

Appendix H. Forestry & Land Use

Overview

Forestland emissions refer to the net carbon dioxide (CO₂) flux¹ from forested lands in Iowa, which account for about 8% of the state's land area.² The dominant forest type in Iowa is Oak-hickory which makes up about 36% of forested lands. Other common forest types are Mixed upland hardwoods at 26%, Hackberry-elm-ash-cottonwood at 18%, Maple-beech-birch at 12%, and Elm-ash-cottonwood-willow at 5% of forested land. All other forest types make up less than 6% each of the State's forests.

Through photosynthesis, CO₂ is taken up by trees and plants and converted to carbon in biomass within the forests. Carbon dioxide emissions occur from respiration in live trees, decay of dead biomass, and combustion (both wildfires and biomass removed from forests for energy use). In addition, carbon is stored for long time periods when forest biomass is harvested for use in durable wood products. Carbon dioxide flux is the net balance of CO₂ removals from and emissions to the atmosphere from the processes described above.

The forestry sector CO₂ flux is categorized into two primary subsectors:

- *Forested Landscape*: this consists of carbon flux occurring on lands that are not part of the urban landscape. Fluxes covered include net carbon sequestration, carbon stored in harvested wood products (HWP) or landfills, and emissions from forest fires and prescribed burns.
- *Urban Forestry and Land Use*: this covers carbon sequestration in urban trees, flux associated with carbon storage from landscape waste and food scraps in landfills, and nitrous oxide (N₂O) emissions from settlement soils (those occurring as a result of application of synthetic fertilizers).

Inventory and Reference Case Projections

Forested Landscape

For over a decade, the United States Forest Service (USFS) has been developing and refining a forest carbon modeling system for the purposes of estimating forest carbon inventories. The methodology is used to develop national forest CO₂ fluxes for the official *US Inventory of Greenhouse Gas Emissions and Sinks*. The national estimates are compiled from state-level data. The Iowa forest CO₂ flux data in this report come from the national analysis and are provided by the USFS. See the footnotes below for the most current documentation for the forest carbon modeling.³ Additional forest carbon information is in the form of specific carbon conversion factors.⁴

¹ "Flux" refers to both emissions of CO₂ to the atmosphere and removal (sinks) of CO₂ from the atmosphere.

² Total forested area and forest type percentages provided by P. Tauke, DNR to M. Stein, DNR on March 21, 2008. The total land area in Iowa is 35.8 million acres (<http://www.50states.com/iowa.htm>).

³ The most current citation for an overview of how the USFS calculates the inventory based forest carbon estimates as well as carbon in harvested wood products is from the US Inventory of Greenhouse Gas Emissions and Sinks: 1990-2005 (and earlier editions), US Environmental Protection Agency, Report # USEPA #430-R-07-002, April 2007, available at: <http://epa.gov/climatechange/emissions/usinventoryreport.html>. Both Annex 3.12 and Chapter 7 LULUCF are useful sources of reference. See also Smith, J.E., L.S. Heath, and M.C. Nichols (in press), *US Forest*

The forest CO₂ flux methodology relies on input data in the form of plot-level forest volume statistics from the Forest Inventory and Analysis (FIA) Program. FIA data on forest volumes are converted to values for ecosystem carbon stocks (i.e., the amount of carbon stored in forest carbon pools) using the FORCARB2 modeling system. Coefficients from FORCARB2 are applied to the plot level survey data to give estimates of C density [megagrams (Mg) per hectare] for a number of separate C pools (see Table H1 for Iowa C pools). Additional background on the FORCARB system is provided in a number of publications.⁵

Carbon dioxide flux is estimated as the change in carbon mass for each carbon pool over a specified time-frame. Forest biomass data from at least two points in time are required. The change in carbon stocks between time intervals is estimated for specific carbon pools (Live Tree, Standing Dead Wood, Understory, Down & Dead Wood, Forest Floor, and Soil Organic Carbon) and divided by the number of years between inventory samples. Annual increases in carbon density reflect carbon sequestration in a specific pool; decreases in carbon density reveal CO₂ emissions or carbon transfers out of that pool (e.g., death of a standing tree transfers carbon from the live tree to standing dead wood pool). The amount of carbon in each pool is also influenced by changes in forest area (e.g., an increase in area could lead to an increase in the associated forest carbon pools and the estimated flux). The sum of carbon stock changes for all forest carbon pools yields a total net CO₂ flux for forest ecosystems.

