Supplementary 3 – Baseline and BAU Scenario

Baseline Forest Area Data

The baseline forest area data used in the report (Table 1) reflect static data on New England's forests from the most recent years available from FIA (2019/2020): forest area and loss, harvest area, urban area, and carbon storage and sequestration associated with rural and urban areas. These baseline data are derived from FIA data sources and from the Harvard Forest Protected Open Space database (DOI here). Baseline data on urban area is from Urban FIA (Nowak and Greenfield 2018); population data are from the US Census.

Table 1: Baseline estimates for land and forests in New England States

State	CT	ME	MA	NH	RI	VT	New England
Overall Land Base							
Total area (square miles, excluding water)	4,842	30,843	7,800	8,953	1,034	9,217	62,689
Total land area (acres)	3,203,694	21,199,988	5,289,392	5,940,580	781,971	6,153,029	42,568,654
Urban land area (acres) 2020	1,396,811	318,000	2,300,886	528,712	359,707	129,214	5,033,328
% urban land	43.60%	1.50%	43.50%	8.90%	46.00%	2.10%	11.82%
Total population (2019 estimate)	3,565,287	1,344,212	6,892,503	1,359,711	1,059,361	623,989	14,845,063
Pop density (per square mile)	736	44	884	152	1,025	68	237
Forests							
Total forest area (acres)	1,763,459	17,372,795	2,966,472	4,686,704	358,617	4,508,984	31,657,031
% forested	55%	82%	56%	79%	46%	73%	74%
Total timberland area (acres)	1,737,978	16,873,315	2,848,785	4,420,004	343,736	4,273,598	30,497,416
% forest that is timberland	99%	97%	96%	94%	96%	95%	96%
Total reserved forest area (acres) [1]	25,481	499,480	117,687	266,700	14,881	235,386	1,159,615
% of forest that is reserved	1.44%	2.88%	3.97%	5.69%	4.15%	5.22%	3.66%
Forestland acres protected from development (acres) [2]	519,448	3,956,176	1,206,494	1,831,965	128,914	1,340,670	8,983,667

% forestland protected from development	30%	23%	43%	41%	38%	31%	29%
Acres harvested (average annual) [3]	8,757	446,336	13,553	67,918	3,553	42,914	583,031
% of timberland area harvested annually	0.5%	2.6%	0.5%	1.5%	1.0%	1.0%	1.9%

Notes:
[1] Reserved forest land from the FIA Evalidator database is defined as "land permanently reserved from wood products utilization through statute or administrative designation. Examples include National Forest wilderness areas and National Parks and Monuments." Source: Forest Inventory and Analysis Glossary, https://www.nrs.fs.fed.us/fia/data-tools/state-reports/glossary/. These areas reflect protection from conversion to other land uses and harvest and are the proxy for Wildland Reserves in this study.
[2] Forest land protected from development is from the Harvard Forest Protected Open Space database, https://zenodo.org/record/3606763#.YE_F5J1KiUk.
[3] Harvested acres presented here reflect unadjusted acres from FIA State Fact Sheets for the New England states.
Sources: FIA, FIA State Factsheets, Harvard Forest Protected Open Space database, Nowak and Greenfield 2018, US Census.

Baseline Carbon Data

Baseline carbon stock and sequestration estimates are based on Domke 2021, Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2019, a summary of US EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019 (US EPA 2021).

As an input to Chapter 6: Land Use, Land Use Change, and Forestry of the US EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019 (US EPA 2021), Domke et al 2021 conduct a high-resolution analysis and annualization of FIA plot data (down to the sub-plot level) and provide roughly 30 years of annualized data (1990-2019) on forest carbon stock and sequestration from forests remaining as forests, and on the carbon implications of forestland area loss and gain to and from other land categories for each state in New England. The EPA report and Domke et al 2021 follow guidance from The Intergovernmental Panel on Climate Change's *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006). The EPA report states on page 6-9 that "All emissions and removals estimates are calculated using internationally-accepted methods provided by the IPCC in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines)* and the *2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands*."

The Domke et al 2021 data provide carbon stock data from FIA that have been assessed using remote sensing information and field-level data collection from FIA plots. Carbon stocks and net fluxes from forestland are provided for five carbon pools: aboveground biomass (pool 1); belowground biomass (pool 2); dead wood (pool 3); litter (pool 4); and soil carbon (pool 5). This study's assessment of aboveground carbon for the baseline estimate includes pools 1, 3 and 4. The study does not include carbon pools 2 and 5 as these pools estimate belowground carbon. The aboveground biomass pool (pool 1) reflects the biomass of live trees with diameter at diameter breast height (d.b.h.) of at least 1 inch. The detailed methodology employed to estimate carbon stocks using FIA data for the US EPA GHG Inventory as documented in Domke et al 2021 is available in Section 3.13 of Annex 3 of the US EPA Inventory.

