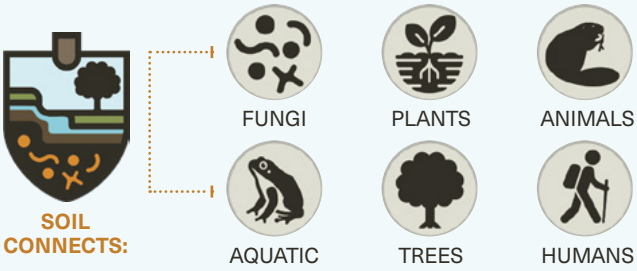
MASSACHUSETTS HEALTHY SOILS INITIATIVE

Introduction to Healthy Wetland Soils

Soil

Life on land comes from soil. **Soil is the foundation and the connecting living matrix for all of the ecosystems that we are a part of and that we depend on for life.** Soil is a living ecosystem in itself yet is an integral part of the larger ecosystem that it supports and connects. Fungal networks connect trees and plants below ground, allowing them to share nutrients and communicate. Soil microbes, macroinvertebrates, and larger animals live, move, and transform soil.



A GREAT READING OPPORTUNITY

Dirt: The Ecstatic Skin of the Earth

The body of a soil is the sky where seeds and worms and ions fly. Just as the sky links outer space to Earth's surface by means of increasingly dense atmospheric layers, so the soil links the surface to planetary bedrock by means of increasingly dense layers called, appropriately, horizons. Where the bottom layer of the sky rubs up against the top horizon of the soil, all terrestrial life is found.

– William Bryant Logan

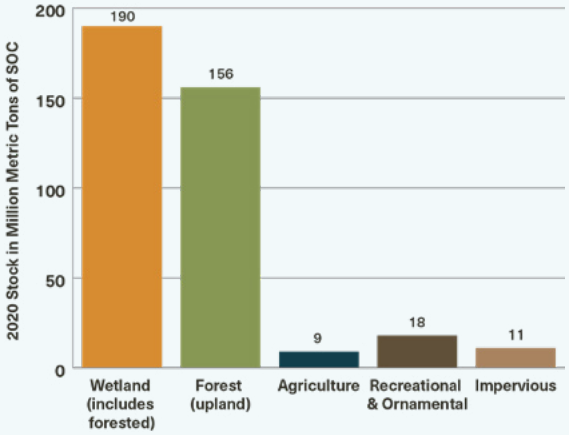
Wetland Soils

Wetland soil is where water and land meet and mingle, creating and supporting some of the most biodiverse and carbon-dense ecosystems on Earth. Because of the lack of oxygen in wetland soils, decaying organic matter (high in carbon) accumulates over long periods of time, creating carbon banks that help cool the planet by keeping greenhouse gases (carbon dioxide (CO_2) and methane (CH_4)) out of the atmosphere.

Water stored in wetland soil cools the landscape, reduces flooding, and provides a clean water supply during dry times. Wetland soil binds chemical pollutants, while plants and a variable microtopography trap sediments such that water leaving a wetland is cleaner than water entering it.

Total Soil Organic Carbon (SOC) Stocks by Land Cover in MA

From Massachusetts Healthy Soils Action Plan[1]



Wetland Soil Health

Wetland soils stay healthy when they maintain natural seasonal water levels and are protected from pollutants and disturbance. Physically disturbing wetland soils breaks the soil structure, breaks the living network of roots and fungi, and removes or damages the vegetative cover that protects soil from wind, erosion, and desiccation. Water table drawdowns, drought, drainage, and disturbance expose wetland soils to oxygen, often leading to release of methane, a greenhouse gas many times more potent than carbon dioxide, thereby accelerating climate heating. This release of methane creates a "carbon debt" which often takes decades, hundreds, or thousands of years to repay[2]. Such a delay in repayment makes it more difficult to achieve a stable climate within an effective timeframe. Preserving existing wetlands is the most effective approach to preventing such greenhouse gas emissions. Restoration of damaged wetlands can help restore wetland carbon and reduce greenhouse gas emissions.[3]

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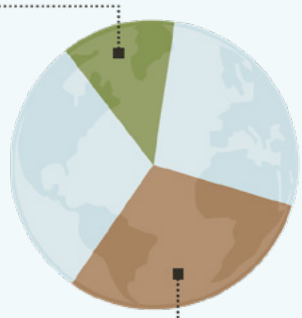
Wetlands & Their Soils Support Resilient Communities

Wetlands and their soils support resilient communities, communities that include the whole web of life – animals, microbes, people, plants. Although they occupy only ~13%[4] of the Earth's land surface, they store ~30% of the world's soil carbon[5], helping to keep the planet cooler! When we restore damaged wetlands, we help them store more carbon. Wetlands are also some of the most biodiverse ecosystems on the planet (everybody needs water!). Wetlands store flood waters, clean waters that flow through them, and provide water supplies during dry times of year.

