Value of Carbon Sequestered by Tree Cover

This EnviroAtlas community map estimates the value ($/yr) of the total metric tons (mt) of carbon that are removed annually from the atmosphere and sequestered in the above-ground biomass of trees in each census block group.

Why is carbon sequestration important?

Carbon is one of the most abundant elements on earth that forms the basic building blocks of most living organisms. Carbon comes in many forms, though carbon in the form of carbon dioxide (CO_2) is the dominant greenhouse gas (GHG) released into the atmosphere as a result of human activities.[1] The atmospheric concentration of CO_2 has increased by almost 40% since the start of the industrial revolution in the middle of the 18th century.[2] Trees, among other natural resources, can capture carbon and store it long-term, a process known as carbon sequestration. Sequestering atmospheric carbon dioxide (CO_2) in natural resources called carbon sinks reduces the amount of CO_2 that is available to heat the atmosphere and helps to maintain a more stable climate.

Climate change refers to any significant change in measures of climate (e.g., temperature, precipitation) that occurs over an extended period (e.g., decades).[1] This change can be from natural factors, human activities, or a combination of the two. Increasing levels of atmospheric CO_2 and other greenhouse gases (e.g., methane, chlorofluorocarbons, and nitrous oxides) are thought to significantly contribute to an increase in atmospheric temperatures by trapping certain wavelengths of heat in the atmosphere.

Though several gases contribute to the greenhouse effect, CO_2 is estimated to be responsible for 80% of the current increases in climate forcing due to all greenhouse gases since 1990.[3] The most recent decade was the hottest in recorded U.S. history and extreme weather events, such as heat waves and floods, have increased in frequency and intensity.[4] The U.S. has also experienced wildfires, droughts, increases in surface-water temperatures, more frost-free days and heavy downpours, more frequent and intense winter storms, and sea level rise; these changes can directly and indirectly affect human health in a number of ways.[4]

This map illustrates the value of the amount of carbon that trees may remove from the atmosphere annually. By fixing carbon during photosynthesis and storing it as biomass, growing trees act as a sink for CO_2. Thus, growing trees

reduce the level of atmospheric carbon and help to maintain a stable climate by slowing down the build-up of CO_2 in the atmosphere over the long-term. Carbon that is sequestered in tree biomass can remain there for decades unless those trees are disturbed or removed. This map uses the "social cost of carbon" as an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year.[5]

How can I use this information?

The map, Value of Carbon Sequestered by Tree Cover, can help users identify areas with significant tree cover that are actively sequestering carbon within cities and the dollar value associated with that sequestration. The annual sequestration amounts illustrate the amount of carbon that is removed by a city's trees and forests annually, illustrating potential gains through additional reductions in carbon dioxide. The carbon values are directly proportional to tree cover based on average sequestration rates per unit of tree cover. This map can be used to determine where cities may benefit from tree plantings to increase their carbon sequestration potential. It can be compared with other community ecosystem service layers in EnviroAtlas (e.g., air pollution removal and air temperature effects) to calculate the magnitude of multiple ecosystem services contributed by trees within a given area.

How were the data for this map created?

The data for this map were derived from a high-resolution tree cover map developed by EPA. Within each census block group derived from U.S. Census data, the total amount of

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tree cover (m^2) was determined using this remotely-sensed land cover data. The USDA Forest Service i-Tree model was used to estimate the annual carbon sequestration rate from state-based rates of kgC/m^2 of tree cover/year. The state rates vary based on length of growing season and range from 0.168 kgC/m^2 of tree cover/year (Alaska) to 0.581 kgC/m^2 of tree cover/year (Hawaii).[7] The national average rate is 0.306 kgC/m^2 of tree cover/year. These national and state values are based on field data collected and analyzed in several cities by the USDA Forest Service. These values were converted to metric tons of carbon removed and sequestered per year by census block group.

To estimate the monetary value associated with urban tree carbon storage and sequestration, carbon values were multiplied by $78.5 per ton of carbon (range = $17.2–128.7 tC^{-1}) based on the estimated social costs of carbon for 2010 with a 3% discount rate.[6] To assess for the year 2016, users can multiply listed values by 1.87.

What are the limitations of these data?

All of the EnviroAtlas community maps that are based on land cover use remotely-sensed data. Remotely-sensed data in EnviroAtlas have been derived from imagery and have not been verified. These data are estimates that are inherently imperfect. The main limitations of these data derive from the fact that no field measurements were collected in the area. Carbon storage and annual sequestration rates will vary locally based on tree diameter distribution, tree density, tree health, and to a lesser extent, species composition. These local variations will affect carbon storage estimates, but the average effects per unit of tree cover provide a first-order estimate of carbon storage. The block group summary assumes that tree cover is accurately portrayed on the land cover map. Estimates of below-ground carbon storage are not included.

How can I access these data?

EnviroAtlas data can be viewed in the interactive map, accessed through web services, or downloaded. To find the EnviroAtlas 1-meter land cover grids created for each community, enter *land cover community* in the interactive map search box.

Where can I get more information?

There are numerous resources on climate change and carbon sequestration by trees; a selection of these resources is listed below. To learn more about i-Tree tools and how they can be used to support research, planning, and policy efforts, visit the i-Tree website. For more information on how the removal of air pollutants may positively affect human health, visit the Clean Air section of the Eco-Health Relationship Browser. For additional information on the data creation process, access the metadata for the data layer from the drop down menu on the interactive map table of contents and click again on metadata at the bottom of the metadata summary page for more details. To ask specific questions about these data, please contact the EnviroAtlas Team.

Acknowledgments

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Selected Publications

1. IPCC (Intergovernmental Panel on Climate Change). 2013. Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

2. National Research Council of the National Academies. 2012. Climate change: Evidence, impacts, and choices. Accessed March, 2013.

3. National Oceanic and Atmospheric Administration. 2012. The NOAA annual greenhouse gas index. Accessed March, 2013.

4. National Climate Assessment Development Advisory Committee. 2014. Climate change impacts in the United States: U.S. national climate assessment. Accessed January, 2015.

5. Nowak, D.J., E.J. Greenfield, R.E. Hoehn, and E. LaPoint. 2013. Carbon storage and sequestration by trees in urban and community areas of the United States. *Environmental Pollution* 178: 229–236.

Nowak, D.J. 1993. Atmospheric carbon reduction by urban trees. *Journal of Environmental Management* 37(3): 207–217.

Nowak, D.J., and D.E. Crane. 2002. Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution* 116(3):381–389.