NEW YORK SOIL HEALTH

POLICY BRIEF
SUMMER '23

Drivers of Soil Health and Strategies for Enhancement

Overview

Healthy soils are critical for sustainable food production and environmental protection, but there are uncertainties around the processes that support optimum soil functioning. Recent advances in soil health analytics are boosting our understanding of the drivers of soil health and the development of strategies that support a more regenerative agricultural system. We regard soil health as the result of three factors: natural (inherent) properties, land use systems, and management practices. It can be improved by utilizing cropping systems and management practices that increase biomass inputs.

Background

The New York Soil Health Program is a leader in characterizing the health status of soils through the Comprehensive Assessment of Soil Health framework. New metrics and data analytics, combined with research results, provide deep insights into the drivers of soil health and factors associated with soil and climate, land use systems, and management practices.

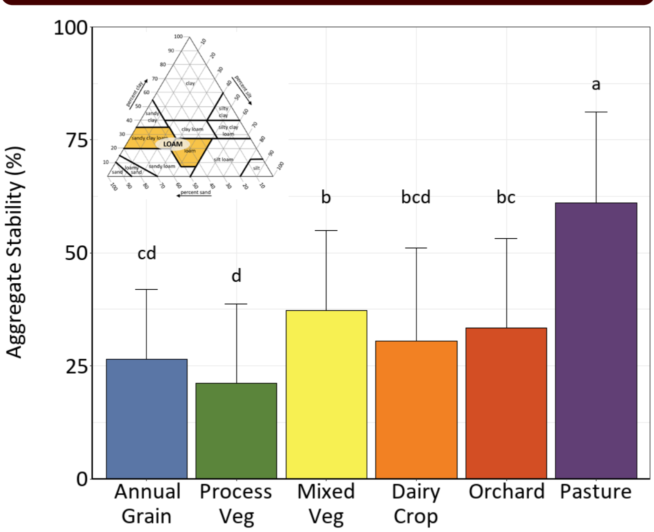

Fig. 2. The soil health indicator aggregate stability is impacted by cropping system. Mixed vegetable systems represent mostly small-scale organic farms, while processing vegetables represent larger conventional operations.

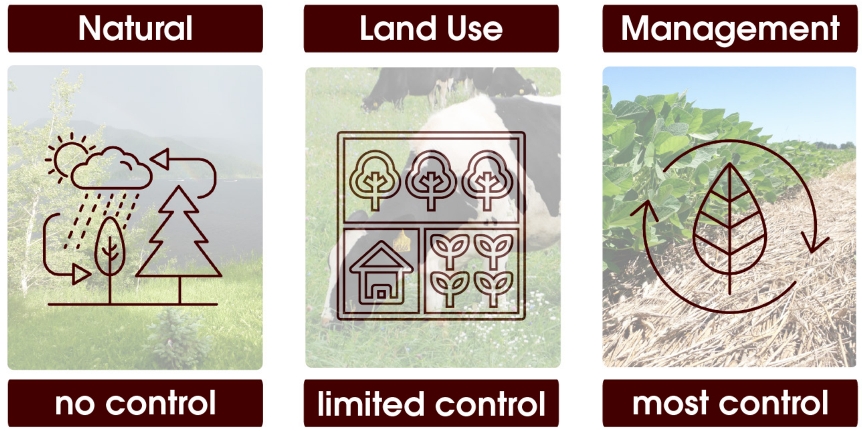

Fig. 1. General factors of soil health.

Policy Considerations

- **Evaluate soil health and regenerative practices through the lens of biomass production and cycling.** Soil health enhancement should focus on increasing biomass and organic matter inputs and maximizing active plant growth periods.
- **Interpret soil health and soil health benchmarks in the context of inherent soil characteristics and cropping systems.** Soil health benchmarks and standards need to account for natural soil differences as well as intrinsic differences among land uses and cropping systems[1].
- **Promote cropping systems that optimize carbon and nutrient cycling.** Soil health enhancement should include crop management strategies that support biomass inputs from multiple sources, including crop residues, organic wastes, and cover crops, and minimize carbon and nutrient losses from soil erosion and nutrient leaching.
- **Promote carbon and nutrient reallocation at the field and regional scale.** The circular bionutrient economy concept should be applied to maximize organic waste capture and processing and target regional allocation to lands in need of soil health regeneration.
- **Promote management practices that enhance crop growth and maximize the return of biomass to the soil.** Recognize the role both organic and inorganic nutrients play in supporting soil health, and promote practices that address yield-limiting concerns.

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Results

Elements of a production environment that impact soil health can generally be grouped into three major factors based on natural and human factors (Fig. 1):

1. **Inherent properties** include soil characteristics that are the result of natural processes, like parent material, climate, landscape characteristics, and biological processes. Parent material defines soil texture and mineralogy, landscape slope influences the water regime, and natural vegetation and climate influence soil organic matter levels.
2. **Land use and cropping system** define the specific crops grown and impact a soil's health because they influence two main drivers: perenniality and biomass cycling. Perennial systems like hayland, pasture, orchards, and vineyards generally result in better soil health outcomes than annual systems (Fig. 2), because they have longer active growing periods and less soil disturbance[1,2].

   Biomass cycling is critical for soil health because soils naturally lose carbon through biological respiration and nutrients are removed through plant uptake. A cropping system is more beneficial when it produces and cycles greater amounts of biomass and replenishes the carbon and nutrients in the organic matter pool. For example, in annual grain production systems 40-50% of the crop biomass is harvested and removed for sale, but the remainder is returned to the soil as residue (although more with some than others). Meanwhile processing vegetable cropping systems often have worse soil health because they involve plants that are almost entirely harvested and removed from the field (Fig. 2). Corn silage production also has negative soil health impacts because almost the entire crop is harvested, but this is often mitigated by rotating with perennial forages or through manure applications.
3. **Management practices.** A field's biomass balance (inputs-outputs) and soil health can be improved by better cycling of *organic wastes*. Animal manure can be returned to fields or reallocated to low-carbon fields to optimize benefits. Compost, treated organics, or raw biomass can also enhance carbon and nutrient balances through the capture of waste materials.

   Cover crops extend the active plant growing period, increase biomass inputs to the soil, and offer benefits for disease, weed, and nutrient management. The benefits are less when harvested for feed. Fields that are double or triple-cropped have soil health benefits if they lead to greater net biomass inputs from crop residues.

   Reduced tillage enhances soil health when associated with residue return and reduces erosion rates and organic matter losses on sloping lands. These benefits are lower when biomass is removed, like with corn silage and processing vegetable systems, unless cover crops, mulches, or organic wastes are applied.

   Reducing soil compaction further increases biomass production and is beneficial for soil health.

   Synthetic fertilizers are inorganic, thus lack organic carbon that supports the soil biological system. Organic nutrient sources (manure, compost, etc.) have greater benefits for soil health, but synthetic fertilizers are still critical to prevent nutrient deficiencies and optimize biomass production and cycling.

Overall, soil health is relative to the production environment and needs to be interpreted in the context of both natural and human factors[1].

[1]Amsili, J. P., van Es, H. M., Aller, D. M. & Schindelbeck, R. R. 2023. Empirical approach for developing production environment soil health benchmarks. Geoderma Regional, 34, e00672. https://doi.org/10.1016/j.geodrs.2023.e00672

[2]Amsili, J. P., van Es, H. M., & Schindelbeck, R. R. 2021. Cropping system and soil texture shape soil health outcomes and scoring functions. Soil Security, 4, 100012. https://doi.org/10.1016/j.soisec.2021.100012

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