APPROXIMATELY **13%** of the world's land surface is occupied by wetlands.



APPROXIMATELY **30%** of the world's soil carbon is stored in wetlands, helping to keep our planet cooler!

A GREAT READING OPPORTUNITY

Entangled Life: How Fungi Make our Worlds, Change Our Minds & Shape Our Futures

The difference between animals and fungi simple: Animals put food in their bodies, whereas fungi put their bodies in the food. Mycelium is a living, growing, opportunistic investigation – speculation in bodily form...Mycelium decants itself into its surroundings.

– Merlin Sheldrake

A GREAT READING OPPORTUNITY

Finding the Mother Tree: Discovering the Wisdom of the Forest

They are complex. Self-organizing. They have the hallmarks of intelligence. Recognizing that forest ecosystems, like societies, have these elements of intelligence helps us leave behind old notions that they are inert, simple, linear, and predictable.

– Suzanne Simard

Wetland Activities

Many wetlands are open to the public. Can you find one near you? A walk, swim, picnic, bike ride, canoe, kayak, or birding or fishing expedition could be just the thing you and your family/friends need this weekend to relax!

1 **Zaltzberg-Drezdahl** K, Gutwein S, Lawlor G, Krok-Horton L, Lindsay R, Newman J, Johnson I, Toensmeier E, Roszell C, Dagoberto M. 2023. *The Massachusetts Healthy Soils Action Plan*. Massachusetts Executive Office of Energy & Environmental Affairs. Boston, Massachusetts, USA. https://www.mass.gov/doc/healthy-soils-action-plan-2023/download

2 **Neubauer**, SC. 2014. *On the challenges of modeling the net radiative forcing of wetlands: Reconsidering Mitsch* et al (2013. Landscape Ecology, 29, 571–577 and **Neubauer** SC, & Megonigal JP. 2015. *Moving Beyond Global Warming Potentials to Quantify the Climatic Role of Ecosystems*. Ecosystems, 18(6), 1000–1013. https://doi.org/10.1007/s10021-015-9879-4

3 **Moomaw** et al. 2018. *Wetlands in a Changing Climate: Science, Policy and Management.* Wetlands. 38:183-205. https://doi.org/10.1007/s13157-018-1023-8

4 **Lehner**, B., Anand, M., Fluet-Chouinard, E., Tan, F., Aires, F., Allen, G. H., Bousquet, P., Canadell, J. G., Davidson, N., Finlayson, C. M., Gumbricht, T., Hilarides, L., Hugelius, G., Jackson, R. B., Korver, M. C., McIntyre, P. B., Nagy, S., Olefeldt, D., Pavelsky, T. M., Pekel, J.-F., Poulter, B., Prigent, C., Wang, J., Worthington, T. A., Yamazaki, D., and Thieme, M. (2025) *Mapping the world's inland surface waters: an upgrade to the Global Lakes and Wetlands Database* (GLWD v2), Earth Syst. Sci. Data Discuss, 17: 2277-2329. https://doi.org/10.5194/essd-17-2277-2025 (Accessed 2025-10-28).

5 **Jackson**, R.B., Lajtha, K., Crow, S.E., Hugelius, G., Kramer, M.G. & Piñeiro, G. (2017). *The ecology of soil carbon: pools, vulnerabilities, and biotic and abiotic controls.* Annu. Rev. Ecol. Evol. Syst. 48: 419–445; **Poulter**, B., Fluet-Chouinard, E., Hugelius, G., Koven, C., & Fatoyinbo, L. (2021). *A review of global wetland carbon stocks and management challenges.* In Geophysical Monograph Series; **Zhang**, Z., Fluet-Chouinard, E., Jensen, K., McDonald, K., Hugelius, G., Gumbricht, T., Carroll, M., Prigent, C., Bartsch, A., Poulter, B. (2021). *Development of the global dataset of Wetland Area and Dynamics for Methane Modeling* (WAD2M). Earth Syst. Sci. Data, 13, 2001-2023, 2021. https://doi.org/10.5194/essd-13-2001-2021 (Accessed 2025-01-09).

MASSACHUSETTS HEALTHY SOILS INITIATIVE

Restoring Wetlands and Their Soils

> Ecological restoration is the process of assisting the recovery of a native ecosystem that has been degraded, damaged, or destroyed.
>
> – Society for Ecological Restoration

wetlands

Restoring Wetlands and their Soils

Let's keep wetlands and their soils wet!
Successful wetland restoration often depends on re-establishing the natural seasonal water levels for the wetland in question, which can vary from brief seasonal saturation for a few weeks in the spring (common for forested wetlands/swamps) to permanently flooded conditions (such as ponds, lakes, and perennial streams and rivers). Once natural seasonal water levels are re-established, organic material can accumulate and build soil or sediment typical for the particular wetland type in question, thereby improving soil/sediment health, and planting with native species can begin.

