Appendix 8: Mapping Soil Attributes: Soil Carbon Estimation

Soils and carbon

Soil carbon is one of the main drivers of dynamic soil health, and this pool of carbon is one of the largest terrestrial pools on the planet. This fact, understood by the NRCS and many soil managers, has led many to test and track carbon in the form of organic matter and/or soil organic carbon (SOC). However, a historic failure to account for the differences of SOC concentrations between land cover types (like forest, pasture, or lawns) has led to an enormous underestimation of existing soil carbon stocks in heavily forested Massachusetts. By examining the effects of land cover on soils of the same drainage class, we determined that there is a strong correlation between land cover and soil organic carbon concentrations.

Using these findings, the consultant team recalculated the SOC stocks for a three-town region in central Massachusetts with a land cover composition representative of Massachusetts as a whole. Like much of the Commonwealth, slightly more than half of this area is covered by forest and trees (55% of land cover). Forested soils, according to a meta-analysis of regional and global studies, have the highest mean concentration of SOC of any upland soils.

Many of the soils samples used to generate the SOC values in the Soil Survey Geographic Database (SSURGO), however, were taken from cropland, hay/pasture, grassland, or shrublands, which typically have lower SOC concentrations than forested land.

When adjusted for land cover by drainage class, the total stock of SOC in Apple Country increased from 2.2 million metric tons (SSURGO) to 2.8 million metric tons, a difference of 400,000 tons.
This work suggests that the amount of carbon stored in the soils of this region, and for

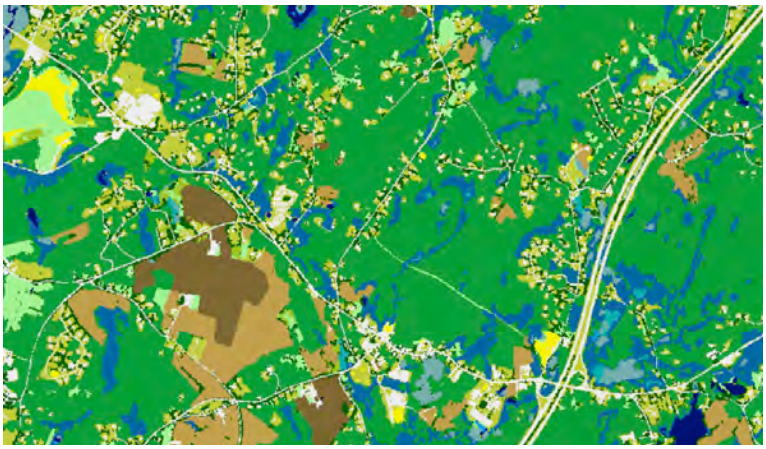
Massachusetts more broadly, is underestimated. This underestimation diminishes the significance of conserving and regenerating forests and wetlands. It also depresses carbon emissions estimates from land consumption and other land management, like forestry. If the Commonwealth is going to achieve the outcomes sought through the Decarbonization Road Map and the Global Warming Solutions Act, it is essential to account for and protect these vulnerable pools of carbon.

Side Box: A Graphic Summary of Our Process

Below is a visualization of the SOC re-estimation process developed by the Consultant Team. As noted above, this process results in a slight increase in estimated carbon stored in the soils of Apple Country from approximately 2.2 million metric tons of SOC (SSURGO) to 2.8 million metric tons of SOC. This difference of 600,000 metric tons of soil organic carbon is the equivalent of 2.2 million tons of atmospheric carbon dioxide, or the annual carbon emissions of 200 thousand Massachusetts residents.

The Massachusetts GIS 2016 land cover, reclassified to 9 inland classes.

