U.S. National Inventory Reporting for the LULUCF Sector

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Outline

- U.S. Greenhouse Gas Inventory Development
- U.S. Approach for Consistent Representation of the national land base
- U.S. Approach to estimate forest C stocks and fluxes
  - Forest Inventory and Analysis (FIA) Data
  - Estimating forest C from FIA survey data
  - Other LULUCF carbon stock and flux estimates

U.S. GHG Inventory Development

- Institutional Arrangements
  - Interagency effort led by EPA
  - Data and input provided by Department of Energy, US Department of Agriculture, the State Department, and others
  - US Forest Service provides carbon stock and flux estimates for US forests and harvested wood products
  - Colorado State University provide estimates for cropland, grassland soil C

IPCC Guidance: Consistent Representation of Lands

- Guidance provided to represent land-use categories and conversion between uses
- Define 6 main land-use categories for Inventory reporting
  - Forest Land, Cropland, Grassland, Wetlands, Settlements, Other Land
- 3 categories of approaches:

  Approach 1: Total land-use area, no data on conversions

  Approach 2: Total land-use area, includes changes between categories

  Approach 3: Spatially-explicit land-use conversion data

Characterizing the Need for US GHG Inventory Land Reconciliation Analysis

- IPCC 2003, 2006 guidance on Consistent Representation of Lands
- The USDA National Resources Inventory (NRI) and the FIA are the 2 main land area and land use data sources for the US GHG Inventory
  - do not provide complete coverage
  - use different criteria for classifying forest land, leading to discrepancies

Methodology for Reconciliation

- National Land Cover Dataset (NLCD) was used to fill in gaps
- NRI and NLCD were then compared to and adjusted to match FIA forest area estimates
- NRI/FIA reconciliation for non-federal lands
- NLCD/FIA reconciliation for federal lands

Land-Use Areas During the Inventory Reporting Period (1990-06)

Land Use Class	1990	1995	2000	2001	2002	2003	2004	2005	2006
Cropland	169	166	163	163	162	162	162	162	162
Forest Land	243	246	249	250	250	251	251	252	252
Grassland	301	296	296	295	295	294	294	293	293
Other Land	28	28	25	25	25	25	25	25	25
Settlements	32	36	40	41	41	42	42	42	42
Wetlands	32	32	31	31	31	31	31	31	31
Total	805	805	805	805	805	805	805	805	805

(Estimates shown in millions of hectares)

Percent of Total land Area in Key Land-Use Categories (2006)

Upcoming Improvements

- 1990-07 inventory (April 2009)
  - Advance from IPCC Approach 1 to Approach 3
  - Disaggregation of main land use categories (e.g., forest land, cropland) and land use change categories (e.g., grassland converted to forest land)
  - NRI adopted as source of official total land area estimate

- Future inventory reports
  - Estimate area data by land-use category for currently excluded areas
    - United States Territories, parts of Alaska, federal lands in Hawaii
  - Improve FIA/NRI/NLCD reconciliation process
    - Refine underlying assumptions
  - Evaluate additional databases for reconciliation with NRI/NLCD
    - Ongoing wetlands analysis

Overview of U.S. Approach to Estimate Forest C Stocks and Fluxes

- IPCC 2006 guidelines applied
- Tier 3 Stock-difference method
  - Tree species and diameter data collected
  - C calculated based on this periodic forest inventory data and applied equations and factors
  - Estimates of C stocks are interpolated for intervening years
  - Understory, litter, deadwood based on modeled ratios
  - Soil C estimates by forest type

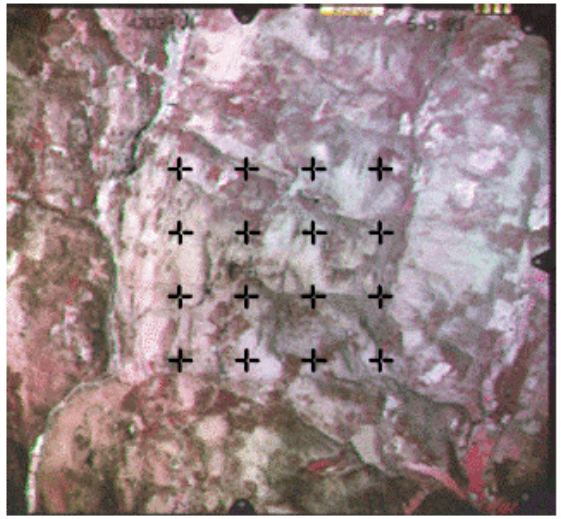
U.S. Forest Service Forest Inventory and Analysis (FIA) Program

