List of Citations and References related to the Nashua River Watershed Association Climate Series Webinar, "Getting to Know the Soils of Massachusetts, and Why it Matters," presented by Ralph S. Baker, Ph.D. on **Tuesday, March 22, 2022.**

Citations

Slide 2:

Citations to "NRCS, 2019" throughout this presentation refer to the following slide presentations given at the MA Soils Conference in Princeton, MA on Tuesday, June 25, 2019 by the USDA Natural Resources Conservation Service (NRCS) Massachusetts Soil Staff:

1. "Soils of Massachusetts", Al Averill, NRCS State Soil Scientist (by permission)
2. "Soil-Water Relationships", Maggie Paine, NRCS Resource Soil Scientist (by permission)
3. "Understanding Soils Survey MA", Al Averill, NRCS State Soil Scientist (by permission)

Note: Where the NRCS, 2019 slides included a citation, I repeated that citation on my slides.

Citations to "Regenerative Design Group" slides near the end of this presentation are from the following slide presentation:

> "Massachusetts Healthy Soils Action Plan – Soil Health + Conservation: Briefing for Creating Resilient Communities", Nov. 12, 2020, Regenerative Design Group (courtesy of Sebastian Gutwein)

Slide 7:

"Sand, Silt and Clay" image, Maurya, 2020: https://madhavuniversity.edu.in/soil-types.html

Slide 8:

Soil biodiversity image, FAO.org, 2020: http://www.fao.org/3/ca8251en/ca8251en.pdf

Slide 9:

Oliver, MassGIS: http://maps.massgis.state.ma.us/map_ol/oliver.php

Slide 12:

Series of Drumlins in Paxton and Rutland, Worcester County, MA: http://maps.massgis.state.ma.us/map_ol/oliver.php

Photo of drumlin in Worcester County, MA: http://nesoil.com/images/drumlins.htm

Slide 16:

Official State Soil of Massachusetts: Paxton (with map showing its distribution):
https://www.soils4teachers.org/files/s4t/k12outreach/ma-state-soil-booklet.pdf

Some sources of information about Drumlins in Massachusetts:
http://www.northshorenature.com/north-shore-shoreline-13000-to-12000-years-ago/
https://historyofmassachusetts.org/geological-history-massachusetts/
http://www.gulfofmaine.org/kb/files/9688/Rosen%20&%20Fitzgerald_Processes_and_Evolution_of_Boston_Harbor_Islands.pdf
https://www.geocaching.com/geocache/GC82N03_walking-to-the-beat-of-a-different-drumlin?guid=10cd1bef-9f89-4913-93d1-056293742bb7
https://www.clarku.edu/centers/george-perkins-marsh-institute/wp-content/blogs.dir/7/files/sites/47/2020/02/PLos_ONE.pdf

Image of stone wall:
https://qph.fs.quoracdn.net/main-qimg-d9ea8a12d31e345579b266221541b689.webp

Slide 19:

Block diagram, "Typical areal and vertical distribution of glacial and post-glacial deposits in the Connecticut R. Valley": https://pubs.usgs.gov/sim/3402/sim3402.pdf, Fig. 9A

Slide 21:

Map of proglacial and prehistoric lakes of New England during the end of the Wisconsin Glacial Epoch of the Pleistocene Era, based on map from Hooke and Ridge, 2016:
https://www.researchgate.net/profile/Roger_Hooke/publication/301281001/figure/fig1/AS:398429214789632@1472004335904/Map-of-New-England-and-parts-of-adjacent-New-York-and-Quebec-showing-locations-of-sites.png

Slide 22:

Photos of varved glaciolacustrine deposits by Kurt Hollocher, Union College Geology Dept.