Table 2 summarizes baseline carbon data for New England states. These baseline data reflect the "forests remaining forests" category from Appendix I of Domke 2021 and reflect 2020 stock data and flux data for 2019. Average carbon density per acre of forestland is calculated in each state by dividing the ABG carbon stock in 2020 by the acres of forestland in the state. For example, the average aboveground carbon density for the aboveground carbon pools in Connecticut in 2020 is estimated at 52 tons of carbon per acre of forestland, while the average density in Maine (33 tons carbon/acre forestland) is lower. ABG carbon sequestration estimates from 2019 and the calculated sequestration per acre of forestland in each of the New England states both in terms of tons of carbon and tons of CO2e are also summarized in Table 2.

Table 2: Baseline Carbon Data (2020), short tons on forestland

Metric	CT	ME	MA	NH	RI	VT	New England Total/Average
Carbon stock (total, million tons) – 2020	209	1,563	356	526	42	530	3,226
Carbon stock (ABG) [1]	91	574	150	206	17	212	1,251
% C stock ABG	44%	37%	42%	39%	41%	40%	39%
Carbon stock density 2020 (ABG C/acre forestland)	52	33	51	44	48	47	46
Carbon stock density (tons ABG CO2e/acre forestland)	189	121	186	161	176	172	168
ABG carbon seq (tons) - 2019 [2]	(837,756)	(2,436,105)	(1,168,449)	(1,256,633)	(110,231)	(1,477,095)	(7,286,269)
ABG carbon seq (tons/acre forestland) – 2019 [2]	(0.48)	(0.14)	(0.39)	(0.27)	(0.31)	(0.33)	(0.23)
Average annual ABG CO2e seq (tons/acre forestland) – 2019 [2]	(1.74)	(0.51)	(1.44)	(0.98)	(1.13)	(1.20)	(1.17)

Notes:
[1] ABG = Aboveground carbon. ABG is estimated as the sum of carbon pool 1 (aboveground biomass), carbon pool 3 (dead wood), and carbon pool 4 (litter).
[2] Negative numbers indicate sequestration, or absorption, of carbon from the atmosphere into the forest carbon pools.
Source: Stock and sequestration numbers from Domke 2021 Appendix I; average annual densities are calculated by the authors.

Business-as-Usual (BAU)

The business-as-usual (BAU) scenario employed in the study accounts for forest dynamics, including growth, conversion, and harvest. The scenario does not account for harvested wood products.

Focusing on harvest and conversion as the primary land use drivers of forest change in New England is supported by the literature, including Harris et al 2016 (Table 3) who estimates that harvest in New England accounts for most carbon removals from forests, especially in Northern New England. In New England, conversion is the second most significant factor in carbon removal, except for Maine, where Harris et al estimate that damage from wind is estimated to result in more carbon removal than conversion. It is important to note the balance of forest loss in terms of acres and carbon removal: conversion results in a greater carbon loss per acre on a fewer number of acres across New England while harvest results in less carbon loss on a per acre basis but occurs on a much greater number of acres.

Table 3: Attribution of carbon loss to disturbance type in New England states (Harris et al 2016)

State	Forest area (2005, acres)	Short Tons C/Year			% of C loss attributable to disturbance type						Short Tons C/Year	
		C gain	C loss	Net C change	Fire (%)	Insect (%)	Wind (%)	Conversion (%)	Drought (%)	Harvest (%)	Lost to Conversion	Lost to Harvest
CT	2,223,945	-1,322,773	220,462	-1,102,311			1	31%		68%	68,343	149,914
ME	16,803,140	-8,487,795	7,385,484	-1,102,311			15	1%		84%	73,855	6,203,806
MA	3,706,575	-2,094,391	661,387	-1,433,004			4	18%		78%	119,050	515,882
NH	5,189,205	-2,866,009	881,849	-1,984,160		2	4	6%		88%	52,911	776,027
RI	494,210	-220,462	110,231	-110,231			3	11%		85%	12,125	93,696
VT	4,942,100	-2,755,777	661,387	-2,094,391			2	1%		96%	6,614	634,931
Total	**33,359,175**	**16,424,434**	**9,920,799**	**-6,503,635**							**332,898**	**8,374,257**
Source: Harris et al 2016. Harris et al 2016 estimated the impacts of disturbance on carbon based on FIA and remote sensing data.												