Where Do We Begin?

Restoring a wetland begins with understanding the site history and natural site conditions prior to degradation, and by identifying how the wetland has been impacted. What was the site like when it was in a natural condition? What is the history of the site? Has it been filled or drained? Are pollutants degrading water and soil quality? Are invasive species present? Is trash or debris present? Understanding the site history and it's prior natural condition, as well as the type of impact that the wetland has experienced will determine what steps are necessary to restore wetland and soil health and how to develop a wetland restoration plan. Once the plan has been developed, plan implementation can begin.

Before Restoration

During Restoration

During Restoration

After Restoration

After Restoration

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Restoring Wetlands & Their Soils Supports Resilient Communities

By restoring wetlands and their soils, our communities become more resilient to severe storms, flooding, high heat, and drought. Local water quality and water supply improve and fish and wildlife become more abundant. If the wetland has been filled or drained, the restored wetland will likely provide more cooling of the surrounding environment.

As a result of improving wetland and soil health, the community becomes more resilient to the impacts of climate change and biodiversity tends to increase.

Wetland Restoration Activities

Wetland restoration activities range from small-scale to very large scale. Locally, we can restore and support the health of our wetlands and their soils by:

- Removing trash, yard clippings, and fill
- Rewilding a buffer zone between your managed yard and an adjacent wetland, including planting native plants and installing bat boxes and bird houses
- Removing invasive species and planting native wetland species such as highbush blueberries
- Avoiding/minimizing use of pesticides and fertilizers for yard maintenance
- Supporting projects to daylight streams and reconnect streams and rivers to their floodplains
- Managing stormwater runoff
- Increasing culvert size and widening bridges to support wildlife passage and decrease flooding risk

Large Scale Restoration

At larger scales, we can support larger wetland restoration projects such as dam removals, bridge replacements that increase the span of the bridge, removal of fill and removal of drainage structures from historic wetlands, and restoration of salt marshes so they can be resilient in the face of sea level rise.

MASSACHUSETTS HEALTHY SOILS INITIATIVE

Peatlands: Bogs, Fens, Peatland Forests and Their Soils

Peatlands are wetlands where water levels remain high enough for long enough during the year so that the soil is primarily saturated with water and has limited exposure to oxygen. The lack of oxygen in the soil creates an environment where microbes and other decomposers are only able to decompose dead plant material at a very slow rate, leading to the accumulation of thick layers of decomposing plant material, called peat.

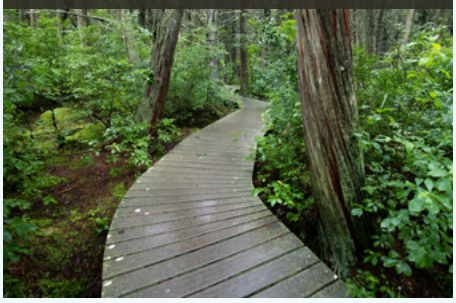
wetlands

Bogs, fens, and peatland forests are different types of peatlands.

Kettlehole Bogs

Fens

Peatland Forests



In Massachusetts, over the thousands of years since the last ice age, these organic deposits can reach depths of as much as 30 – 60 feet. In other parts of the world peat accumulations can be even deeper. **Some of the deepest peat deposits in Massachusetts occur in kettlehole bogs.** These are bogs that have formed in holes where giant ice blocks sat on the landscape when the glaciers were receding, and sediments built up around them. Eventually the ice blocks melted, leaving deep depressions in the glacial sediments that trapped and pooled water. Then vegetation began to grow, and dead organic material accumulated over the last several thousand years.

Bogs are highly acidic, often are dominated by sphagnum mosses, and generally form where there are no surface water connections, primarily relying on rainfall for water inputs. **Fens, on the other hand, are fed by mineral-rich surface and ground waters and have a higher pH than bogs.** They are often very biodiverse, and are typically dominated by sedges, rushes, and other freshwater herbaceous species. Like bogs, they can accumulate deep peat deposits. Atlantic white cedar swamps, an uncommon forest type in Massachusetts, are **peatland forests** with peat deposits accumulating over mineral soils that form where there are natural wet and dry periods that allow them to survive and reproduce. Black spruce bogs, another uncommon peatland forest in Massachusetts, often develop in thick peat deposits where little disturbance has occurred over long periods of time. Species in these acidic bogs include tamarack, heath shrubs, and sphagnum moss.

Sphagnum Moss

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Peatland Soil Health

Peatland soil health is often dependent upon maintenance of a high water table for much of the year. Loss of the high water table, whether due to drainage or drought, can lead to release of carbon from the soil into the atmosphere in the form of methane, a potent greenhouse gas, and thus can accelerate the trapping of heat in the atmosphere and associated global heating. Likewise, clearing of vegetation in a peatland can increase exposure to oxygen and solar heat, causing release of soil carbon. Restoration of drained water tables or revegetating damaged peatland wetlands can reverse the soil carbon releases.