- Forest census program of U.S. Forest Service
  - Since 1952 have conducted forest surveys based on extensive statistically-based sampling of most of the forest land in the conterminous United States
- FIA reports on:
  - status and trends in forest area and location
  - species, size, and health of trees
  - total tree growth, mortality, and removals by harvest
  - wood production and utilization rates
  - forest land ownership

FIA Sampling Design

- National plot design
- Annual system since 1998
  - Portion of plots in each state sampled each year
  - All plots measured once every 5 – 10 years
- Hierarchical system of sampling
  - Phases 1 – 3

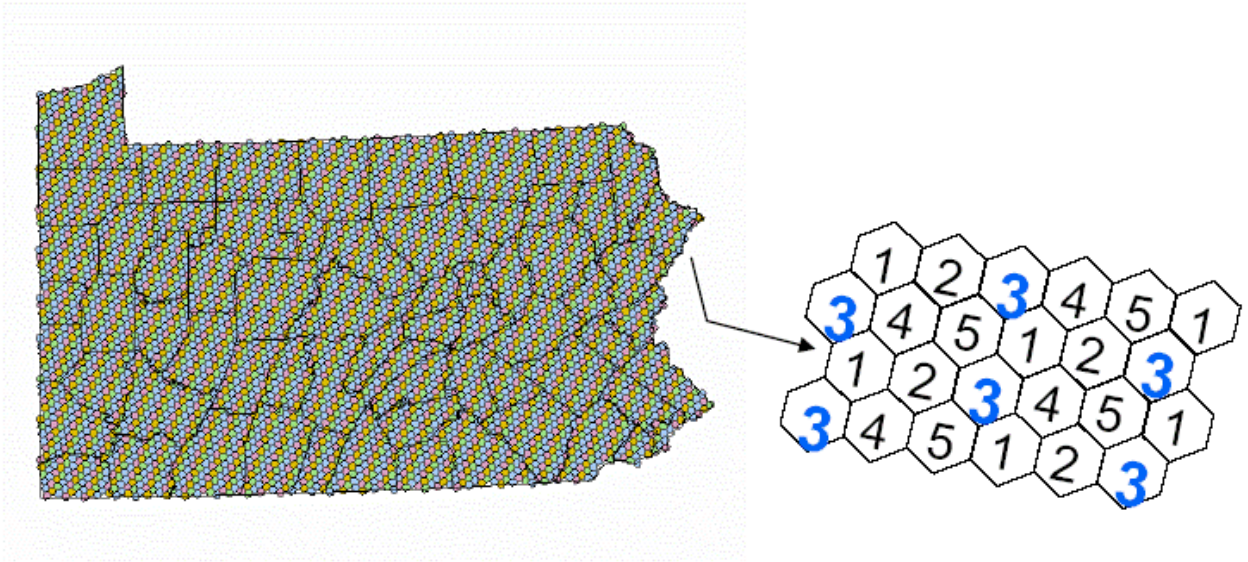
FIA data – the FIADB



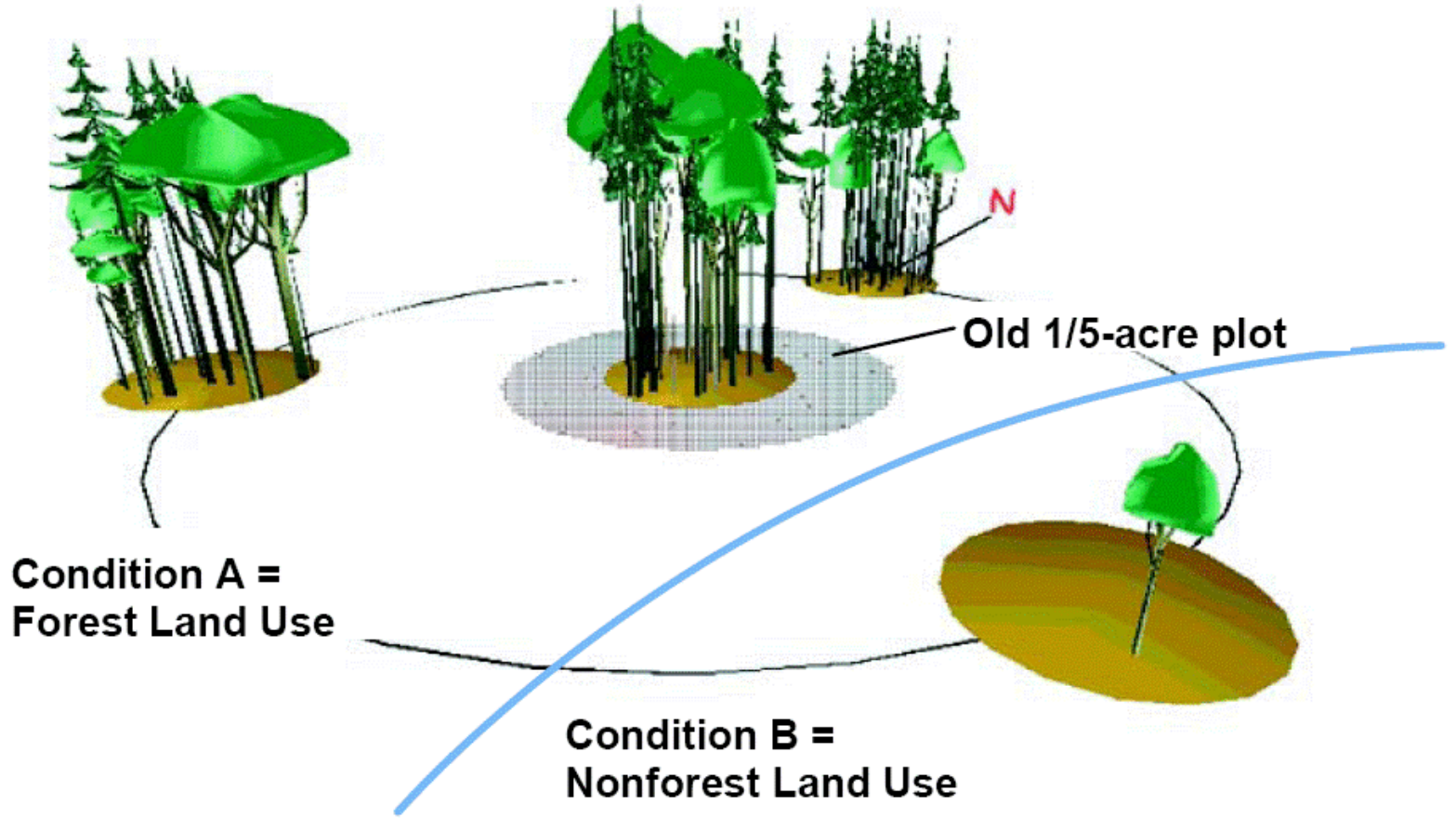
Current annual inventory

Phase I – Remote sensing to determine forest area

Phase 2 – Large array of permanent plots



Phase 2 – Sample Location Design



Plot measurements: age, disturbance, owner, elevation, etc.
Tree measurements: species, dimensions, damage, etc
Phase 3 measurements: down wood, forest floor, soil C