The re-estimation process begins with the SOC values for each map unit from NRCS SSURGO data tables

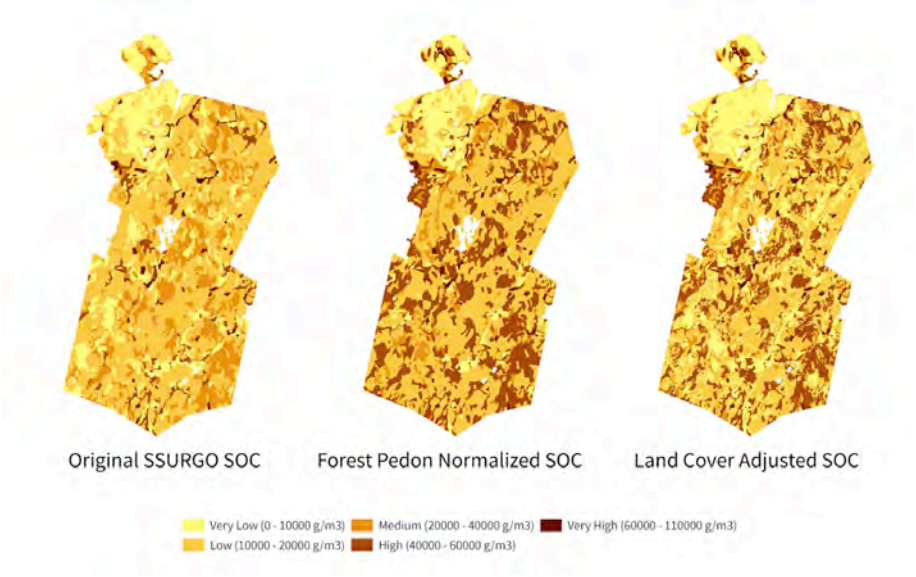


The SOC values were then adjusted to normalize for the influence of land cover on the typical pedon used by the Soil Survey when describing the soil map unit. This assumes that for upland soil map units, forest cover has the greatest average SOC concentration (98.2 t/ac). Therefore, in a Paxton soil, where the typical pedon is from a shrubland, we adjusted upward by the average SOC difference measured between shrubland (47.2 t/ac) and forest.

Then, using the 2016 land cover layer, we degrade SOC concentrations by the average difference between forested land cover and 'current' land cover. According to Peter Fletcher, a retired NRCS soil scientist, when deforestation occurs, the SOC concentrations tend to find their new equilibrium within 5 years (personal communication, 2020). When regrowth occurs, the literature suggests it takes between 15 and 70+ years to rebuild SOC levels (HSAP).

The regional view below illustrates the impact of this re-estimation.

When adjusted for land cover by drainage class, the total stock of SOC in Apple Country increased from 2.2 million metric tons (SSURGO) to 2.8 million metric tons, a difference of 400,000 tons, a 21% increase.



Adjusted average SOC concentration (Metric Ton/AC) for the major land cover types of Apple Country