Peatlands and Their Soils Support Resilient Communities

Peatlands support the resilience of human and ecological communities by storing flood waters, capturing and binding pollutants, and providing a source of water during droughts and dry seasons. They cool nearby areas in the same way that water bodies cool surrounding areas, due to their high water content. Forested peatlands can provide shade. They provide cooler places on the landscape for wildlife to retreat to during high heat events.

Peatland Activities

Because of the persistent high water tables in peatlands, and the fragility of the vegetation, **it is often best not to walk in peatlands unless there is a constructed boardwalk.** However, where boardwalks exist or where walking or biking trails occur nearby, peatlands offer unique and beautiful views, ripe for photography. Try visiting one at different seasons to watch and photograph the changes!

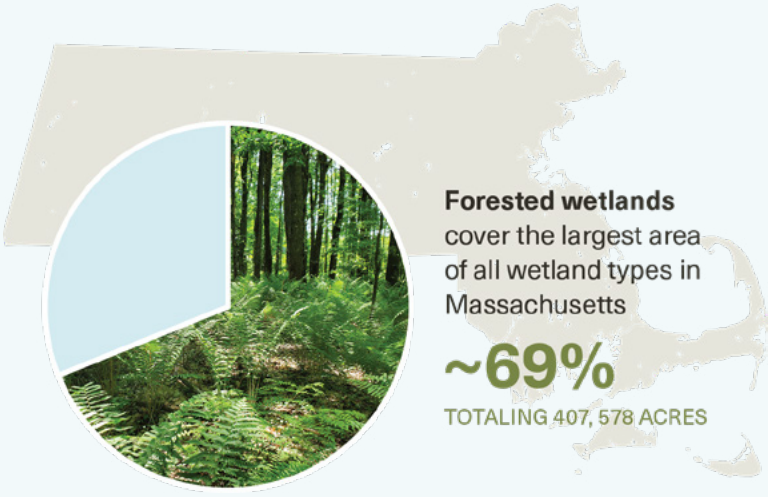
MASSACHUSETTS HEALTHY SOILS INITIATIVE

Forested Wetlands and Their Soils

wetlands

Forested Wetlands

Forested wetlands, like other wetlands, give us cool and beautiful spaces for outdoor activities! Forested wetlands are also known as wetland forests and swamps. In Massachusetts, forested wetlands cover the largest area of all wetland types in Massachusetts (~69%), totaling ~407,578 acres and holding the majority of Massachusetts wetland carbon[2]. Wetter wetlands, such as peat bogs and fresh and salt marshes, generally hold more soil carbon per cubic yard, but forested wetlands are so much more extensive, and have the most biomass carbon, that cumulatively, they hold the largest total amount.



Forested wetlands cover the largest area of all wetland types in Massachusetts

~69%

TOTALING 407, 578 ACRES

Forested wetlands are the most common type of wetland in Massachusetts.

HOLDING

~56%[1]

of MA wetland carbon.

Red maple *(Acer rubrum)* swamps are the most common type of wetland in Massachusetts[3].

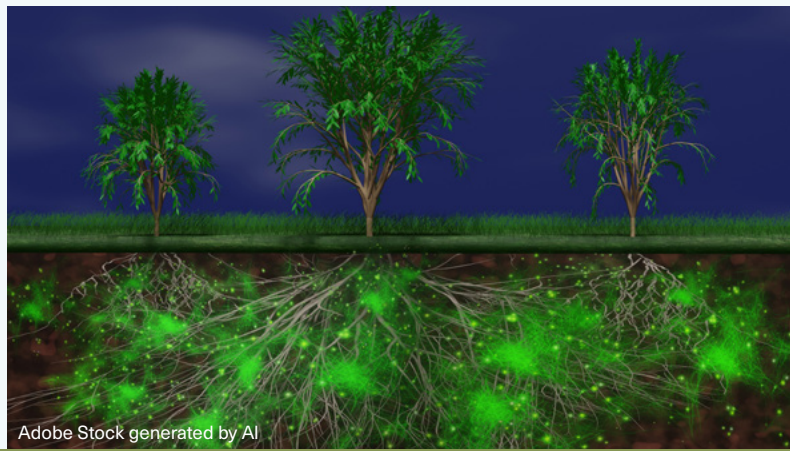
Wooded swamps[4] are the most likely wetland type to be permanently converted to other land uses in Massachusetts[3].

Wetland forests contain more carbon than upland forests per unit area due to the greater amounts of carbon stored in wetland forest soil[5].

Wetland Forest Soils

Soil in forests is a complex network of plant, animal, and fungal connections and relationships nestled in a matrix of decomposing organic matter that is high in carbon, and mineral material (clay, silt, sand, gravel, and stones) that can provide important nutrients. Trees can share nutrients and communicate (chemically) through the fungal-root networks. Avoiding disturbance of these complex underground networks helps keep wetland forest soils healthy, as does maintaining a natural hydrologic regime and water table.

