Appendix 13: Greenhouse Gas Inventory of Forests and Trees for the Towns of Bolton, Devens, and Harvard Project Description

Methods to Assess Carbon in Forests and Trees Outside Forests, and Additional Details of Results

Overview of methods with links to online documentation

In the LEARN tool, activity data are calculated for forests and trees across the contiguous United States at a spatial resolution of 30 m, i.e., all land within any community's inventory boundary is represented as a grid of individual pixels with an area of approximately 0.1 hectare (0.22 acres). Default activity data for all communities are calculated automatically in the tool using nationally consistent data products. In the LEARN tool, communities can select any county within the contiguous United States. Alternatively, communities can upload their own boundary file into the tool for analysis such as a city, precinct, municipality or any other custom boundary to serve as the analysis area for the inventory.

Areas of land cover and land cover change for the inventory are calculated in the LEARN tool using the National Land Cover Database (NLCD), produced by the United States Geological Survey (USGS). The NLCD serves as the definitive Landsat-based, 30-meter resolution land cover database for the United States. NLCD was chosen as the default because it is nationally consistent, updated periodically, and currently supports a wide variety of Federal, State, local and nongovernmental applications. The product is systematically aligned over time to enable trend assessments and provides the ability to understand both current and historical land cover and land cover change. The NLCD products are created by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of Federal agencies led by the U.S. Geological Survey. Geographic coverage includes the conterminous United States, coastal Alaska, Hawaii and Puerto Rico. Maps are currently available for the following years:

2001, 2004, 2006, 2008, 2011, 2013, 2016. Each map contains a 16-class legend (Figure 1). Release of a 2019 map is planned for early 2021.

Areas of tree canopy and tree canopy loss outside NLCD-defined forests are calculated in the LEARN tool using the NLCD's tree canopy cover products, produced by the United States Forest Service (USFS). Areas of tree canopy and tree canopy loss are also estimated using higher-resolution aerial imagery to improve detection of individual trees. Areas of forest disturbance over a selected inventory period are calculated in the LEARN tool using a variety of geospatial datasets concerning incidences of fire, insects, and harvesting.

NLCD forest area estimates were adjusted to match the Mass-GIS forest area estimates which are the base area estimates used throughout this report. Tables A1 and A2 show the differences between the two sets of data, for the common year of 2016. For Apple Country as a whole, the Mass-GIS data indicates less forest, settlement, and grassland areas than NLCD, and correspondingly higher areas of the other land-cover classes (cropland, wetland, and other). The individual jurisdictions do not all follow this overall pattern. The total area of Apple Country and the individual jurisdictions varies slightly between the two data sets. The Mass-GIS areas were used to calculate the removals and emissions from forest land remaining forest land (see tables A11 and A12 below to compare the adjusted and unadjusted estimates).

Removal and emission factors are calculated by type of activity, forest type and age class for each of 11 regional variants of the forest and tree GHG protocol. The factors are comparable to those presented in Intergovernmental Panel on Climate Change (IPCC) guidance documents, estimated by forest biome and age class, with separate factors for plantations. National forest inventory data are used to derive factors that are representative of regions and more local jurisdictions within the U.S. To apply locally, the regional factors are combined with local activity data from the specific community that is being inventoried. The emission and removal factors used for Apple Country are shown in tables A3 to A6. Details of the methodology are described in the following on-line documents:

Appendix J of the U.S. Community Protocol for Accounting and Reporting of Greenhouse Emissions

Description of methods for the Land Emissions And Removals Navigator (LEARN) tool

Methods to apply the i-Tree CANOPY tool

Table A1. Area by major land class from NLCD data, 2016.

Land-cover class	Total	Bolton	Devens	Harvard
	(Acres)			
Forest	21,855	9,527	1,489	10,841
Grassland	2,628	1,119	168	1,344
Cropland	74	15	0	59
Wetland	810	188	116	506
Settlement	6,457	1,927	2,643	1,890
Other	165	77	59	32
Total	31,989	12,851	4,476	14,672

Table A2. Area by major land class from Mass GIS data, 2016.

Land-cover class	Total	Bolton	Devens	Harvard
	(Acres)			
Forest	21,057	8,973	2,138	9,946
Grassland	2,365	1,011	312	1,042
Cropland	887	345	0	543
Wetland	1,435	495	139	801
Settlement	5,396	1,858	1,682	1,857
Other	839	169	159	511
Total	31,980	12,850	4,430	14,700

Tables of emission and removal factors

Table A3. Emission and removal factors for Apple Country.

	Emission factor (tC/ha)	Removal factor (tC/ha/yr)
Forest Change		
Deforestation		
To Cropland	31.79	
To Grassland	46.58	
To Settlement	100.52	
To Wetland	52.26	
To Other	N/A	
Reforestation		-1.96
Forest Remaining Forest		
Undisturbed		-1.78
Disturbed		
Fire	N/A	
Insect/Disease	N/A	
Harvest/Other	72.32	
Trees Outside Forests		
Tree Canopy Loss	70.21	
Canopy maintained/gained		-2.73

Table A4. Emission and removal factors for Bolton.

