Forest Carbon Uptake Over 22 Years in a Northeastern U.S. Temperate Forest

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PURPOSE

Temperate forests play an important role in the global carbon cycle by sequestering atmospheric carbon dioxide and storing above-ground and below-ground carbon (Figure 1). Quantifying these carbon (C) pools and fluxes is critical in understanding temperate forests' relevance in reversing global warming. As forests age, tree growth is one of the primary ways in which carbon accumulates. Our purpose it to measure the above-ground increase in C stock at a local Penn State Forest from 1997 to 2019.

METHODS

Above-ground C (1997-2019)

20 plots located in the Pennsylvania Game Commission Lands 176 (PGCL176) were surveyed in 1997 and 2019 to compare the change in above-ground C over the last 22 years. Trees with greater than 11 cm diameter at breast height (DBH) were used in allometric equations to estimate above-ground wood carbon (Chojnacky et al 2013). Tree stem carbon estimates and leaf litter values from similar forest sites (Aber 1993) were added to yield an estimated Above-ground Net Primary Productivity (ANPP) for each site.

Below-ground C (2019)

Plots 16,17,and 18 were surveyed in 2019 to estimate the forests' below-ground C stock. O-horizon soil was sampled by extracting the top 3 cm of organic material. A-Horizon soil cores were extracted at a depth of 15 cm. These soil samples were analyzed by the CHNS-O elemental instrument to yield the concentration of C within each soil mixture.

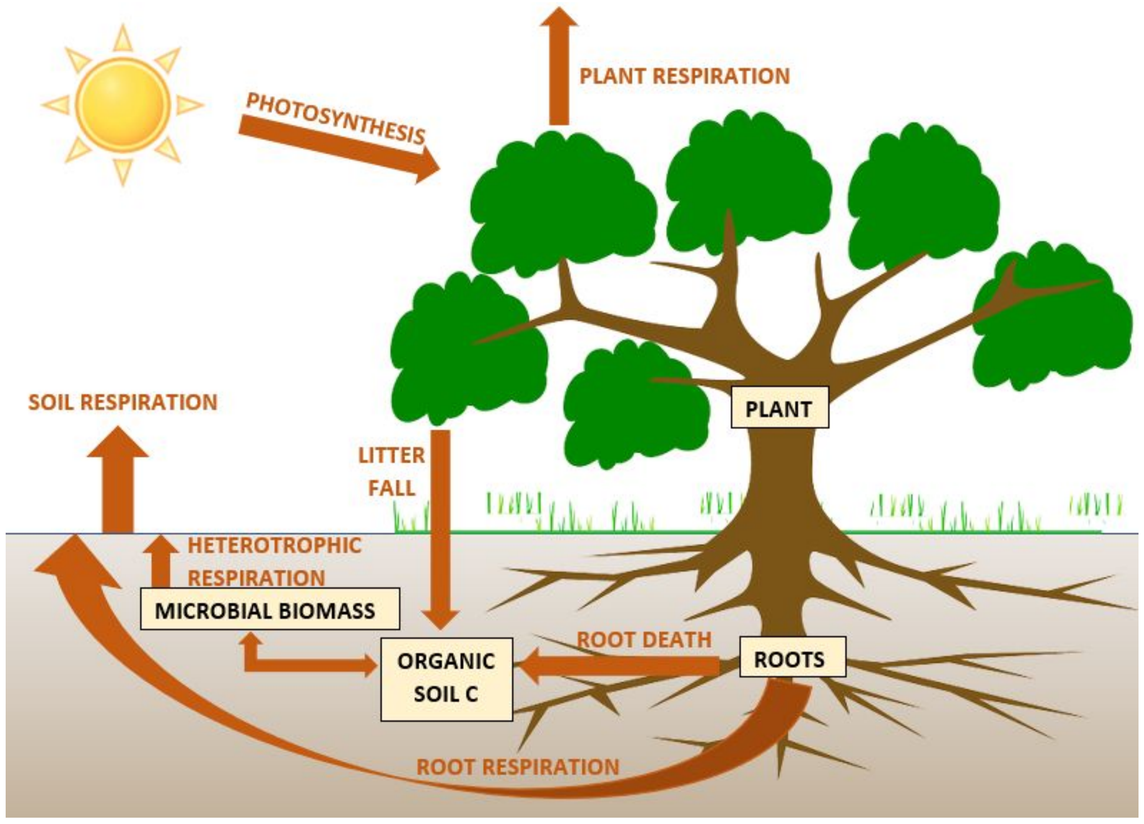

Figure 1. Forest Carbon Cycle. Carbon stocks are represented with yellow boxes. Carbon fluxes are represented with orange arrows.