Forest Conversion

Forest loss to conversion estimates by state in New England were obtained from Grant Domke and his team at the USFS; these data underlie estimates summarized in Domke et al 2021 and provide acres of forest lost to three land categories over the period 1990-2019 (Table 4): settlements, cropland, wetlands, and "other land". These forest loss data are used as the BAU forest loss estimates in the current study.

Other land is defined here following IPCC 2006 as a category that "…includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available." (IPCC 2006) Conversations with USFS have indicated that this category may include some areas of bare soil, rock and ice but also include errors in the data where a land-use category was not included and may reflect conversion to settlements as most forestland conversion in New England is to settlements: roughly 50% of forestland lost in New England is to settlements (Table 4).

Forest land in New England is also being lost to solar development, though consultation with USFS staff on the FIA dataset has shown that there is not a robust way to isolate forest loss to solar development in FIA data yet.

Table 4: Forest Loss Estimates (acres)

Forest Converted to Non-forest Land Use Types (annual average acres, 1990-2019)							
State	CT	ME	MA	NH	RI	VT	New England Total
Wetland [1]	1,701	4,820	721	3,352	-	1,212	11,807
Cropland	-	2,371	2,119	2,765	630	6,474	14,358
Other Land	44	1,867	443	132	-	229	2,716
Settlements	1,652	12,392	2,874	4,585	926	5,761	28,191

Total average annual acres of forest loss (1990-2019)	**3,398**	**21,450**	**6,156**	**10,835**	**1,556**	**13,676**	**57,071**
% of conversion to settlements (excluding water)	**49%**	**62%**	**51%**	**50%**	**40%**	**41%**	**52%**
Forest Converted to Non-forest Land Use Types (total acres, 1990-2019)							
State	**CT**	**ME**	**MA**	**NH**	**RI**	**VT**	**New England Total**
Wetland [1]	51,027	144,606	21,622	100,572	-	36,374	354,200
Cropland	-	71,117	63,555	82,953	18,904	194,225	430,753
Other Land	1,334	56,019	13,294	3,954	-	6,870	81,471
Settlements	49,569	371,769	86,215	137,563	27,775	172,825	845,717
Source: Domke et al 2021							
Notes: [1] We do not include loss to water in our analysis. [2] Other land is defined here following IPCC 2006 as a category that "…includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available." (IPCC 2006)							

Harvest

New England's ecologically diverse forests support multiple forest-based industries, including harvest of timber for wood-based products. Harvest is a key driver of carbon loss from the forest, particularly in the northern New England states of Vermont, New Hampshire, and Maine. Social, ecological, and environmental differences across New England's forests, including regulations in the states and varying landowner decisions on why and when to harvest, make singular prescriptions on how to sustainably harvest difficult for the region. Decisions made by the large number of small, private forestland owners in New England play an important role in determining the condition and fate of the forests, especially in southern and central New England. In the northern parts of the region, the situation is reversed: few, large landowners make management decisions that have proportionately large impact on the region's carbon stores and sequestration potential.

As much as 40% of forestland in northern New England (Vermont, New Hampshire, and Maine) may be degraded in terms of forest stocking (Gunn et al 2019). Another study of harvesting in New England more broadly concluded that nearly one-third of harvests in the region involved commercial clear-cuts and high-grading (Belair and Ducey 2018); these practices are considered exploitative because in their singular focus on removing high-quality trees, stands are left with dynamics that result in reduced overall biomass growth rates and timber values.[1] While clearcutting was more common historically, frequent partial harvest accounts for most of the harvest in New England currently (Canham et al 2013). Harvest is also the largest source of carbon removal from the landscape in New England: while on a per-acre basis carbon removals from conversion to non-forest uses may be larger, total carbon loss from forest harvesting is far larger since it occurs over such a large area of New England's forest. One study estimated that harvest accounts for between 68% (Connecticut) and 96% (Vermont) of carbon loss in New England states (Harris et al 2016). Another study states that "[h]arvesting is the leading cause of

[1] Harvest practices that target only high-value trees from a stand and ignore overall stand dynamics may result in stands where lower-value trees prevent regrowth of high-value species (Belair and Ducey 2018).

adult tree mortality in forests of the northeastern United States" (Brown et al 2018). While this is the case, on average, New England's forests are generally not being harvested above net annual growth (Table 5): annual net growth in New England's forests exceeds harvest removals by a factor of 2x (New Hampshire, Rhode Island, Vermont); 4x (Massachusetts) and 6x (Connecticut). Maine is the exception, where harvest removals come closer to the forest's growth (1.2x) (FIA EVALIDator Data). Importantly, state averages such as these do not show the underlying variation in forest sustainability.