Forested wetland soils store significantly more carbon than upland forest soils because they often experience high water tables and/or flooding and the anaerobic environment prevents decomposition of organic material in the soil. These dark, mucky soils support trees and other plants that are particularly adapted to soggy conditions, such as red maples, black gum, Atlantic white cedar, swamp white oak, and American elm. These water-saturated soils cool the landscape in ways similar to bodies of water.



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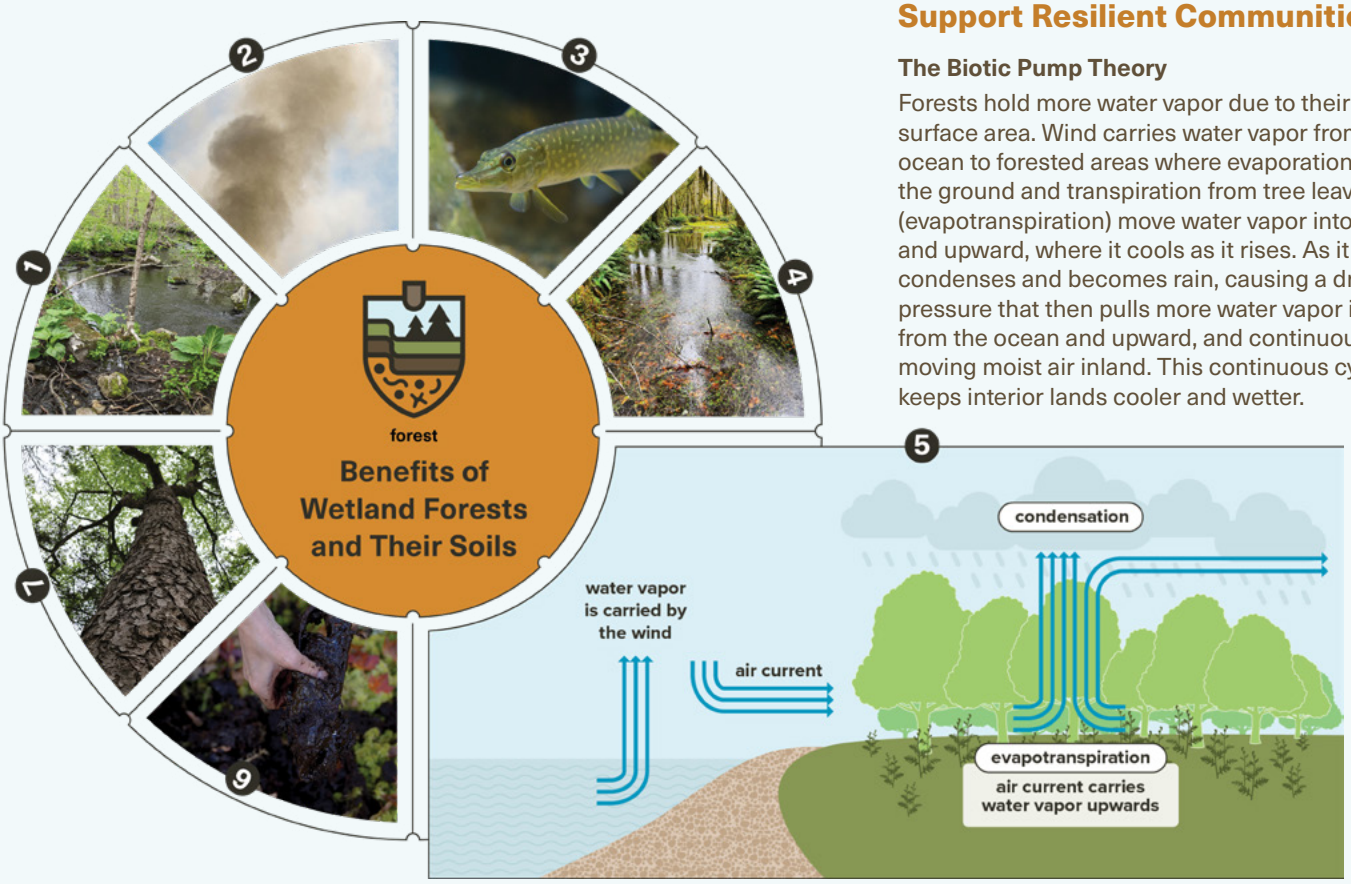
MASSACHUSETTS HEALTHY SOILS INITIATIVE

Wetland Forests & Their Soils Support Resilient Communities

The Biotic Pump Theory

Forests hold more water vapor due to their large surface area. Wind carries water vapor from the ocean to forested areas where evaporation from the ground and transpiration from tree leaves (evapotranspiration) move water vapor into the air and upward, where it cools as it rises. As it cools, it condenses and becomes rain, causing a drop in air pressure that then pulls more water vapor inland from the ocean and upward, and continuously moving moist air inland. This continuous cycle keeps interior lands cooler and wetter.