	Emission factor (tC/ha)	Removal factor (tC/ha/yr)
Forest Change		
Deforestation		
To Cropland	N/A	
To Grassland	41.92	
To Settlement	104.6	
To Wetland	58.78	
To Other	N/A	
Reforestation		-1.9
Forest Remaining Forest		
Undisturbed		-1.77
Disturbed		
Fire	N/A	
Insect/Disease	N/A	
Harvest/Other	66.5	
Trees Outside Forests		
Tree Canopy Loss	70.21	
Canopy maintained/gained		-2.72

Table A5. Emission and removal factors for Devens.

	Emission factor (tC/ha)	Removal factor (tC/ha/yr)
Forest Change		
Deforestation		
To Cropland	N/A	
To Grassland	56.86	
To Settlement	94.69	
To Wetland	42.58	
To Other	N/A	
Reforestation		-2.13
Forest Remaining Forest		
Undisturbed		-1.81
Disturbed		
Fire	N/A	
Insect/Disease	N/A	
Harvest/Other	69.33	
Trees Outside Forests		
Tree Canopy Loss	70.21	
Canopy maintained/gained		-2.77

Table A6. Emission and removal factors for Harvard.

	Emission factor (tC/ha)	Removal factor (tC/ha/yr)
Forest Change		
Deforestation		
To Cropland	31.79	
To Grassland	47.7	
To Settlement	89.48	
To Wetland	51.48	
To Other	N/A	
Reforestation		-1.97
Forest Remaining Forest		
Undisturbed		-1.79
Disturbed		
Fire	N/A	
Insect/Disease	N/A	
Harvest/Other	75.99	
Trees Outside Forests		
Tree Canopy Loss	70.2	
Canopy maintained/gained		-2.72

NLCD land-cover change matrices

Table A7. Land-cover change matrix from NLCD data for Apple Country, 2011-2016 (acres).

	2016						
2011	Forest land	Grassland	Cropland	Wetland	Settlement	Other land	Total area
Forest land	21,616	62	0	91	75	0	21,844
Grassland	161	2,571	0	5	35	3	2,775
Cropland	0	0	74	0	0	0	74
Wetland	78	0	0	711	0	0	789
Settlement	0	0	0	0	6,331	0	6,331
Other land	1	0	0	3	14	163	181
Total area	21,855	2,634	75	811	6,455	166	31,996

Table A8. Land-cover change matrix from NLCD data for Bolton, 2011-2016 (acres).

	2016						
2011	Forest land	Grassland	Cropland	Wetland	Settlement	Other land	Total area
Forest land	9,462	29	0	31	46	0	9,567
Grassland	49	1,091	0	0	32	1	1,173
Cropland	0	0	15	0	0	0	15
Wetland	15	0	0	159	0	0	174
Settlement	0	0	0	0	1,833	0	1,833
Other land	0	0	0	0	14	74	89
Total area	9,526	1,121	15	190	1,925	76	12,852

Table A9. Land-cover change matrix from NLCD data for Devens, 2011-2016 (acres).

	2016						
2011	Forest land	Grassland	Cropland	Wetland	Settlement	Other land	Total area
Forest land	1,480	8	0	18	26	0	1,532
Grassland	1	158	0	0	3	2	164
Cropland	0	0	0	0	0	0	0
Wetland	5	0	0	102	0	0	107
Settlement	0	0	0	0	2,615	0	2,615
Other land	0	0	0	0	0	57	57
Total area	1,486	166	0	120	2,644	59	4,474

Table A10. Land-cover change matrix from NLCD data for Harvard, 2011-2016 (acres).

	2016						
2011	Forest land	Grassland	Cropland	Wetland	Settlement	Other land	Total area
Forest land	10,680	23	0	46	4	0	10,754
Grassland	108	1,321	0	5	0	0	1,435
Cropland	0	0	59	0	0	0	59
Wetland	58	0	0	451	0	0	509
Settlement	0	0	0	0	1,883	0	1,883
Other land	0	0	0	2	0	32	35
Total area	10,845	1,345	60	505	1,888	33	14,676

Adjustments to NLCD-based Net CO2 Balance from using Mass-GIS Area Data and Aerial Imagery for Tree Canopy Outside Forests

Table A11. Net CO_2 balance of forests and trees outside forests (removals plus emissions) based on NLCD data.

	Total	Bolton	Devens	Harvard
	(Metric tons CO_2e/yr)			
Forest remaining forest	-54,827	-24,073	-3,836	-26,919
Forest to nonforest	4,619	2,329	1,092	1,198
Nonforest to forest	-690	-181	-20	-488
Trees outside forests	-10,514	-3,860	-2,241	-4,412
Total	-61,412	-25,785	-5,005	-30,621

Table A12. *Adjusted* net CO_2 balance of forests and trees outside forests (removals plus emissions) based on Mass-GIS Area Data and Aerial Imagery for Trees Outside Forests.

	Total	Bolton	Devens	Harvard
	(Metric tons CO_2e/yr)			
Forest remaining forest	-52,821	-22,674	-5,506	-25,934
Forest to nonforest	4,619	2,329	1,092	1,198
Nonforest to forest	-690	-181	-20	-488
Trees outside forests	-27,958	-10,236	-5,026	-12,680
Total	-76,850	-30,762	-9,460	-37,904