Above-ground Carbon Stock 1997-2019

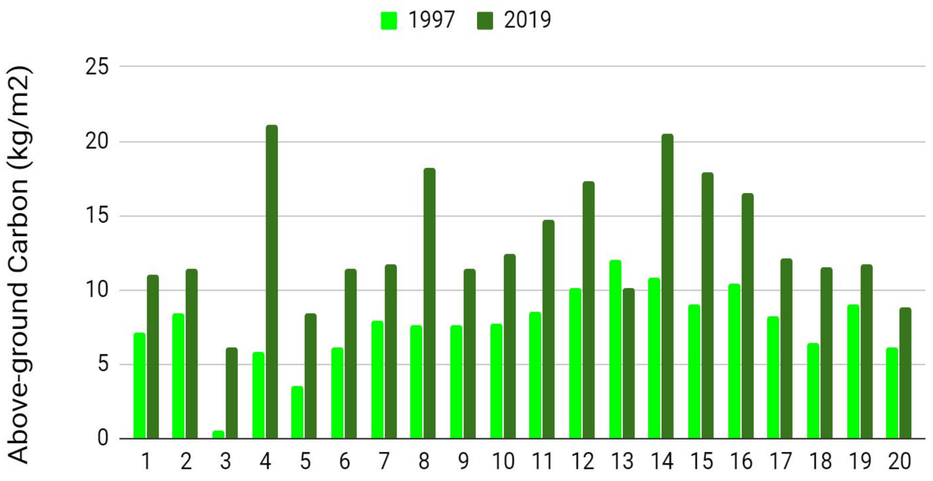

Figure 2. Change in above-ground Carbon stock (kg/m^2) over the last 22 years.

Above-ground Net Primary Productivity

Plot	C Stem Growth (kg/m^2/yr)	Leaf Litter (kg/m^2/yr)	ANPP (kg/m^2/yr)
1	0.179	0.287	0.466
2	0.139	0.287	0.426
3	0.255	0.287	0.542
4	0.694	0.287	0.981
5	0.223	0.287	0.510
6	0.240	0.287	0.527
7	0.175	0.287	0.462
8	0.479	0.287	0.766
9	0.170	0.287	0.457
10	0.213	0.287	0.500
11	0.280	0.287	0.567
12	0.329	0.287	0.616
13	-0.088	0.287	0.199
14	0.441	0.287	0.728
15	0.403	0.287	0.690
16	0.277	0.287	0.564
17	0.174	0.287	0.461
18	0.234	0.287	0.521
19	0.123	0.287	0.410
20	0.122	0.287	0.409
AVERAGE ANPP (kg/m^2/yr)=			**0.540**

Figure 3. C Stem Growth and Leaf Litter values were used to estimate ANPP (kg/m^2/yr).

Below-ground Soil Carbon Stock 2019

		O-Horizon		A-Horizon		
Plot	**Orientation**	**% C**	**Soil Carbon (kg/m^2)**	**% C**	**Soil Carbon (kg/m^2)**	**Total Soil C (kg/m^2)**
16	0°	34.3	0.258	3.31	0.835	1.09
16	120°	39.6	0.675	1.70	0.666	1.34
16	240°	23.6	0.432	2.99	1.22	1.65
17	0°	45.7	2.96	2.42	1.19	4.16
17	120°	37.9	0.990	1.75	0.743	1.73
17	240°	23.2	0.583	1.74	0.829	1.41
18	0°	40.1	1.07	2.45	0.735	1.81
18	120°	46.7	1.03	2.03	0.552	1.58
18	240°	41.2	1.35	1.73	0.812	2.17
					AVERAGE TOTAL SOIL C (kg/m^2) =	**1.88**

Figure 4. 2019 Below-ground soil C Concentration and Total Soil Carbon per unit area at three sites.

RESULTS

Above-ground C (1997-2019)

The different C stocks in 1997 and 2019 reveal a significant increase in forest carbon stock over the last 22 years (Figure 2). ANPP (kg/m^2/yr) values for each plot were calculated (Figure 3). As a result, an average ANPP value of 0.540 kg/m^2/yr is representative of the entire forest.

Below-ground C (2019)

O-Horizon and A-Horizon soil carbon concentrations were used to calculate the total amount of soil C per unit area for each plot (Figure 4). The two soil horizons averaged a total soil C of 1.88 kg/m^2 .

SIGNIFICANCE

The positive ANPP value of 0.540 kg/m^2/yr indicates a stable increase in above-ground carbon storage over the last 22 years. ANPP values are critical in understanding forests' capacity to sequester carbon. Further research must be conducted to establish a proper assessment of the US regional carbon cycle. Since forests serve as large carbon sinks, estimating the most accurate total carbon sequestration in temperate forests is essential in reversing global warming.

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