Table 5: Growth and Removals Data for New England States

Tree Growth and Removal Data (trees>1 in dbh, dry short tons on timberland)	**CT**	**ME**	**MA**	**NH**	**RI**	**VT**	**New England Total**
Net growth [1]	2,002,363	15,241,173	2,358,190	4,392,947	174,467	3,975,642	28,144,783
Harvest	338,523	13,482,441	604,571	2,282,067	94,335	1,932,900	18,734,837
Harvest/net growth	**17%**	**88%**	**26%**	**52%**	**54%**	**41%**	**65%**
Harvest as % of total removals	80%	96%	82%	94%	77%	93%	94%
Notes: [1] Net growth = gross growth - mortality. [2] Net change = net growth - removals. Source: FIA EVALIDator.							

The study relies on harvest area and removals data for New England states from FIA to assess the BAU scenario (Table 6). FIA state profiles provide an annual average estimate of forest land treated by cutting (harvest/thinning) (acres), noting that these estimates are based on data collected across 5 to 10 years and may not be indicative of the nominal year presented in the title by itself. According to these data, annual harvest in New England states ranges from less than 1% of total timberland acres in CT to almost 3% in Maine. These data are similar to other existing harvest estimates for New England states. For example, Maine's 2018 Silvicultural Activities Report shows a similar annual average harvest area in Maine as that presented in Table 6 (~400,000 acres per year on average from 2009 to 2017, with a high of 444,000 acres in 2011 and a low of ~338,000 acres in 2017) (Maine Forest Service 2020). Kittredge et al 2003 analyze 17 years of harvest data in the North Quabbin Region of MA (168,000 ha) and estimate a 1.5% annual disturbance (harvest) rate. In MA, McDonald et al 2006 use 20 years (1984-2003) of harvest data to estimate that annual forest harvest in the state varied from 0.01% to 1.48%. In a study of 30 years of harvest data in MA, Kittredge et al 2017 found that for towns within MA that experienced a harvest during the time period of analysis (1984-2013), the average percent of the town's forest that supported harvest ranged from 3.3% to 7.3% on private lands and 5.1% to 7.0% on public lands. Using FIA data in Northeastern states, Thompson et al 2017 find an annual probability of harvest (including a range of harvest types from firewood removal to commercial clearcuts) on privately owned forests of 3% per year and on publicly owned forests of 1.5% per year.

Table 6: Forest harvest by state in New England

State	**CT**	**ME**	**MA**	**NH**	**RI**	**VT**	**New England**

Forest land treated by cutting annually (harvest/thinning) (acres)	8,757	446,336	13,553	67,918	3,553	42,914	583,031
Total timberland (acres)	1,737,978	16,873,315	2,848,785	4,420,004	343,736	4,273,598	30,497,416
% of total timberland acres harvested per year	0.5%	2.6%	0.5%	1.5%	1.0%	1.0%	1.9%
Note: Data reflect 2019 or 2020 values, depending on the state. Source: FIA; FIA State Factsheets 2019/2020.							

The current study adjusts harvest data from FIA (Table 6) using data from Belair and Ducey 2018 as summarized in Table 7. Belair & Ducey 2018 use FIA plot data to assess harvest patterns across New England States and provide information on the proportion of harvest events assigned to different harvest categories; the current study selects for those harvest types (highlighted in red) that are stand replacing and represent the major timber harvest practices of clearcutting, shelterwood, and selection systems that would likely occur only once in the 30-year time period of analysis on any specific acre. Adding these percentages together generates a discount factor for each New England state (e.g., 75.10% for CT, 62.5% for VT) that, when applied to the FIA data on total acres harvested, removes incidental harvest and other harvest types in order to reflect an annual average harvest area that would be independent in each year of the 30-year analysis. In other words, harvest categories such as "incidental harvest – firewood" in Table 7 are assumed to potentially occur more than once on the same acres of timberland in the 30-year time period of analysis, thereby inflating the harvest area from FIA where acres may be counted twice if firewood removal occurred twice over 30 years. The discount factor controls for this when applied to FIA harvested acres. Using this methodology yields a 0% discount factor for Rhode Island because the Belair and Ducey 2018 data show 100% incidental harvest in the state. The FIA data, however, show harvest in Rhode Island. For this reason, the discount factors for CT and MA are averaged and applied as the discount factor for Rhode Island (65%).