Slide 31:

Photo of dissected drumlin (Woodcock et al. 2012):
https://www.clarku.edu/centers/george-perkins-marsh-institute/wp-content/blogs.dir/7/files/sites/47/2020/02/PLos_ONE.pdf, Fig. 2a

Slide 32:

Diagram of Pressure Distribution Beneath a 2-Ton Load (NCASI 2004):
https://www.ncasi.org/wp-content/uploads/2019/02/tb887.pdf, Fig. 1.1

Slide 33:

Figure showing soil biota (FAO, 2020): FAO, ITPS, GSBI, SCBD and EC. 2020. State of knowledge of soil biodiversity - Status, challenges and potentialities, Report 2020. Rome, FAO. https://doi.org/10.4060/cb1928en

Slide 34:

Climate Reality Project.org on "What is Regenerative Agriculture?": file:///Users/admin/Documents/Vyanahnu/Forestry%20and%20Climate%20Change/Soil%20Carbon%20and%20Soil%20Health/What%20is%20Regenerative%20Agriculture_%20_%20Climate%20Reality.htm

Project Drawdown, "Farming our Way out of the Climate Crisis", Dec. 2020. www.drawdown.org

"Kiss the Ground: Awakening People to the Possibilities of Regeneration": https://kisstheground.com/?gclid=Cj0KCQiArvX_BRCyARIsAKsnTxMJ5s1VRsmJaQHkCYOwckvFGVAqs7MaZW2phTgDJ7msbKqJfv4D2v0aAqzZEALw_wcB

"Regenerative Agriculture and the Soil Carbon Solution". Jeff Moyer, Andrew Smith, PhD, Yichao Rui, PhD, Jennifer Hayden, PhD. Sept. 2020. Rodale Institute: https://rodaleinstitute.org/education/resources/regenerative-agriculture-and-the-soil-carbon-solution/

Slide 35:

Photo by Anna Gilbert-Muhammed, NOFA-MA is from her presentation entitled "Youth, Gardening and Food Security", Biodiversity for a Livable Climate's "Blessed Unrest" Online Conference, May 9, 2020. A Youtube video of her presentation is available here: https://www.youtube.com/watch?rel=0&listType=playlist&list=PLsWWRqCX9eSZW0jCzrvwyB934M9BpvJQC&v=P7uYO1snvNU&feature=youtu.be

Photo from Fenway Garden Society: https://www.bu.edu/files/2019/07/resize-19-1468-URBAN-013.jpg

Practice Safe Gardening links provided on the slide:
http://sites.bu.edu/sciencegardenercollaborative/
https://www.epa.gov/sites/production/files/2014-03/documents/urban_gardening_fina_fact_sheet.pdf

Nanoplastics:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6863350/
https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.15074

Slide 36:

Bar graph showing distribution of above- and below-ground biomass by Intergovernmental Panel on Climate Change (IPCC) climate regions (Scharlemann et al. 2014) Fig. 3: https://doi.org/10.4155/cmt.13.77

"Wild Carbon and Wild Forests", Maloof, J. and V. Goold. 2020. Recent findings on carbon storage in old-growth forests. An online publication of the Old-Growth Forest Network. www.oldgrowthforest.net.

Anderson, M.G. 2021. *Wild Carbon: Analysis of sequestration in old forests.* Northeast Wilderness Trust. Montpelier, VT USA. https://newildernesstrust.org/about/wild-works/

Finzi, A. C., M.-A. Giasson, A. A. Barker Plotkin, J. D. Aber, E. R. Boose, E. A. Davidson, M. C. Dietze, A. M. Ellison, S. D. Frey, E. Goldman, T. F. Keenan, J. M. Melillo, J. W. Munger, K. J. Nadelhoffer, S. V. Ollinger, D. A. Orwig, N. Pederson, A. D. Richardson, K. Savage, J. Tang, J. R. Thompson, C. A. Williams, S. C. Wofsy, Z. Zhou, and D. R. Foster. 2020. "Carbon budget of the Harvard Forest Long-Term Ecological Research site: pattern, process, and response to global change." *Ecological Monographs* 90(4):e01423. 10.1002/ecm.1423

Slide 38-41:

Refer to Citations to Regenerative Design Group, under Slide 2, above. The MA Healthy Soils Action Plan was slated to be released in early 2021. See: https://www.regenerativedesigngroup.com/massachusetts-healthy-soils-action-plan/

N.B.: Slide 41 is a key slide in that it highlights the overwhelming importance in Massachusetts of our wetland and forest soils as stores of carbon. Although we can protect them better, we cannot readily increase the carbon stored in our wetland soils. In the case of our forest soils, however, there is the potential to increase the carbon stored by 2 to 4 times, by allowing our forests to mature and age, rather than harvesting them (Moomaw et al. 2019).