Wetland forests and their soils:

1. Store floodwaters
2. Remove pollutants from air and water
3. Provide important habitat for many species of fish, birds and other wildlife
4. Help prevent storm damage
5. Move water vapor from coastal areas towards continental interiors (when forests are large enough)
6. By pulling CO_2, a greenhouse gas, out of the atmosphere and storing carbon in soil and biomass, healthy forested wetlands help us avoid a hotter climate, since greenhouse gases trap heat. Healthy, undisturbed wetlands are climate-cooling carbon storage powerhouses.
7. Provide cool, shady places for recreation and respite during hot weather, creating social resilience. At any time of year, they can restore a sense of calm or offer energizing and exciting opportunities for exercise and recreation, improving our health.

Forest-dwelling barred owl

Forested Wetland Activities

Can you find a forested wetland near you? A walk, picnic, bike ride, or birding or fishing expedition could be just the thing you and your family/friends need this weekend to relax!

1 https://masshealthysoils.org/socma + https://research.fs.usda.gov/treesearch/63638 + https://link.springer.com/article/10.1007/s13157-010-0139-2

2 **Zaltzberg-Drezdahl** et al., 2023. *The Massachusetts Healthy Soils Action Plan*. Massachusetts Executive Office of Energy & Environmental Affairs. Boston, MA.

3 **Rhodes** et al. 2019. *Inland and Coastal Wetlands of Massachusetts: Status and Trends.* Massachusetts Department of Environmental Protection. Boston, MA.

4 **In Rhodes** et al. 2019, wooded swamps are defined as wetlands, "dominated by woody vegetation that is greater than 20 feet tall".

5 **Sapkota** et al. 2025. A synthesis of freshwater forested wetland soil organic carbon storage. Frontiers in Forests and Global Change. Vol 8. https://doi.org/10.3389/ffgc.2025.1528440

MASSACHUSETTS HEALTHY SOILS INITIATIVE

Floodplain Forests and Their Soils

Floodplain Forests

Floodplain Forests and their soils are dynamic systems that develop within the floodplain of both large and small rivers. Floodplain species must be able to withstand intermittent flooding and drying, and in some cases, forceful water currents when water levels are high. Silver maples commonly dominate floodplain forests. Other species include cottonwood, American elm, slippery elm, sycamore, box elder, and red maple. When water drainage is slow, the resulting poorly drained soils can allow red maples to dominate. When flood waters are frequent enough and strong enough, shrubs are largely absent, creating beautiful forest galleries, often with ferns and other herbs on the forest floor.

wetlands

Floodplain species must be able to withstand intermittent flooding and drying, and in some cases, forceful water currents when water levels are high.

Silver Maple Floodplain Forest Soil Pit

Floodplain Forest Soils

Some floodplain soils are typically saturated, and some are not. Often floodplain soils are silty and have a pattern of alternating layers of mineral soil and soil high in organics, giving a soil pit a horizontal striping look. When the floodplain floods, silt and other mineral sediments are deposited, creating a new mineral soil layer. Between floods, if the time period is long enough, leaves and other organic materials accumulate, decompose, and create a dark topsoil layer high in organics. Then another flood happens and deposits a mineral soil layer, and on and on.

Floodplain Forest Soil Health

Healthy floodplain soils are dependent upon maintenance of a natural flood regime, and clean water flows that are free of chemical pollutants, trash, and invasive species seeds. Floodplains and their soils are particularly vulnerable to invasive species as each flood represents an opportunity for invasive species such as Japanese knotweed or common reed *(phragmites)* to wash into the area. Once established, these species can be very difficult to eradicate, so prevention is the best cure!

Floodplains and their soils are vulnerable to contaminants and invasive species.

Trash

Chemical Pollutants

Invasive Species

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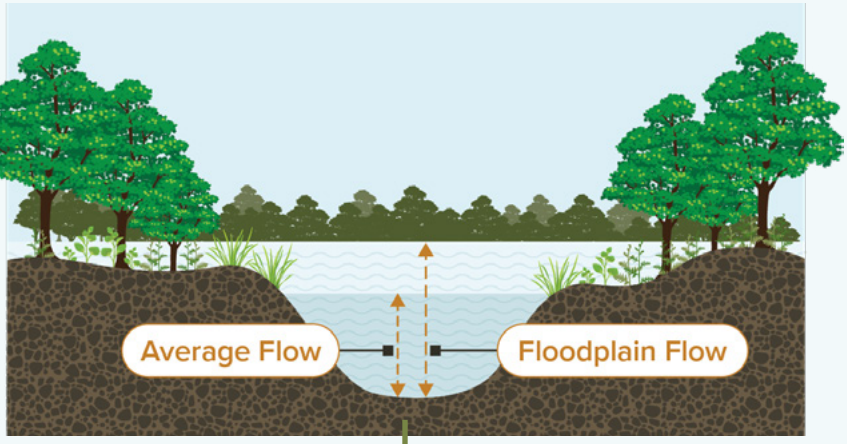
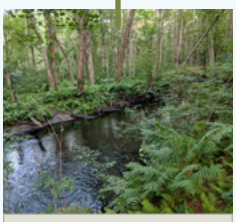
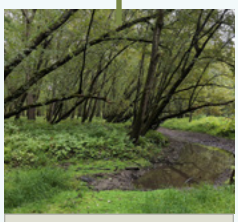
Floodplain Forests & Their Soils Support Resilient Communities

