and complexity, and support biodiversity conservation. Creating a BDA could be a fun activity that requires teamwork, a little creativity, and a willingness to get one's hands dirty (Luberto, 2023). A helpful video that provides instructions and visuals on how to make a BDA can be found here, it is created by Stephen Bennett from Utah State University.

Using live stakes while creating a BDA is a cost effective conservation technique used to stabilize stream banks and reduce erosion during rain events. The process involves cutting or buying limbs from a live tree or shrub and then replanting the limbs or stakes in areas with little vegetation. These stakes have the ability to sprout roots to establish a new tree in the future (RVA Regional Commission, n.d).

Appendix A. Educational Fliers

How To Create Beaver Dam Analogs (BDA)

The solution to combatting the amount of erosion at a headwater stream is constructing BDAs! Creating a BDA is meant to mimic a beaver dam's capability to slow down the flow of water for longer periods of time in the landscape.

BDAs are a low-tech, cost-effective stream restoration tool that can help restore and maintain fish and wildlife habitat, improve connectivity and complexity of the stream, and support biodiversity conservation.

In April 2024, Howard EcoWorks began creating BDAs at stream restoration sites in partnership with EcoSystem Services (as pictured).

All it takes is a little teamwork, creativity, and being willing to get your hands dirty!

1. Ensure proper permitting is acquired, if applicable.
2. Target key areas along the stream prior to the point of erosion that can help slow the flow of water.
3. Purchase or create your own live stakes to use for BDA stability (plus they may grow into trees in the future!).
4. Gather and use local resources (leaves, stems, dirt, etc.) to fill in the BDA, much like how a Beaver would!
5. Stop and Check: How will the rainwater now flow with your BDA in place? What is your local topography? Make adjustments as needed.
6. Monitor your BDA in the coming months and after big storms to make enhancements, a Beaver's work never stops!

Our Crew can create BDAs for your stream restoration needs!

www.howardecoworks.org | Columbia, MD | (443) 518-7665

How To Create Biochar

Biochar is a charcoal produced from the burning of super-heating biomass in a low to no oxygen environment.

Biochar is used as a sustainable soil amendment made from the char remains of burning dried out plants, in particular for Howard EcoWorks, invasive species. Howard EcoWorks has been experimenting and adopting biochar burning practices with a kiln since 2019, based on the practice and teachings from Kelpie Wilson of Wilson Biochar in Oregon.

1. Create or purchase a Flame-Cap Kiln, it's the simplest and most accessible way to make biochar.
2. Organize and stack uniform pieces of dry wood (MD invasives are a plus!) into a cone-like shape.
3. Burn the pile within the kiln at temperatures of at least 662°F for the organic matter to volatize and converge to char.
4. Pour LOTS of water to extinguish the fire rapidly to prevent ash formation.
5. Once cooled, apply biochar to a number of different applications for improved health results!

Biochar Benefits

- ↑ Soil's Organic Carbon
- ↑ Crop Yield & Soil Moisture
- ↑ Nutrient Retention Levels
- ↓ Soil Acidity

CO_2

Sequesters Carbon for 100+ Years to Come!

Biochar Applications

Agriculture | Composting | Urban Landscaping | Water Treatment

Our Crew can apply Biochar to your landscaping needs!

www.howardecoworks.org | Columbia, MD | (443) 518-7665