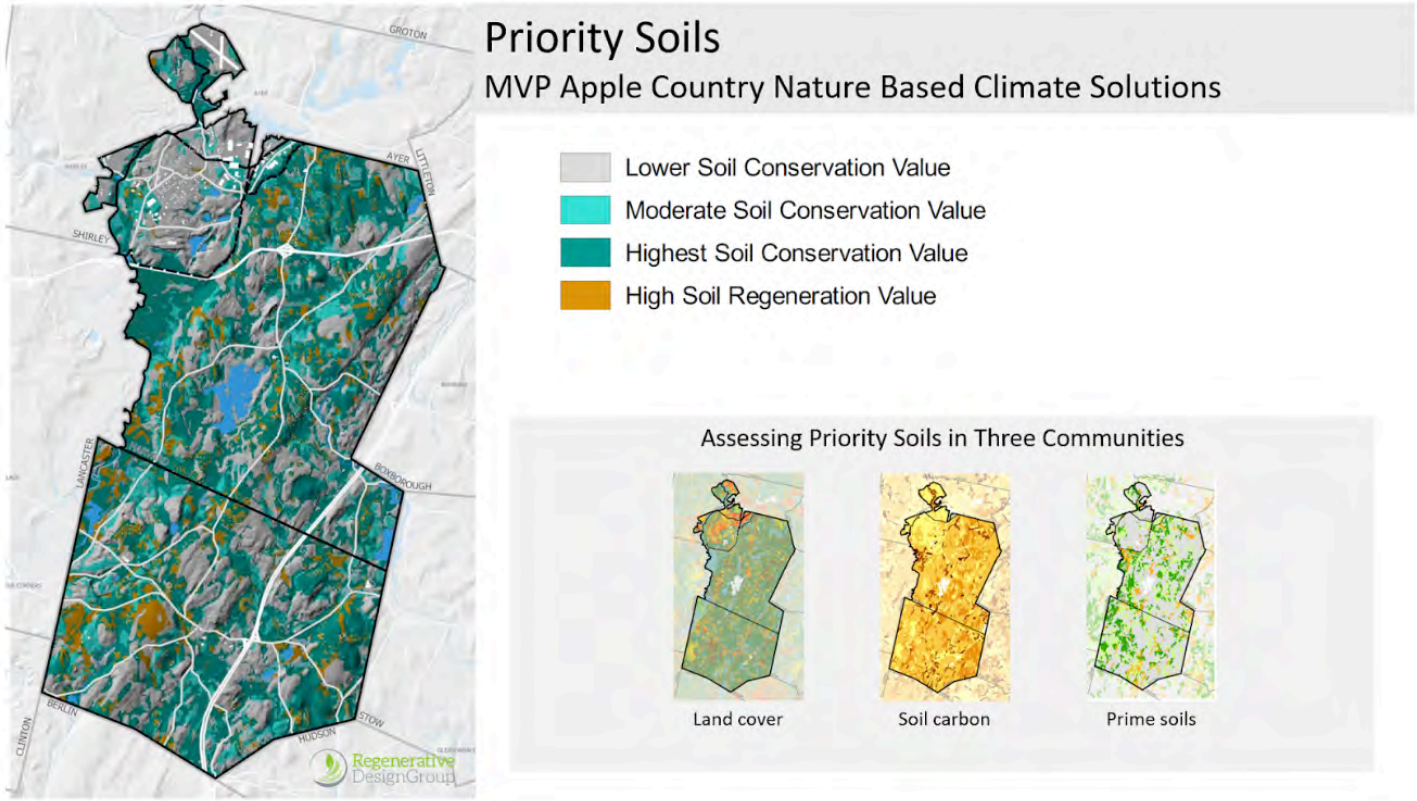
Land Cover		Harvard	Devens	Apple Country
Impervious	22	22	22	22.5
Turf, Lawn, and Landscaped	47	43	15	36.0
Annual and Perennial Cropland	32	33	23	32.9
Pasture and Hay	47	46	21	46.5
Grassland	57	50	23	45.4
Isolated Trees	101	95	44	90.6
Forest	105	99	69	98.2
Wetland	153	153	146	152.8
Water	44	14	19	19.9
Weighted Average	96	92	51	87.8

Mapping Soils Resource Priorities

The High Value Soil Resources map classifies the soils of Apple Country into four categories based on the interaction between a number of soils and land cover data.

These categories-- high soil conservation value, moderate conservation value, lower conservation value, and areas of high regeneration opportunity-- are intended to help the people of Apple Country to identify and protect specific significant areas, and shift development toward less valuable locations, and identify areas where restoration and better management would have meaningful impact on soil health and community resilience.

Areas of High Conservation Value are places where soil SOC values exceed 80 t/ac or are either classified wetlands or as Prime Farmland.



Priority Soils for Apple Country Process.png

Areas of Moderate Conservation value have soils with SOC values between 60 and 80 t/ac or are classified as Farmland of Statewide Importance.

These two categories are places where conversion through development or other use changes would result in large losses of carbon stocks and should be prioritized for protection.

Areas of Lower Soil Conservation Value have adjusted SOC values below 60 t/ac and a 2016 land cover that suggests an irreversible degradation.

The Areas of High Regeneration Value are places with normalized forest SOC values above 80 t/ac and a 2016 land cover identified as carbon reducing, but reversible. These include turf, cultivated agriculture, pasture, and isolated trees. These are places where concerted efforts at reforestation or other types of restoration, or better land management practices, could result in gains of carbon stock and improved carbon sequestration.

Soil priority areas were divided into priorities for conservation and regeneration.
First we determined areas that should be prioritized for regeneration. These areas were identified as areas that had un-adjusted soil organic carbon (SOC) above 80 t/ac and in 2016 had a land cover that was identified as carbon reducing but reversible these included turf, cultivated agriculture, pasture, and isolated trees.

From the remaining soils we determined areas that should be prioritized for soil conservation. Areas classified as Highest Conservation value had either wetlands, prime farmland, or Soils with SOC values above 80 t/ac. Farmland of Statewide Importance and Soils with SOC values between 60 and 80 t/ac were classified as Moderate Conservation value.