Healthy floodplain forests and their soils support resilient communities, communities that include the whole web of life – animals, microbes, people, plants. Floodplain forests store flood water, thereby preventing or reducing flooding and erosion in downstream and adjacent communities. These ecosystems then slowly release the stored water over time, helping to provide a clean and plentiful water supply and aquatic habitat during drier times of the year for all of nature including people. Floodplain forest vegetation traps particles and soils bind chemical pollutants, helping to clean the water. Floodplain forests create shade and cool the air and landscape, something that is particularly valuable as our climate heats up. Many animals, birds, fish, and plants live and move along river corridors, allowing them to find the right habitat or transit across the landscape when they need to find new homes, food, or mates. Species that can be seen in these riparian areas include bald eagles, wood ducks, hooded mergansers, mole salamanders, various types of frogs, rabbits, deer, and people.

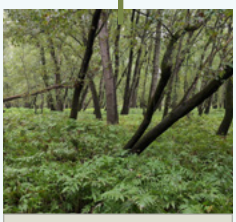




Store flood water, reducing flooding and erosion.



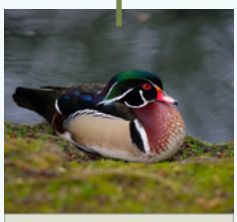
Slowly releases stored water to provide a clean water supply and aquatic habitat for dry spells.



Create shade and cool the air and landscape.

Trap particles and soils bind chemical pollutants.

Create the right habitats for many animals, birds, fish, and plants.



Support the whole web of life; animals, microbes, people, and plants.

Floodplain Forest Activities

Many rivers and their floodplains have public access. Can you find one near you? A walk, swim, picnic, bike ride, canoe, kayak, or birding or fishing expedition could be just the thing you and your family/friends need this weekend to relax!

MASSACHUSETTS HEALTHY SOILS INITIATIVE

Freshwater Marshes and Their Soils

Freshwater marshes occur in the shallows along edges of streams, rivers, ponds, and lakes, and in poorly drained depressions, typically having frequently or continually inundated water levels. They are too wet for most tree species to survive but are shallow enough for emergent soft-stemmed vegetation adapted for saturated soil to grow. Freshwater marshes are fed by surface and groundwater, and are nutrient rich, typically with neutral pH. Freshwater marsh soil is high in organics and often underlain by rich mineral soil. Plants and wildlife are abundant. These rich wetlands are highly biodiverse. Freshwater marshes can be non-tidal or tidal.

wetlands

Tidal freshwater marshes occur along coastal rivers, too far inland for salt water but close enough to the coast to experience tidal flows.

Freshwater Marsh Soil Health

Healthy freshwater marsh soils depend on maintenance of natural seasonal water levels that keeps these wetlands wet! Plant life is adapted to saturated soils and shallow water depths. Extended dry periods, drought, or extended abnormal flooding can be disruptive to these systems, making them vulnerable to the increased frequency of drought and severe storms/flooding that is occurring due to climate change. Exposure of normally saturated organic soil can lead to release of carbon in the form of methane, contributing to worsening climate change. Where freshwater marshes occur along flowing waterways, they are vulnerable to repeated influxes of invasive species transported by flowing water.

Freshwater Marsh

Freshwater Marsh

Exposure of normally saturated organic soil can lead to release of carbon in the form of methane, contributing to worsening climate change.

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Freshwater Marshes and Their Soils Support Resilient Communities

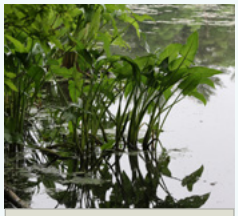
Freshwater marshes store large amounts of water, reducing flooding in nearby and downstream communities. This stored water is released gradually, supporting base flows in streams and rivers and water supplies during dry times and droughts. Freshwater marsh soil and vegetation trap pollutants, nutrients, and sediment, cleaning the water and reducing costs for drinking water purification. Freshwater marshes, like water bodies, create cooler spaces on the landscape, refuges from heat for both people and wildlife.