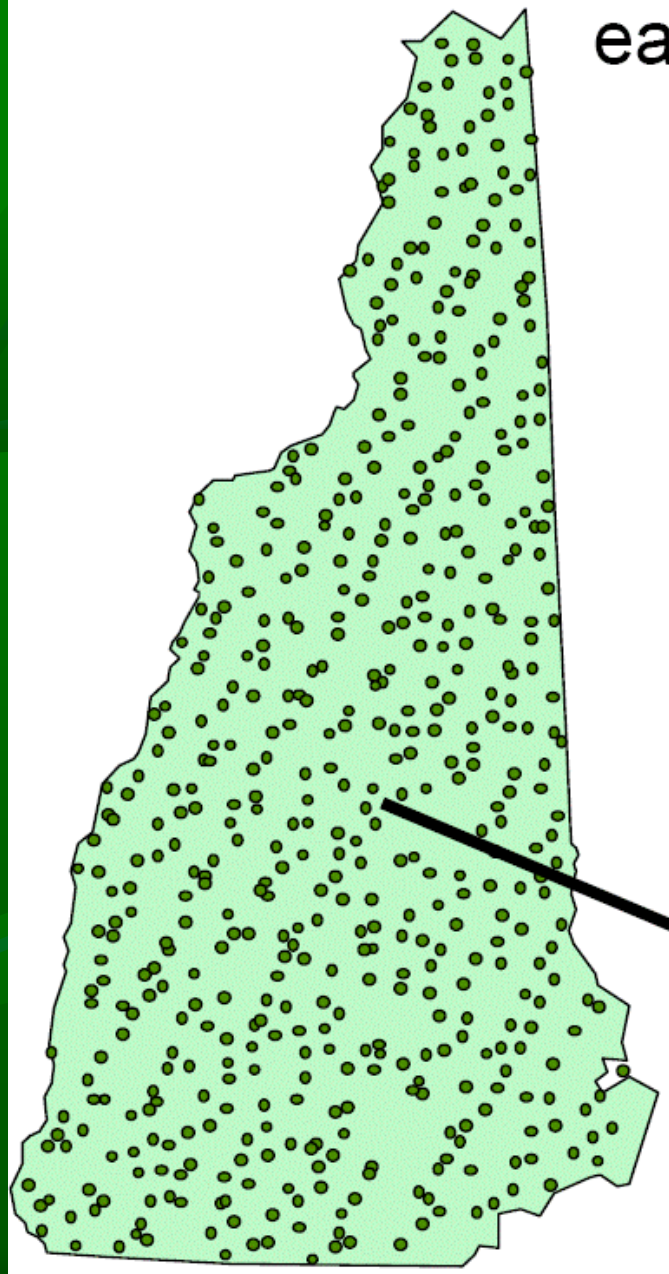
FIA Forest Survey Data

- Permanent inventory plot system
- Survey data organized into separate datasets by state
  - Recent inventory data freely available for download
  - Each represents a complete inventory or survey within an individual state
  - Frequency and level of disaggregation varies by state
    - Some states sub-divided to sub-state inventories

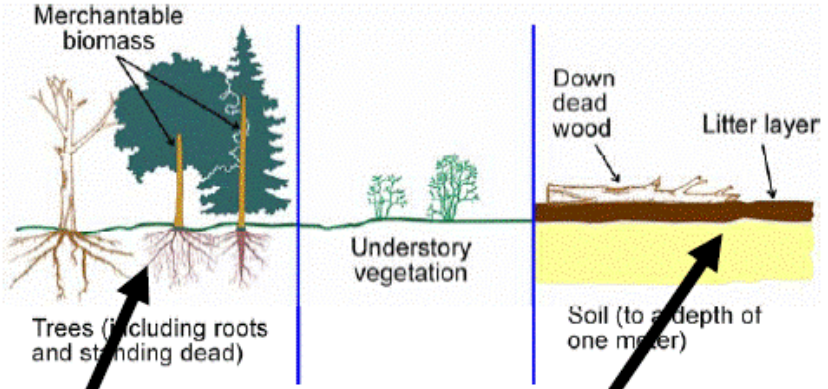
Estimating C Stocks from Forest Inventory Data

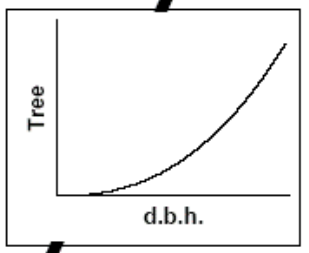
- Use allometric equations and C conversion factors are applied at the plot-level and then expanded to population
  - Specific to forest type and region
- Results in plot-level estimates of C density (Mg C/ha) for the 5 forest ecosystem pools
- Expanded to population estimates
- Summed to state or sub-state C stocks
- C stock estimates are annualized by interpolation and extrapolation
- Net annual C stock change, or flux, is the difference between 2 successive years