Table 7: Harvest patterns across New England states

Harvest Category [1]	Proportion of harvested events assigned to each harvest type [2]					
	CT	ME	MA	NH	RI	VT
Total plots	240	5,339	419	809	90	794
Percent of plots harvested	6.7%	16.6%	4.1%	12.1%	2.2%	9.1%
*Commercial clearcut	12.50%	28.40%	0.00%	8.20%	0.00%	6.90%
*Crown thinning/crop tree release	18.80%	3.30%	29.40%	9.20%	0.00%	9.70%
*High grade	6.30%	8.50%	17.60%	14.30%	0.00%	13.90%
Low thin/shelterwood prep cut	0.00%	0.70%	5.90%	1.00%	0.00%	2.80%
*Overstory removal	0.00%	2.70%	0.00%	4.10%	0.00%	0.00%
Pre-commercial/geometric thinning	0.00%	12.00%	0.00%	5.10%	0.00%	5.60%
*Seed tree/clearcut with reserves	0.00%	0.20%	0.00%	0.00%	0.00%	1.40%
*Shelterwood	37.50%	14.60%	5.90%	12.20%	0.00%	9.70%
*Silvicultural clearcut/ group/patch selection	0.00%	8.60%	0.00%	6.10%	0.00%	2.80%

*Single-tree/group selection'	0.00%	8.00%	0.00%	16.30%	0.00%	18.10%
Incidental harvest - firewood etc	25.00%	13.10%	41.20%	23.50%	100.00%	29.20%
***Red text included in discounted harvested acres**	75.10%	74.30%	52.90%	70.40%	65%	62.50%
Notes: [1] *Red text signifies inclusion of the harvest type in the analysis. [2] Percentages reflect % of plots assigned to the harvest category. Source: Belair and Ducey 2018						

Table 8 shows the adjusted harvested acres calculated by applying the discount factor to the FIA data on forest land treated by cutting annually, and the % of total timberland acres that are harvested per year according to the discounted number. The analysis uses these adjusted acres as the baseline annual average harvest area. The discounted average annual harvest area ranges from 7,650 acres per year (0.27% of timberland by area) in Massachusetts to over 300,000 acres per year (1.94% of timberland by area) in Maine.

Table 8: Discounting harvested acres in New England states

State	CT	ME	MA	NH	RI	VT	New England
Forest land treated by cutting annually (harvest/thinning) (acres)	8,757	446,336	13,553	67,918	3,553	42,914	583,031
Discount Factor (Table 7)	75.10%	74.30%	52.90%	70.40%	65%	62.50%	
Adjusted average annual harvest area (acres)	6,577	331,628	7,170	47,814	2,274	26,821	422,283
Total timberland (acres)	1,737,978	16,873,315	2,848,785	4,420,004	343,736	4,273,598	30,497,416
% of total timberland acres harvested per year (discounted)	0.38%	1.97%	0.25%	1.08%	0.66%	0.63%	1.38%
Note: Data reflect 2019 or 2020 values, depending on the state. Source: FIA; FIA State Factsheets 2019/2020.							

Carbon Implications of Harvest

The carbon implications of harvest will be determined in part by the type of harvest conducted on a particular forest stand. Certain types of harvest will affect growth differently, leading to differing rates of growth and therefore carbon sequestration and accumulation in the harvested area over time. The scope of the current study did not allow for a detailed treatment of harvest and growth dynamics; the study relies instead on an average static estimate of carbon removal associated with harvest and does not estimate future sequestration rates on harvested stands/acres to account for greater growth rates associated with certain harvest practices.

To estimate the carbon implications of harvest on New England timberlands, FIA data on average annual harvest removals by state of aboveground biomass of trees (at least 1 inch d.b.h) on timberland are used. Average annual harvest removals are divided by the harvest acres from FIA State Factsheets to obtain harvest removal in tons per harvested acre. Carbon removal per harvested acre is estimated following general convention that dry wood is ~50% carbon by weight. Using this methodology, the average carbon removal per harvested acre ranges from ~20 tons/acre in Connecticut to ~22 tons/acre in Massachusetts (Table 9). Total annual carbon removal from harvest is then calculated as the average carbon removal per harvested acre multiplied by the adjusted annual harvested timberland acres calculated in Table 8. The total annual carbon removal from harvest across New England is estimated as nearly 7 million tons per year (Table 9).