Freshwater marsh soil and vegetation trap pollutants, nutrients, and sediment, cleaning the water and reducing costs for drinking water purification.

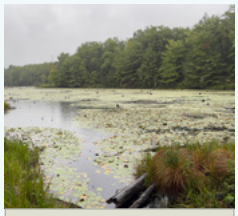
Benefits of Freshwater Marshes

Store large amounts of water that reduce flooding in nearby communities.

Releases stored water gradually to support stream and river flow during dry periods.



Soil and vegetation traps pollutants, nutrients, and sediment to keep water clean.



Create cooler spaces for both people and wildlife.

Freshwater Marsh Activities

Freshwater marshes are great locations for birding, especially for observing water birds. The open spaces make viewing easier than in forested or shrub/scrub wetlands. While most freshwater marshes are too wet to walk in most of the time, often you can find walking and biking trails nearby, and sometimes you can find boardwalks through a marsh. Where marshes have deep enough channels or are fringes along rivers, you can view them from the water in kayaks, canoes, or other small boats.

MASSACHUSETTS HEALTHY SOILS INITIATIVE

Salt Marshes and Their Soils

Salt marshes occur in the dynamic zone where the ocean meets land, and between the high and low tide lines. They are typically found in relatively low energy coastal areas. Salt marshes accumulate deep organic-rich deposits combined with mineral sediments washed in by daily tides and also deposited by inland waters as they flow into the ocean. Salt marsh soils, generally referred to as sediments, are high in salinity (i.e. salty), which creates a unique ecosystem where only salt tolerant plant, animal, and microbial species thrive.

wetlands

A unique ecosystem:
Only salt tolerant plant, animal, and microbial species survive in salt marsh soils due to high salinity from ocean waters.

Each year, salt marsh plants pull 4–10 times more carbon out of the atmosphere during photosynthesis than upland forests[1], acre for acre.

Salt Marsh

Massachusetts salt marshes are estimated to store nearly

~2.8 million metric tons of carbon in the top 12 inches of soil[1].

The average passenger vehicle emits

~4.6 metric tons of CO_2 per year[2].

Salt Marsh Soil Health

Salt marsh soils are both strong and fragile. On the one hand, they have evolved to thrive in a dynamic coastal environment with tides and water levels that fluctuate on a daily basis, and to withstand the barrage of coastal storms that normally occur in coastal areas. On the other hand, they are highly vulnerable to sea level rise. If they are unable to accumulate enough sediment and organic material to increase their elevation at a rate that keeps up with sea level rise, they can essentially drown. They are also vulnerable to releases of nutrients from upgradient land, often in the form of sewage or agricultural or landscaping runoff with high levels of fertilizers, as well as erosive stormwater flows from upgradient areas with impervious surfaces. The increase in nutrients allows algae and other aquatic plants to grow and outcompete natural salt marsh species. Invasive species such as common reed *(Phragmites)* and the European green crab pose threats to salt marshes. **Green crab burrows loosen sediments and cause erosion. Green crabs disrupt natural salt marsh food chains.**

Invasive European Green Crab

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Taking Action

Actions we can take to protect salt marsh soil health include controlling stormwater, sewage, agricultural and landscaping runoff, and supporting salt marsh restoration projects that restore natural flows into and out of the salt marsh, such as filling of mosquito ditches, adding runnels (shallow drainage channels), restoring tidal flows where they have been artificially restricted, and managing invasive species. We can support healthy salt marshes and their soils through society-wide efforts to slow and reverse climate change, the main cause of the rapid sea level rise that is currently occurring and that poses a threat to salt marshes.

Salt Marshes and Their Soils Support Resilient Communities

Salt marshes and their soils are a frontline defense against sea level rise and coastal storms. When they and their soils are healthy, they are an effective natural buffer that protects people, communities, and inland freshwater ecosystems. Salt marshes are nurseries for many fish and bird species, thereby supporting local fisheries and the ocean's food web. The deep organic deposits in salt marshes store large amounts of carbon, keeping it out of the atmosphere and helping to slow global heating.

Salt marshes store the most carbon per cubic meter of soil/sediment of any ecosystem type in Massachusetts.

Salt Marsh Activities

Salt marshes are iconic coastal wetland ecosystems in Massachusetts, and are **great locations for photography**, fishing, sea kayaking (in the channels), and plein air painting or drawing, or simply watching the sun rise. In some locations, boardwalks allow access out into the marshes. It is generally not wise to walk in salt marshes without a boardwalk, due to the deep mucky sediment and the daily tides. It can be easy to get stuck in the muck!

1 **Colarusso** P, Libohova Z, Shumchenia E, Eagle M, Christian M, Vincent R, & Johnson B (2023) EPA Region 1—*The Blue Carbon Reservoirs from Maine to Long Island*, NY. EPA

2 *Greenhouse Gas Emissions from a Typical Passenger Vehicle* | US EPA (Accessed 2024-03-21)