Supplementary 8 – Urban and Suburban Forests

Urban trees are a focus of climate change action in Southern New England states, both because urban areas in these states (CT, MA, RI) are projected to grow significantly over the next 30 years and due to the many benefits trees bring to urban areas. The study estimates the potential benefits of a 3%, 5%, and 8% increase in urban tree density across existing urban areas in New England states from 2020-2030. While the study focuses on benefits for climate change mitigation from carbon storage and sequestration, urban trees also confer numerous and extensive co-benefits to energy use and human health in urban areas as they reduce home cooling needs and air pollution; urban tree planting programs and maintenance requirements can also be important engines of job growth. Urban trees also address important equity and environmental justice issues as they can be leveraged to improve environment and human health in urban areas suffering from poor environmental quality.

The study uses USFS's Urban FIA data in order to estimate the carbon benefits of an increase in tree density in urban areas of New England. USFS initiated the Urban FIA program in 2014 in order to capture information about trees that fall outside the FIA definition of forestland. The carbon benefits of urban trees are important to capture given the extensive and growing urban areas in Southern New England. Urban land is defined by Urban FIA following the US Census definition of urban areas and is there not limited to dense, downtown urban areas. In 2010, the US Census defined urban areas as comprising "…a densely settled core of census tracts and/or census blocks that meet minimum population density requirements, along with adjacent territory containing non-residential urban land uses as well as territory with low population density included to link outlying densely settled territory with the densely settled core. To qualify as an urban area, the territory identified according to criteria must encompass at least 2,500 people, at least 1,500 of which reside outside institutional group quarters." (US Census Bureau 2010) This is the urban definition employed in the Urban FIA data used in the current study for urban pathway.

While under the umbrella of the USFS, the Urban FIA methodology for obtaining urban tree data and related ecological benefits such as carbon storage and sequestration differs from the FIA program, and is detailed in Nowak et al 2013. Urban FIA does not rely on FIA plot data but rather uses field data collected by urban partners or FIA crews. For carbon storage and sequestration specifically, field data collection conducted by the Urban FIA program yielded carbon storage, sequestration, and tree cover estimates for a selection of 28 U.S. cities and urban areas. Field-based data were extrapolated to the state level by applying average carbon densities per m^2 tree cover to all tree cover in urban areas of each state using satellite data. More recent estimates of carbon storage and sequestration are provided in Nowak & Greenfield 2018 (Table 1).

Table 1: Carbon storage and sequestration on urban land areas

State	CT	ME	MA	NH	RI	VT	New England Total
Urban land (acres) 2010	1,168,000	229,000	1,898,000	412,000	256,000	100,000	4,063,000
Carbon storage (tons) 2010	24,700,000	4,600,000	37,200,000	8,000,000	4,400,000	1,700,000	80,600,000

Carbon sequestration (tons/year)	766,800	132,400	1,229,200	224,700	149,100	46,700	2,548,900
Carbon storage (tons/acre urban land)	21	20	20	19	17	17	20
Source: Nowak & Greenfield 2018							

Nowak et al 2013 provides data on the number of forest and urban plots in each state, including the percentage of urban plots that are forested and would have been measured by FIA as forested plots because they meet the FIA definition of forestland (Table 2). We use these data to avoid double-counting between forested urban areas that could be picked up by FIA plot data, so that the carbon stock and sequestration benefits we attribute to urban areas do not include FIA areas. The urban area and carbon estimates are adjusted to account for this potential overlap as shown in Table 3. The adjusted carbon storage and sequestration estimates are then increased by the urban pathway tier selected (3%/5%/8%), and the additional storage and sequestration reflected by the tier increase is multiplied by the adjusted number of urban acres in 2020 to arrive at the total carbon benefit for the urban pathway.

Table 2: Forest and urban plot data

Plot Data	**CT**	**ME**	**MA**	**NH**	**RI**	**VT**
Forest plots	283	3027	488	847	62	757
Urban plots	181	37	302	65	44	18
Urban forest plots [1]	61	12	106	31	10	4
Urban forest (%) [2]	33.8%	31.9%	35.0%	47.6%	23.0%	19.9%
Notes: [1] Estimated number of urban plots that were measured. [2] Urban forest % = % of urban plots laid that are forested (urban forest plots/urban plots) and therefore considered as part of the FIA dataset and excluded from the urban pathway analysis. Source: Nowak et al 2013						

Table 3: Adjusted urban carbon storage and sequestration data

Urban Estimates	**CT**	**ME**	**MA**	**NH**	**RI**	**VT**	**New England Total or Average**
Urban land 2020 [1]	1,396,811	318,000	2,300,886	528,712	359,707	129,214	5,033,328
Adjusted urban land 2020 [2]	924,689	216,558	1,495,576	277,045	276,974	103,500	3,294,341
Adjusted carbon storage (tons/acre urban land) [3]	21.15	20.09	19.60	19.42	17.19	17.00	21.15
Adjusted carbon sequestration (tons/year/acre urban land) [3]	0.55	0.42	0.53	0.42	0.41	0.36	0.55
Notes: [1] The quantity of urban land in 2020 is calculated from the percent urban land projection for 2020 applied to total state land area as contained in Nowak & Greenfield 2018. [2] Adjusted urban land area in 2020 is estimated as the urban land 2020 area adjusted by the urban forest % in Table 2.							

[3] Adjusted urban carbon storage and sequestration on a per acre basis is estimated by adjusting total urban carbon storage and sequestration data from Nowak & Greenfield 2018 by the urban forest % and dividing by the number of adjusted acres of urban land for each New England state.

Other studies

The climate benefits of urban trees in New England have been noted by numerous studies. New England's urban forests store and sequester considerable carbon, especially in the Southern New England states of CT, MA, and RI where urban areas are large and expanding. One study estimates that New England's urban and community forests sequester 8.2% of the region's net forest ecosystem carbon sequestration (Zheng et al 2013). Annual carbon sequestration of urban forests in the U.S. has been estimated as 25.6 million tons of carbon/year, equivalent to 94 million tons of CO2e, or the emissions of 18 million cars (Nowak et al 2013). Nowak and Greenfield 2008 also provide numerous estimates of the benefits of urban trees, including carbon storage and sequestration and air pollution removal.