Table 9: Estimate of annual carbon removal from harvest in New England states

FIA Data	CT	ME	MA	NH	RI	VT	New England Total
0406 Average annual harvest removals of aboveground biomass of trees (at least 1 inches d.b.h./d.r.c.), in dry short tons, on timberland	338,523	13,482,441	604,571	2,282,067	94,335	1,630,577	18,432,514
Forest land treated by cutting annually (harvest/thinning) (acres) (FIA State Factsheets, 2019 or 2020)	8,757	446,336	13,553	67,918	3,553	42,914	583,031
Harvest removal per harvested acre	38.66	30.21	44.61	33.60	26.55	38.00	
C removal per harvested acre (average)	19.33	15.10	22.30	16.80	13.28	19.00	
Adjusted harvested timberland annually (acres) (2019 or 2020)	6,577	331,628	7,170	47,814	2,274	26,821	422,283
Total annual C removal from harvest (adjusted acres)	**127,115**	**5,008,727**	**159,909**	**803,288**	**30,187**	**509,555**	**6,638,781**

Harvested Wood Products

We have not modeled changes to fate of forest products that may result from our alternative future pathways. These forest products include biomass and storage in harvested wood products (HWP). We assumed that forest products delivered from timberland in New England will remain constant through all our future pathways. However, we note that changes could occur that may create additional demand for dimensional lumber, such as increases in mass timber construction. Other significant technologies that might shift the balance of wood fiber usage include laminated veneer lumber, wood fiber insulation, and wood-based plastics. Harvested wood products reflect roughly 15% of the net sequestration from forest-based carbon pools at the U.S. level (2018 data, EPA 2020).

Comparing C Loss to Conversion and Harvest

The estimates for carbon lost to conversion and carbon lost to harvest show that on a per acre basis, carbon losses to harvest are much smaller than for forestland conversion (i.e., the per acre carbon losses for harvest vs. conversion are smaller), but harvest occurs on far more acres in New England than conversions do. In addition, carbon impacts post-harvest may be more dynamic than carbon impacts post-conversion. For example, different harvest prescriptions may result in differing levels of post-harvest growth and sequestration, where conversion will more likely lead to a permanent loss of a proportion of carbon (e.g., the 70% static loss we assume) while the remaining biomass will continue to grow and sequester carbon, but perhaps at a slower rate than new growth on a clear-cut acre of forestland. In addition, as mentioned elsewhere in this report, the lost trees and forest on a converted acre also lead to foregone future sequestration that would have been possible if the trees had not been removed. Table 10 shows the attribution of carbon loss across conversion and harvest both from Harris et al 2016 and the current study. Overall, we estimate that 76% of carbon removal from the landscape in New England results from harvest.

Table 10: Attributing C loss to conversion and harvest in New England states

State	Harris et al 2016		Current Study	
	Conversion (%)	Harvest (%)	Conversion (%)	Harvest (%)
CT	31	68	35	65
ME	1	84	29	71
MA	18	78	16	84
NH	6	88	42	58
RI	11	85	6	94
VT	1	96	53	47
New England	N/A	N/A	12	88

Wildlands Designation

Forest protection and conservation of various types occurs annually throughout New England's states. Wildland designation is a particular kind of forest conservation that precludes all development and harvest and allows forests to grow old as wilderness. The study uses the FIA category of "reserved forests" as a proxy for wildlands as a better estimate that is also associated with carbon stock and sequestration rates – as the FIA reserved forest category is – is not available. To establish average annual BAU wildlands designation, the study relies on forest conservation data from NLCD 2016 & Highstead/Harvard Forest Protected Open Space database for the period 1990-2020 for BAU forest conservation. The average annual forest conservation over this time period for each state is estimated from these data, using data from 1990 to the year in which the most recent data are available for each state. The quantity of reserved forestland as a percentage of total forestland in each state from the FIA database is then applied to BAU forest conservation to estimate a BAU value for average annual reserved forestland as a proxy for average annual wildland designation (Table 11). Under this set of assumptions, the study estimates that around 174,000 acres of wildlands would be designated over 30 years (2020-2050) across the states of New England.

Table 11: Calculation of BAU Wildlands Designation (2020-2050)

Forest Data	CT	ME	MA	NH	RI	VT	New England Total
Average annual additional forestland protected (acres)	6,230	93,060	13,479	23,333	1,698	21,030	158,830
% forestland reserved	1.44%	2.88%	3.97%	5.69%	4.15%	5.22%	3.66%
Additional annual wildlands designation (acres)	90	2,676	535	1,328	70	1,098	5,796
BAU additional wildlands designation (30 years, acres)	2,701	80,266	16,043	39,834	2,113	32,935	174,541

Emissions

This study uses emissions data from EPA's [State Inventory Tool (SIT)] for GHG reporting. New England states uniformly use this tool for GHG reporting. The SIT uses EIA data (emissions from energy), state data, and some default data to calculate GHG emissions for certain GHGs across specified sectors. CO2 makes up the vast majority of GHGs emitted by NE states. CO2 emissions are heavily concentrated in the transportation, building and energy sectors. Land-use change and forestry can be a sink in the emissions estimates. The SIT tool also allows for emissions projections. Table 12 summarizes the emissions reduction goals of New England states and emissions data retrieved for each state.