In preparing these estimates, USFS estimates the amount of forest carbon in different forest types as well as different carbon pools. The different forests also include differences in ownership class: those in the national forest (NF) system and those that are not federally-owned (private and other public forests). Additional details on the forest carbon inventory methods can be found in Annex 3 to the US EPA's 2007 GHG inventory for the US.⁶

Carbon pool data for three FIA cycles to estimate flux for two different periods were available for Iowa. The carbon pool data for three points are shown in Table H1 below. Note that prior to 1999, the Northern FIA Program took periodic forest inventory surveys of Iowa (approximately on a 13-year schedule). Beginning in 1999, Iowa transitioned from periodic to annual inventories as modifications to the FIA program were applied. The annual inventories are on a 5-year cycle and sample 20% of the state forests each year. Iowa completed its first annual inventory cycle in 2003. The 2005 carbon pool data represent 40% of the current 5-year inventory cycle.

Carbon Calculation Tool User's Guide: Forestland Carbon Stocks and Net Annual Stock Change, Gen Tech Report, Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station.

⁴ Smith, J.E., and L.S. Heath (2002). "A model of forest floor carbon mass for United States forest types," Res. Pap. NE-722. Newtown Square, PA: US Department of Agriculture, Forest Service, Northeastern Research Station. 37 p., or Jenkins, J.C., D.C. Chojnacky, L.S. Heath, R.A. Birdsey (2003), "National-scale biomass estimators for United States tree species", *Forest Science*, 49:12-35.

⁵ Smith, J.E., L.S. Heath, and P.B. Woodbury (2004). "How to estimate forest carbon for large areas from inventory data", *Journal of Forestry*, 102: 25-31; Heath, L.S., J.E. Smith, and R.A. Birdsey (2003), "Carbon trends in US forest lands: A context for the role of soils in forest carbon sequestration", In J. M. Kimble, L. S. Heath, R. A. Birdsey, and R. Lal, editors. *The Potential of US Forest Soils to Sequester Carbon and Mitigate the Greenhouse Effect*. CRC Press, New York; and Woodbury, Peter B.; Smith, James E.; Heath, Linda S. 2007, "Carbon sequestration in the US forest sector from 1990 to 2010", *Forest Ecology and Management*, 241:14-27.

⁶ Annex 3 to EPA's 2007 report, which contains estimates for calendar year 2005, can be downloaded at: <http://www.epa.gov/climatechange/emissions/downloads06/07Annex3.pdf>.

The underlying FIA data, as shown in Table H1, displays a net increase in forested area for all inventory years: 615,000 acres between 1990 and 2003 and 210,000 acres between 2003 and 2005. This results in a net increase in forested area of 825,000 acres in the 1990-2005 period. Most of the forested lands in Iowa are considered timberland, meaning that they are unreserved productive forest land producing, or capable of producing, crops of industrial wood. The timberland area is shown to have increased by 635,000 acres between 1990 and 2003 while it increased 241,000 acres between 2003 and 2005. This increase in timberland area resulted in the significant in carbon (52 million metric tons) from all forested areas between 1990 and 2005.

Table H1. USFS Forest Carbon Pool Data for Iowa

| Forest Pool | 1990 (MMtC) | 2003 (MMtC) | 2005 (MMtC) |
|--------------------------|---------------------------------|---------------------------------|---------------------------------|
| Live Tree – Above Ground | 49.3 | 66.7 | 71.6 |
| Live Tree – Below Ground | 9.4 | 12.7 | 13.6 |
| Understory | 1.4 | 1.9 | 2.1 |
| Standing Dead | 3.3 | 4.3 | 4.6 |
| Down Dead | 3.9 | 5.4 | 5.7 |
| Forest Floor | 13.7 | 15.7 | 16.4 |
| Soil Carbon | 50.2 | 64.5 | 68.9 |
| Totals | 131 | 171 | 183 |
| Forest Area | 1990 (10 ³ acres) | 2003 (10 ³ acres) | 2005 (10 ³ acres) |
| All Forests | 2,050 | 2,665 | 2,875 |
| Timberland | 1,944 | 2,579 | 2,820 |

MMtC = million metric tons of carbon. Positive numbers indicate net emission. Multiply MMtC by 3.667 (44/12) to convert to MMtCO₂.

