Sidebar: Soil Restoration, Regeneration and Stewardship

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Setting Soil Restoration, Regeneration and Stewardship Goals and Objectives

In establishing soil restoration, regeneration and stewardship goals, it is important to understand how "healthy" Massachusetts' "living soil" could be, by considering the geology, ecology and climate of our area.

Massachusetts' organic soil horizon (the "living" soil) began following glacial retreat 11,700 years ago. Glaciated soils are mineral soils consisting primarily of sand, silt and clay, initially with no organic matter. Barren post-glacial mineral soils were then seeded on the wind, and by grazing animals, with bacteria, grasses, herbaceous plants, ferns and fungi. Forests beyond the glacial advance started to spread into these "new" soil building land areas. Based on paleoecology, paleolimnological evaluation of lake sediment cores, and extensive archaeological evidence, by 10,000 years ago Massachusetts was dominated by pine forests (Shaw, 2020). The climate then dried, forest fires were common and the pine forests were diminished and replaced in dominance by oak forests and open land or an open forest structure that included grasses, ragweed and herbaceous plants (Shaw, 2020, Hall, 2002). These mixed ("Primary") forests, grasses, herbaceous plants and microbial communities in soil were relatively undisturbed until 1650, when European settlers arrived **--** an approximately 10,000-year timeframe for organic, living soils to be developed from climatic, ecological and soil microbial community interaction with flora and fauna.

By the mid-1850s, approximately 75 percent of Massachusetts was deforested and occupied by urbanized areas, pastures and farmlands. From paleolimnological records, deforestation and agriculture practices led to significant loss of the organic living soil horizon built up over the prior 10,000 years. By 1900, farming in Massachusetts had declined, and reforestation to create our "Secondary" forests began.

The health and quality of Massachusetts' forest soils have been impacted since the 1650s despite whether surrounding lands are preserved or not. For example, beginning in the mid-1800s, Massachusetts and southern New England were subjected to air-borne wet and dry deposition pollution (aka, "acid rain") containing nitrates and sulfates. These acid rains leached minerals, such as calcium, from remaining organic soils, and altered microbial biogeochemical conditions and nutrient ratios needed for healthy soil and plant/tree processes. Calcium in our soils would otherwise support the health and function of our native plants and trees, including sugar maples (Huggett, 2007). Prior to sulfate impacts in particular, these healthy soils would also have been releasing carbon- and iron-rich, organic molecules called dissolved organic matter (DOM) to our natural waters (Likens, 1998, 2002; Monteith, 2007; Ekstrom, 2011; Schiff, 1990). Formation of DOM is a natural process that still occurs beyond the historical range of sulfate and acid rain impacts, creating that red-golden colored water commonly observed in northern New Hampshire and northern and downeast Maine. DOM and the staining or coloration it adds to natural waters supports native flora and fauna over invasive species, and is an important but often unquantified sink for carbon in natural waters and sediment.

Other impacts that affect healthy soils include the introduction of invasive and exotic species, such as earthworms, some insects, and Dutch elm and similar vegetative diseases. Some types of earthworms quickly break down forest leaf litter and detritus, reduce soil macrostructure needed for aeration and water retention, and allow nutrients and minerals (carbon, nitrogen, calcium and others) to be lost more readily (Bohlen, 2004; Yavitt, 2015).

Climate change also has a measurable influence over time on soil health by increasing soil temperatures and microbial activity that releases carbon, reducing snow cover, increasing ground freezing, and allowing less cold hardy pest insects to enter our region. Ground freezing can damage fine roots and microbial communities important for soil health (Contosta, 2019). Warming air and soil and increased carbon dioxide content also favors some microbial communities, plants and trees over others, such as vines and some invasive species otherwise more acclimated to warmer climates.

In our forests, the characteristic closed canopy of our Secondary forests tends to limit light penetration and understory growth, compared to the open canopy, pre-1650 Primary forests that allowed more light into the understory for healthy grasslands, herbaceous plants and related diverse microbial and fungi communities (Hanberry et. al.). It may be that the open nature of our pre-1650 historical Primary forests and healthy soils were also directly related to former herbivore(prey)-predator ecosystem influences not present during development of our present Secondary forests.