Table 12: Emissions Reductions Goals of New England States

Emissions	CT	ME	MA	NH	RI	VT
Emissions Reduction Goal	80% below 2001 levels by 2050	45% GHG reduction in gross emissions by 2030 and 80% by 2050 (from 1990 levels)	85% below 1990 levels by 2050; net-zero by 2050; up to 15% allowed by offset sequestration (previously 80% reduction by 2050)	80% by 2050 from 1990 level	10% below 1990 levels by 2020, 45% below 1990 levels by 2030; 80% below 1990 levels by 2040, and net-zero emissions by 2050	26% below 2005 levels by 2025, 40% below 1990 levels by 2030, and 80% below 1990 levels by 2050
Emissions Reduction Goal Status	Statutory	Statutory	Statutory	Aspirational	Statutory	Statutory
Emissions Reduction Detail	Passed An Act Concerning Connecticut Global Warming Solution (2008) that requires state to reduce GHG emissions to 80% below 2001 levels by 2050.	Passed An Act to Promote Clean Energy Jobs and To Establish the Maine Climate Council in 2019 that requires the state to reduce GHG emissions to 45% below 1990 levels by 2030 and 80% by 2050.	Passed An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy (2021) that requires the state to reduce GHG emissions by 85% below 1990 levels by 2050, and achieve net-zero GHG emissions by 2050.	Published the New Hampshire Climate Action Plan in 2009, which calls for an 80% reduction in GHG emissions below 1990 levels by 2050.	Passed an Act on Climate (2021) that requires the state to achieve the following GHG emissions reductions: 10% below 1990 levels by 2020, 45% below 1990 levels by 2030; 80% below 1990 levels by 2040, and net-zero emissions by 2050.	Passed An Act Relating to Addressing Climate Change (2020) that requires the state to reduce GHG emissions to 26% below 2005 levels by 2025, 40% below 1990 levels by 2030, and 80% below 1990 levels by 2050.

Gross emissions were retrieved for the most recent year available for each state in New England to mark progress towards emissions reductions goals. Figure 1 summarizes the current state of emissions for each New England state, and shows the additional emissions reductions required to reach 2030 and 2050 goals.