Totals may not sum exactly due to independent rounding.

Data source: Smith, James, et al. *US Forest Carbon Calculation Tool: Forest-Land Carbon Stocks and Net Annual Stock Change* (<http://www.nrs.fs.fed.us/pubs/2394>), December 2007.

Table H2 shows the annualized carbon stocks interpolated from Iowa FIA data using the Carbon Calculation Tool (CCT)⁷. These annualized carbon stocks differ from the carbon stocks in Table H1 in that they are interpolated values (between forest inventory years) to January 1st of each year. The difference in carbon between each consecutive year is the carbon flux for that year. The carbon fluxes for each period shown in Table H3 are based on these annualized carbon stock estimates.

⁷ Smith, James, et al. *US Forest Carbon Calculation Tool: Forest-Land Carbon Stocks and Net Annual Stock Change* (<http://www.nrs.fs.fed.us/pubs/2394>), November 2007.

Table H2. Annualized Forest Carbon Pool from Carbon Calculation Tool

| Forest Pool | 1990 (MMtC) | 2003 (MMtC) | 2005 (MMtC) |
|--------------------------|--|--|--|
| Live Tree – Above Ground | 49.7 | 69.8 | 75.3 |
| Live Tree – Below Ground | 9.5 | 13.3 | 14.3 |
| Understory | 1.4 | 2.1 | 2.3 |
| Standing Dead | 3.3 | 4.5 | 4.8 |
| Down Dead | 4.0 | 5.6 | 6.0 |
| Forest Floor | 13.7 | 16.2 | 17.0 |
| Soil Carbon | 50.6 | 67.3 | 72.3 |
| Totals | 132 | 179 | 192 |
| Forest Area | 1990 (10³ acres) | 2003 (10³ acres) | 2005 (10³ acres) |
| All Forests | 2,065 | 2,799 | 3,035 |
| Timberland | 1,959 | 2,732 | 3,003 |

In addition to the forest carbon pools, additional carbon is stored in biomass removed from the forest for the production of harvested wood products (HWP). Carbon remains stored in the durable wood products pool or is transferred to landfills where much of the carbon remains stored over a long period of time. The USFS uses a model referred to as WOODCARB2 for the purposes of modeling national HWP carbon storage.⁸ State-level information for Iowa was provided to CCS by USFS.⁹

As shown in Table H3, about 0.12 million metric tons (MMt) of CO₂ per year (yr) is estimated by the USFS to be sequestered annually (1990-2005) in wood products. Also, as shown in this table, the total flux estimate including all forest pools is -12.2 MMtCO₂e/yr between 1990 and 2003, and its -24.4 MMtCO₂e/yr between 2003 and 2005.¹⁰ These totals include large sink estimates for soil carbon (-4.3 and -9.2 MMtCO₂/yr). Given the changes noted above in timberland, it appears that much of the negative trend in carbon flux (sequestration) is from the increase in timberland between 1990 and 2005.

⁸ Skog, K.E., and G.A. Nicholson (1998), “Carbon cycling through wood products: the role of wood and paper products in carbon sequestration”, *Forest Products Journal*, 48(7/8):75-83; or Skog, K.E., K. Pingoud, and J.E. Smith (2004), “A method countries can use to estimate changes in carbon stored in harvested wood products and the uncertainty of such estimates”, *Environmental Management*, 33(Suppl. 1): S65-S73.