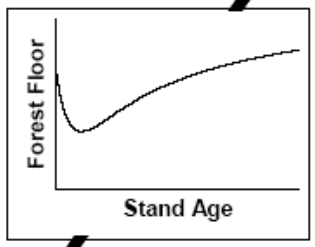
Plot-level carbon: determined for each carbon pool on each plot

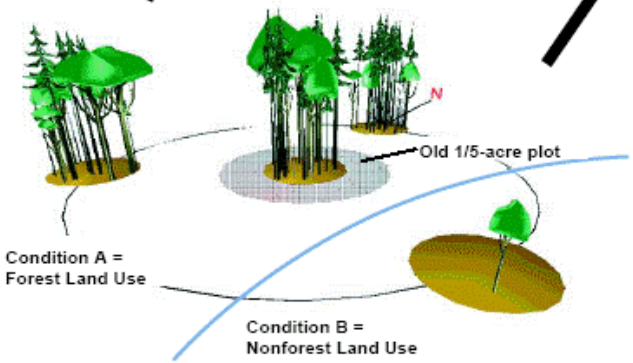


Forest carbon components

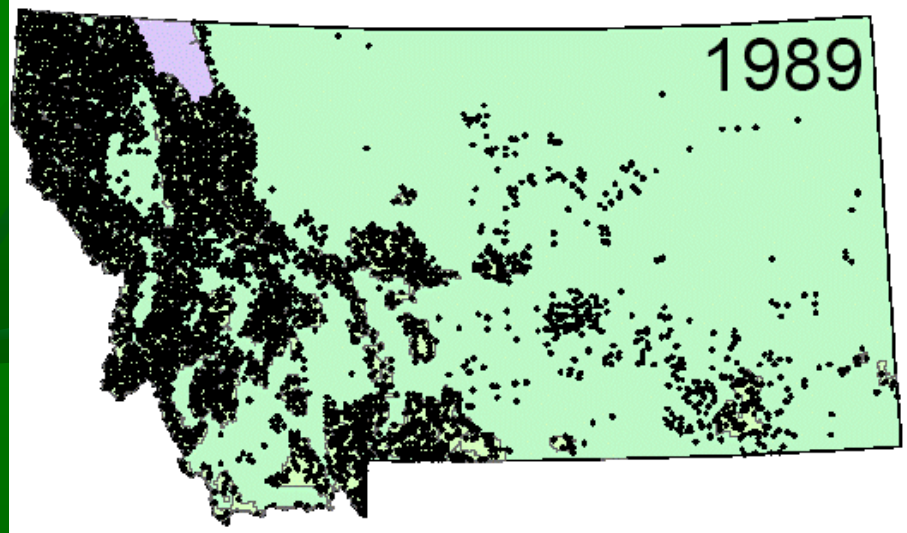


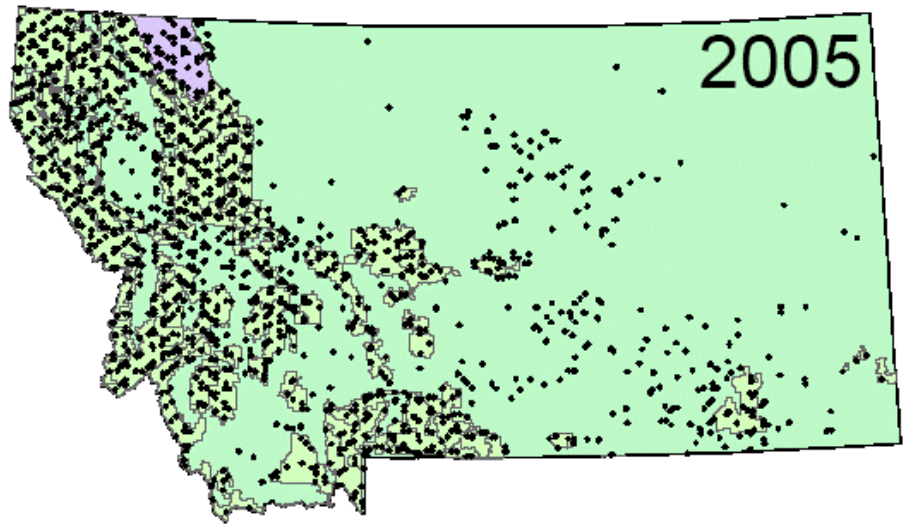


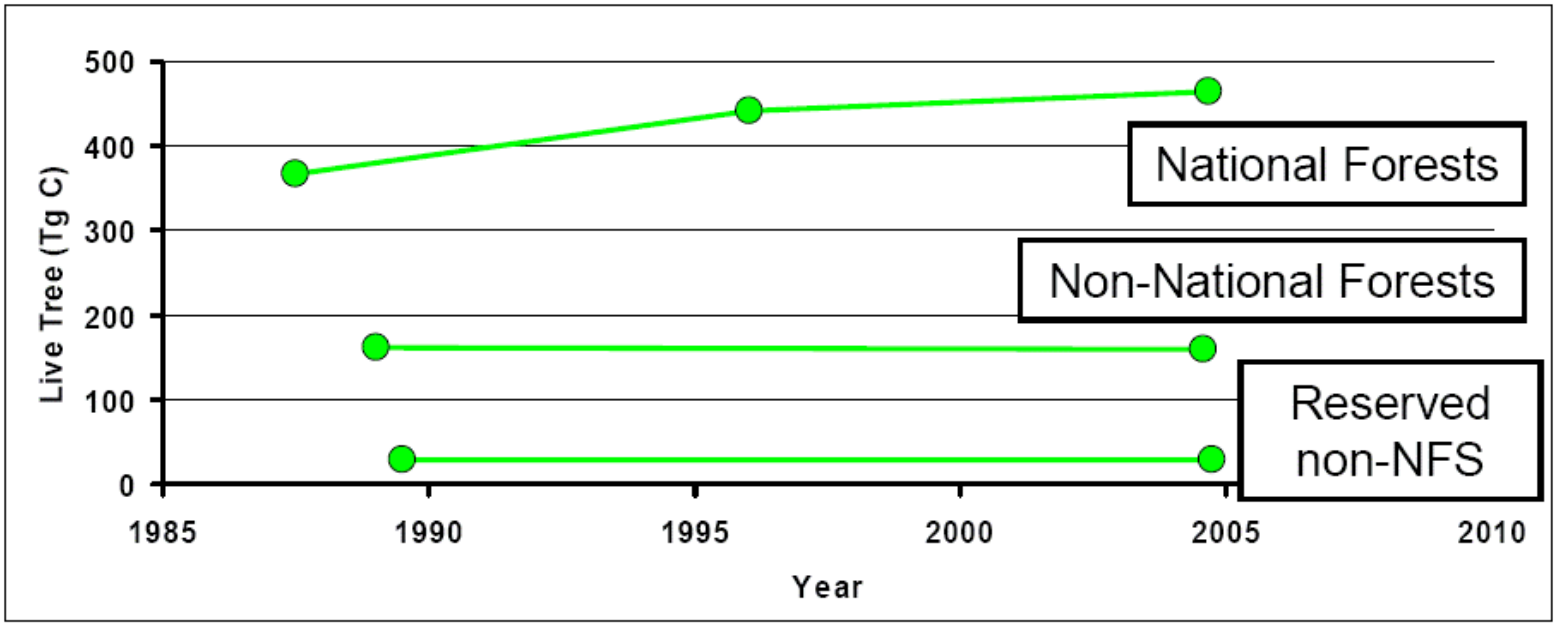




Aggregate to sub-state levels if necessary







Live Tree Carbon

- For plots with live tree data, live tree C is based on species group and diameter
  - Using equations by Jenkins et al. (2003)
- Approximately 5% of inventory plots do not have live tree measurements
  - Instead tree C is based on growing stock volume on those plots
- For about 3% of plots not enough information to calculate C
  - Instead based on averages from similar, more compete plots

Understory Vegetation

- All biomass of undergrowth forest vegetation
  - Includes woody shrubs and trees less than 2.54 cm diameter
- Based on FORCARB2 (Smith and Heath, 2002) equations relating understory C density to live tree C density

Belowground Biomass

- For live tree C:
  - Separate estimates made for whole-tree and AGB
  - BGB determined as the difference
- For understory, 10% BGB assumption
  - Lower limit of 0.11 root to shoot ratio (IPCC 2006)