Moomaw WR, Masino SA and Faison EK (2019) Intact Forests in the United States: Proforestation Mitigates Climate Change and Serves the Greatest Good. *Front. For. Glob. Change* 2:27. doi: 10.3389/ffgc.2019.00027 https://www.frontiersin.org/articles/10.3389/ffgc.2019.00027/full

By contrast with Massachusetts' wetland and forest soils, our agricultural, turf and urban soils have much less potential as carbon stores, because they encompass a much smaller area of the state. Nonetheless, our agricultural soils can potentially be managed much better for carbon storage (see Slide 34 above). Similarly, our turfgrass soils can be managed much better, converted to meadows, and/or interplanted with trees. Finally, our urban soils can be restored to some degree through various "greening" initiatives and ecological design, including by planting trees, maintaining green spaces and gardens, installing rain gardens, riparian buffers, etc.

Slide 42:

Quote from Maya Dutta is from Biodiversity for a Livable Climate's November - December 2020 Newsletter.
https://bio4climate.org/wp-content/uploads/November-December-2020-Newsletter.html

Additional References:

From "THE NEGATIVE IMPACTS OF FOREST MANAGEMENT: Selected Citations" Compiled by Michael Kellett, RESTORE: The North Woods. Reproduced by permission.

V.G. Marshall. 2000. Impacts of Forest Harvesting on Biological Processes in Northern Forest Soils. Forest Ecology and Management 2000; 133:43-60
https://doi.org/10.1016/S0378-1127(99)00297-2

> *Soil is the habitat of plant roots and the home of numerous microflora, including viruses, bacteria, fungi and blue-green algae, and a host of animals from unicellular protozoans to small vertebrates. Simple communities of soil organisms, present from the earliest stages of forest soil genesis, become more complex and grow to astronomical numbers in mature forest soils. Here, they are essential for the maintenance and productivity of these soils, which unlike agricultural systems, generally receive less mechanical treatments and chemical inputs. The soil microflora and fauna complement each other in the comminution of litter, mineralization of essential plant nutrients, and conservation of these nutrients within the soil system. Harvesting directly affects these processes through the reduction and redistribution of organic matter, compaction, changes in plant cover, and modification of microclimate, all of which affect the distribution, composition and activity of the soil biological communities…. [A]ll practices generally affect soil organisms over the short term. Changes over the longer term are less obvious… It is therefore prudent to discourage any qualitative or quantitative changes in the soil biota.*

Dartmouth College. 2014. Logging Destabilizes Forest Soil Carbon Over Time, Dartmouth Study Finds. Public Release 2 December 2014. http://www.eurekalert.org/pub_releases/2014-12/dc-ldf120214.php

> *Despite scientists' growing appreciation for soil's role in the global carbon cycle, mineral soil carbon pools are largely understudied and previous studies have produced differing results about logging's impact. For example, the U.S. Forest Service assumes that all soil carbon pools do not change after timber harvesting.*
>
> *Dartmouth researchers looked at how timber harvesting affects mineral soil carbon over 100 years following harvest in the northeastern United States, where soils account for at least 50 percent of total ecosystem carbon storage….*
>
> *The results showed…there was a significant relationship between the time since forest harvest and the size of the carbon pools, which suggested a gradual decline in carbon across the region that may last for decades after harvesting and result in increased atmospheric carbon dioxide.*

Other References:

"Evidence for Losses from Strongly Bound SOM Pools after Clear Cutting in a Northern Hardwood Forest", Lacroix, Emily M.; Petrenko, Chelsea L.; Friedland, Andrew J., *Soil Science*: May 2016 - Volume 181 - Issue 5 - p 202–207, doi: 10.1097/SS.0000000000000147

"An Assessment of the Forest Resources of Massachusetts", Avril L. de la Crétaz, Lena S. Fletcher, Paul E. Gregory, William R. VanDoren, and Paul K. Barten. Univ. of Massachusetts, Amherst, MA. Prepared for the USDA Forest Service, June 2010.
https://www.mass.gov/doc/assessment-of-forest-resources-appendix/download