⁹ Obtained from the Harvested Wood Product model developed by Ken Skog, USFS

¹⁰ Jim Smith, USFS, *US. Forest Carbon Calculation Tool: Forest-Land Carbon Stocks and Net Annual Stock Change* (<http://www.nrs.fs.fed.us/pubs/2394>), December 2007.

Table H3. USFS Annual Forest Carbon Fluxes for Iowa

| Forest Pool | 1990-2003 Flux (MMtCO₂) | 2003-2005 Flux (MMtCO₂) |
|---|---|---|
| Forest Carbon Pools (non-soil) | -7.76 | -15.1 |
| Soil Organic Carbon | -4.28 | -9.17 |
| Harvested Wood Products | -0.12 | -0.12 |
| Totals | -12.2 | -24.4 |
| Totals (excluding soil carbon) | -7.88 | -15.3 |

Totals may not sum exactly due to independent rounding.

Data source: Smith, James, et al. US Forest Carbon Calculation Tool: Forest-Land Carbon Stocks and Net Annual Stock Change

(<http://www.nrs.fs.fed.us/pubs/2394>), USFS, December 2007.

Based on discussions with the USFS, CCS recommends excluding the soil carbon pool from the overall forest flux estimates due to a high level of uncertainty associated with these estimates. The forest carbon flux estimates provided in the summary tables at the front of this report are those without the soil carbon pool.

For historic emission estimates, CCS used the 1990-2003 carbon flux to represent yearly forest carbon flux prior to 2003. Current flux estimates (2003-2005) are from the 2003 inventory and 2005 annual inventory stocks. For the reference case projections (2005-2025), the forest area and carbon densities of forestlands were assumed to remain at the same levels as in 2005.

Information is not available on the near term effects of climate change and their impacts on forest productivity. Nor were data readily-available on projected losses/increases in forested area.

Urban Forestry & Land Use

GHG emissions for 1990 through 2005 were estimated using the EPA State Inventory Tool (SIT) software and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document for the sector.¹¹ In general, the SIT methodology applies emission factors developed for the US to activity data for the urban forestry sector. Activity data include urban area, urban area with tree cover, amount of landfilled yard trimmings and food scraps, and the total amount of synthetic fertilizer applied to settlement soils (e.g., parks, yards, etc.). This methodology is based on international guidelines developed by sector experts for preparing GHG emissions inventories.¹² Table H4 displays the emissions and reference case projections for Iowa.

¹¹ GHG emissions were calculated using SIT, with reference to EIIP, Volume VIII: Chapter 8.

¹² Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, published by the National Greenhouse Gas Inventory Program of the IPCC, available at (<http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm>; and Good Practice Guidance and Uncertainty Management in

Table H4. Urban Forestry & Land Use Emissions and Reference Case Projections (MMtCO₂e)

| | 1990 | 2000 | 2005 | 2010 | 2020 | 2025 |
|---|--------------|--------------|--------------|--------------|--------------|--------------|
| Urban Trees | -0.48 | -0.54 | -0.57 | -0.57 | -0.57 | -0.57 |
| Landfilled Yard Trimmings and Food Scraps | -2.49 | -0.5 | -0.51 | -0.51 | -0.51 | -0.51 |
| N ₂ O from Settlement Soils | 0.38 | 0.39 | 0.46 | 0.46 | 0.46 | 0.46 |
| Total | -2.59 | -0.65 | -0.63 | -0.63 | -0.63 | -0.63 |

*Data for settlement soils was obtained from AAPFCO (2006) Commercial Fertilizers 2005. Association of American Plant Food Control Officials and The Fertilizer Institute, University of Kentucky, Lexington, KY.

Changes in carbon stocks in urban trees are equivalent to tree growth minus biomass losses resulting from pruning and mortality. Net carbon sequestration was calculated using data on crown cover area. The default urban area data in SIT (which varied from 1,893 square kilometers [km²] to 2,229 km² between 1990 and 2005) was multiplied by the state estimate of the percent of urban area with tree cover (33% for Iowa) to estimate the total area of urban tree cover. These default SIT urban area tree cover data represent area estimates taken from the US Census and coverage for years 1990 and 2000.¹³ Estimates of urban area in the intervening years (1990-1999) and subsequent years (2001-2005) are interpolated and extrapolated, respectively.