Carbon in DOM Pools

- Standing dead tree C based on ratio of dry weight standing deadtree mass to plot-level growing stock volume of live trees by forest type and region
- Down dead wood also based on FORCARB2 ratios but direct C density relationships at the plot-level
- For litter C, plot-level equations applied accounting for loss through decay processes and accumulation of forest floor material with new growth

Forest Soil Organic Carbon

- Regional soil type information from national soils data base (STATSGO)
  - Amichev and Galbraith (2004)
  - Data gaps filled by representative values for similar soils
- Linked to FIA forest inventory plots by overlaying on the soil C map
- Resulted in mean SOC densities stratified by region and forest type group
- Changes in C stocks dependent on changes in forest area
- Limitation: does not reflect effects of past land-use change

Data Challenges/Limitations

- Legacy of the FIA program
  - Timber production goals
- Limitations on coverage
    - Hawaii, U.S. territories
- Time-series consistency
  - Definitional issues

- Different technical solutions
  - Disaggregation to sub-state level
  - Plot-level versus individual tree conversion factors

Uncertainty Analysis

- IPCC Tier 2 methodology
- Separate analyses for forest ecosystem and HWP and later pooled for total uncertainty
- Monte Carlo simulations of the respective models and input data
- Uncertainties quantified as probability distribution functions (PDFs)
  - Series of samples randomly selected
- Uncertainty +/- 26% around 2006 forest ecosystem sequestration of 635.1 Tg CO2E

Reporting CO_2 Emissions From Forest Fires

Net C stock change estimates already include C loss from forest fires

- Interest in forest fires as a source of emissions
  - Informational
  - Estimates serve as basis for non- CO_2 emissions from forest fires

CO_2 from Forest Fires: Data and Methodology

- IPCC (2003) methodology applied
- Wildfire statistics available for "reported area burned"
  - National Interagency Coordination Center (lower 48)
  - Alaska Department of Natural Resources
  - Data includes non-forest land
- US Forest Service FIA forest area data
- Total land under wildland fire protection (USFS data, reported by State foresters)
- Average C densities based on USFS research
- Combustion factor: IPCC (2003) default value

Non-CO2 emissions from forest fires

- IPCC Tier 2 methodology
  - USFS calculations of Tg C emitted from forest fires
    - Using national wildfire statistics
      - Prescribed fires not included
    - Proxy ratio to determine proportion of area burned that is forest
  - Emission ratios (IPCC 2003)
  - N/C ratio (IPCC 2003)

Harvested Wood Products

- WOODCARBII Model (Skog, USFS); consistent with IPCC 2006
- Estimate 5 approach-neutral "HWP variables"
  - 1A) annual change of C in wood and paper products in use in the United States,
  - 1B) annual change of C in wood and paper products in SWDS in the United States,
  - 2A) annual change of C in wood and paper product in use in the United States and other countries where the wood came from trees harvested in the United States,
  - 2B) annual change of C in wood and paper products in SWDS in the United States and other countries where the wood came from trees harvested in the United States,
  - 3) C in imports of wood, pulp, and paper to the United States,
  - 4) C in exports of wood, pulp and paper from the United States, and
  - 5) C in annual harvest of wood from forests in the United States.
- Report HWP Contribution using the Production approach (U.S. Selected accounting approach)

Settlements: Urban Trees

- Consistent with IPCC 2006 Tier 2
- Data Sources
  - US Forest Service field data collected from 15 U.S. cities
    - Stem diameter, Tree height, crown height and width
    - Species, Location, Canopy condition (forested, park, open
- Change in net C flux based solely on change in total U.S. urban area

Methodology for Urban Tree C

- Nowak and Crane (2002)
  1. Annual gross C sequestration rates by species, diameter class, and land-use condition
  2. Annual gross emissions rates by species, diameter, and condition class
  3. Both scaled up to city-level estimates using tree population information
  4. Annual net C sequestration by city derived by subtracting gross emissions from gross sequestration
- Methodology applied to 13 cities

Thank you!

Questions?

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EPA Greenhouse Gas Emissions and Sinks Inventory web page:
http://www.epa.gov/climatechange/emissions/usinventoryreport.html