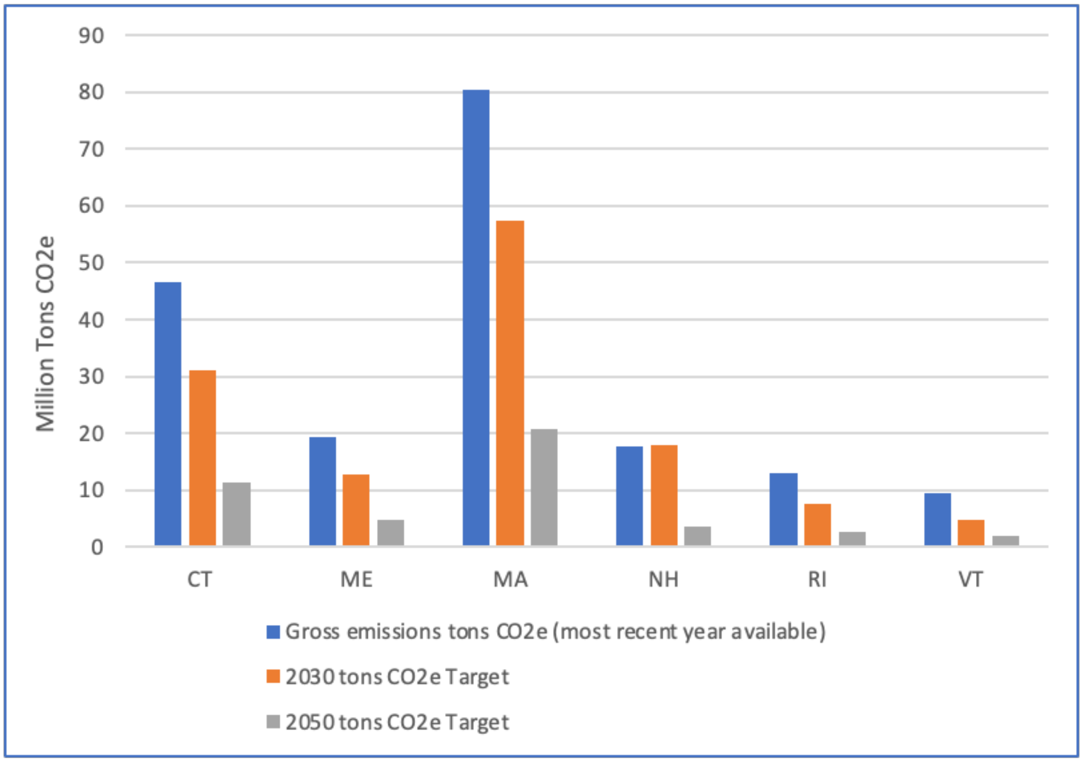

Figure 1: Current Emissions Profile of New England States

BAU Scenario Estimates

Figure 2 shows our estimate of the carbon stock in New England under a BAU scenario, which grows the carbon stock for the 2020-2050 period using the rate of carbon stock growth from the 1990-2019 period detailed in Figure 5.

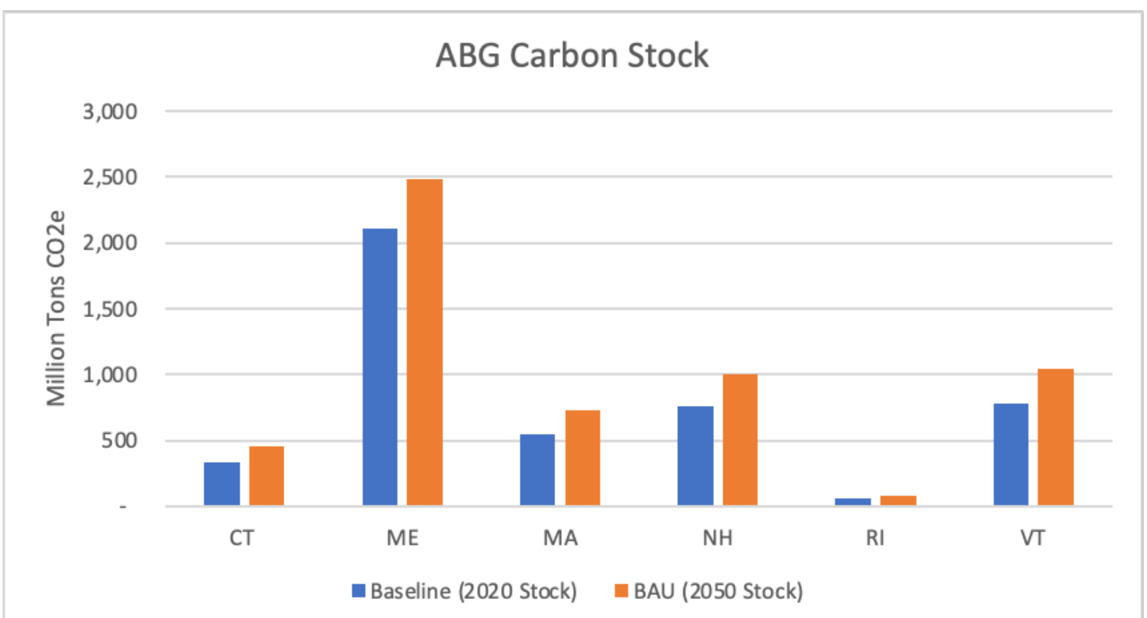

Figure 2: Carbon stock estimates for the baseline and BAU scenarios

This document is a supplement to the paper *New England's Climate Imperative: Our Forests as a Natural Climate Solution*. Read more here.

Comparisons with Recent Studies

A recent study (MacLean et al 2021) of the aboveground carbon implications of alternate future land-use scenarios in New England, formulated through the New England Landscapes Future (NELF) project, provides a useful point of comparison for our BAU estimate, and specifically the "recent trends" scenario evaluated. The recent trends scenario reflects a linear trend of recent harvest and development patterns, projected to 2060. The MacLean et al 2021 study builds on previous work by Duveneck and Thompson 2019, Thompson 2020, and Duveneck et al 2017. Duveneck and Thompson 2019 estimated that without land use changes (harvest or conversion), aboveground carbon would increase 53% from 2010 to 2060; modeled climate change increases aboveground carbon by an additional 8% and changes pursuant to modeled land use change decreases aboveground carbon by 16%, for a net decrease of 8% below the control, or a 45% overall increase in aboveground carbon on the landscape from 2010-2060. Modeling changes in MacLean et al 2021 resulted in an additional 9% aboveground biomass in 2060 compared to Duveneck and Thompson 2019, or a 54% increase in aboveground carbon by 2060.