Estimates of net carbon flux of landfilled yard trimmings and food scraps were calculated by estimating the change in landfill carbon stocks between inventory years. The SIT estimates for the amount of landfilled yard trimmings decreased significantly during the 1990's. CCS believes that this is consistent with changes in the waste management industry during this period.

Settlement soils include all developed land, transportation infrastructure and human settlements of any size. Projections for urban trees, landfilled yard trimmings and food scraps, and settlement soils were kept constant at 2005 levels. Table H5 provides a summary of the estimated flux for the entire forestry and land use sector.

Forest Fires and Prescribed Burning

Biomass burned in forest and rangeland fires emits CO₂, methane (CH₄), and N₂O, in addition to many other gases and pollutants. Since CO₂ emissions in forests are captured under total carbon flux calculations, CCS intends to use the SIT software to estimate CH₄ and N₂O emissions. No default data were available for area burned by forest type for IA, so CCS has requested available state data (1992-2005) from Iowa Department of Natural Resources (DNR). CCS is also requesting any information on rangeland acres burned in Iowa from Iowa DNR for the 1990-2007 timeframe. If these data are available, emission estimates for methane and nitrous oxide

National Greenhouse Gas Inventories, published in 2000 by the National Greenhouse Gas Inventory Program of the IPCC, available at: (<http://www.ipcc-nggip.iges.or.jp/public/gp/english/>).

¹³ Dwyer, John F.; Nowak, David J.; Noble, Mary Heather; Sisinni, Susan M. 2000. *Connecting people with ecosystems in the 21st century: an assessment of our nation's urban forests*. Gen. Tech. Rep. PNW-GTR-490

will be added to the results shown in Table H5 for the Forestry & Land Use Sector.

Table H5. Forestry and Land Use Flux and Reference Case Projections (MMtCO₂e)

| Subsector | 1990 | 1995 | 2000 | 2005 | 2010 | 2020 | 2025 |
|--|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Forested Landscape (excluding soil carbon) | -7.88 | -7.88 | -7.88 | -15.3 | -15.3 | -15.3 | -15.3 |
| Urban Forestry and Land Use | -2.59 | -1.31 | -0.65 | -0.63 | -0.63 | -0.63 | -0.63 |
| Forest Wildfires | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Sector Total | -10.5 | -9.19 | -8.53 | -15.9 | -15.9 | -15.9 | -15.9 |

N/A – not available.

Key Uncertainties

Emissions from wildfires in Iowa have not yet been estimated pending availability of data of acres of forest and rangeland burned from 1990-2007. Based on work conducted in other states, CCS does not believe that these will have a significant effect on the estimated sink for the Forest & Land Use sector.

It is important to note that there were methodological differences in the three FIA cycles (used to calculate carbon pools and flux) that can produce different estimates of forested area and carbon density. For example, the FIA program modified the definition of forest cover for the woodlands class of forestland (considered to be non-productive forests). Earlier FIA cycles defined woodlands as having a tree cover of at least 10%, while the newer sampling methods used a woodlands definition of tree cover of at least 5% (leading to more area being defined as woodland). In woodland areas, the earlier FIA surveys might not have inventoried trees of certain species or with certain tree form characteristics (leading to differences in both carbon density and forested acreage). Given that the forested land in Iowa is dominated by timberlands (productive forests), CCS does not believe that the definitional differences noted above have had a significant impact on the forest flux estimates provided in this report.

Also, FIA surveys since 1999 include all dead trees on the plots, but data prior to that are variable in terms of these data. The modifications to FIA surveys are a result of an expanded focus in the FIA program, which historically was only concerned with timber resources, while more recent surveys have aimed at a more comprehensive gathering of forest biomass data. In addition, the FIA program has moved from periodic to annual inventory methods. The effect of these changes in survey methods has not been estimated by the USFS.

Much of the urban forestry & land use emission estimates rely on national default data and could be improved with state-specific information (e.g. landfill data, urban tree canopy data).