Restoration

The restoration goal is to increase the microbial health and thickness of our "living" soils, whatever the overlying landscape is or is planned to be. This should start with assessing the existing quality, composition and thickness of the organic soil layer (usually the upper 6 to 12 inches of soil, deeper for flood plains).

Soil testing and advisory services are readily available for a nominal fee from the University of Massachusetts. Guidance on soil testing and additional information is provided by the Commonwealth of Massachusetts https://www.mass.gov/service-details/determining-your-soils-nutrient-needs. Additional commercial and publicly-supported laboratory and testing services and guidance on assessing soil health are readily available with public and private institutions, universities, municipal Conservation Commissions and other Federal and State agencies. Massachusetts also has a 4,000-acre Long-Term Ecological Research (LTER) station known as the Harvard Forest in Petersham, with on-line publications and contact information. The Harvard Forest LTER recently published a series of National Science Foundation funded research and outreach publications that provide more information on restoration activities and health of our soils, particularly for forest soils. See the Harvard Forest LTER website https://harvardforest.fas.harvard.edu/research/LTER

Search the web for additional research areas and websites with information for restoring soil microbial health in support of grasslands, wildflowers and native plants. Given past acid rain and soil wasting impacts to our soils, testing for sulfate and calcium content is recommended if not otherwise included in packaged soil testing services. Consider testing for pesticide content, depending upon prior land use and planned future use. Healthy soils are living soil, so assessments (baseline and ongoing) should include organic matter and carbon content, and microbial community assessments (particularly for mycorrhizal fungi and bacterial communities).

Soils restoration is important because healthy soils are more robust to changes and impacts than stressed or depleted soils, are a positive carbon sink, and support diverse native flora and fauna. Research has shown that healthy and thicker layers of organic-rich soil are also more resistant to damage caused by some types of invasive earthworms.

Regeneration

Organic compost and nutrients, and use of diverse plant cover species, help to keep soil healthy **--** if the compost and nutrients are applied judiciously and consistent with local, state or Federal guidelines for sensitive resources. On the local land owner scale, the local Conservation Commission or Natural Resource Commission can be consulted for more information. See also references listed in the Restoration Section. Regional-scale restoration and regeneration efforts should be coordinated directly with local, state and Federal agencies who have oversight of parks, preserves, water supply areas, wetlands, and endangered or threatened species habitat.

Regeneration over time can be measured by increased organic matter and carbon content, a well-balanced aerobic community of bacteria and fungi, healthy soil layer thickness, consistent macro-structure or texture, moisture and nutrient content. Whenever possible, soil surfaces should be covered by a diverse mix of hardy plant species to enhance soil microbial communities, maintain soil structure and moisture content, sequester carbon, and limit erosion and nutrient loss.

Stewardship

Landowners, and any regional coalitions or efforts, should maintain ongoing observation, assessment and testing of restored and regenerated sites. Regardless of initial plans and goals, there will be localized variations in soil health or plant species due to topographic relief, shading, depth to water, soil moisture, anthropogenic impacts (pollution, pesticides, fertilizers, fungicides, etc.), soil chemistry, and microbial communities. Stewardship should be sufficiently observant to recognize and support healthy soil development in the context of local variations, restoration goals or land uses. Diverse, hardy plant and soil microbial communities develop and support healthy soils when they are well-suited to local variations in natural environmental conditions. The goal of the “steward” is to recognize and utilize these local variations to support healthy soil development and to avoid the use of “forcing substances” like pesticides or fertilizers that could harm soil microbial communities. The Steward(s) should also actively seek to limit invasive flora species by non-chemical methods such as hand pulling, clipping, or covers.

Conclusion

Stewardship should seek to obtain and maintain restoration goals regarding land use, while continuing to monitor regeneration of healthy soil over time. Stewardship by land owners in particular should be promoted and supported at the local, state and Federal levels with tax credits, permitting assistance or allowances.

Significant, measurable improvements in healthy soil thickness, biogeochemical function, and importantly climate mitigating increases in soil organic carbon content can be made in a relatively short time frame (Machmuller, et. al). Progress will depend upon good science-based Restoration, Regeneration, and Stewardship actions for healthy soil development, and the support of Federal, state and local agencies.

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