Optimizing field methods for large-scale inventory-based terrestrial C budgets: A pilot test in the Delaware River Basin (USA)

Jennifer C. Jenkins[1]
Richard A. Birdsey[2]

[1]Research Assistant Professor,
Gund Institute for Ecological Economics,
Rubenstein School of Environment and Natural Resources,
University of Vermont, Burlington, VT

[2]Program Manager, Northern Global Change Program,
USDA Forest Service Northeastern Research Station,
Newtown Square, PA

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Purpose of the Collaborative Environmental Monitoring and Research Initiative (CEMRI):

To address ecosystem-level issues through testing of potential national-scale collaborative strategies among existing biological, terrestrial, aquatic, and atmospheric monitoring and research programs.

The National Park Service

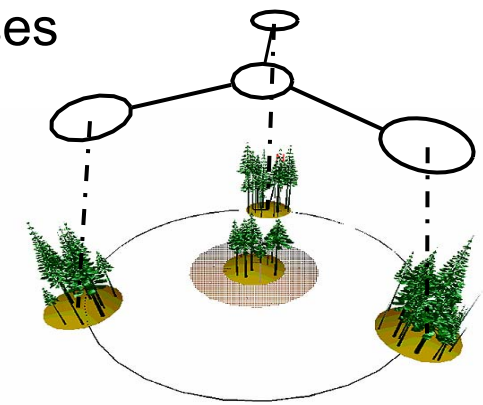
USGS science for a changing world

NASA

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

North American Carbon Program: Multi-tier Monitoring Design

- **Tier One** – Remote Sensing and Mapping
  - ✓ Wall-to-wall coverage; stratification
  - ✓ Temporal resolution = high or low
- **Tier Two** – Extensive Inventories and Surveys
  - ✓ Representative regional statistical sample
  - ✓ Temporal resolution = low
- **Tier Three –** Condition Sample (<u>new</u>)
  - ✓ Representative of specified condition classes
  - ✓ Temporal resolution = medium
- **Tier Four** –Intensive Areas
  - ✓ Relatively small number of specific sites
  - ✓ Temporal resolution = high



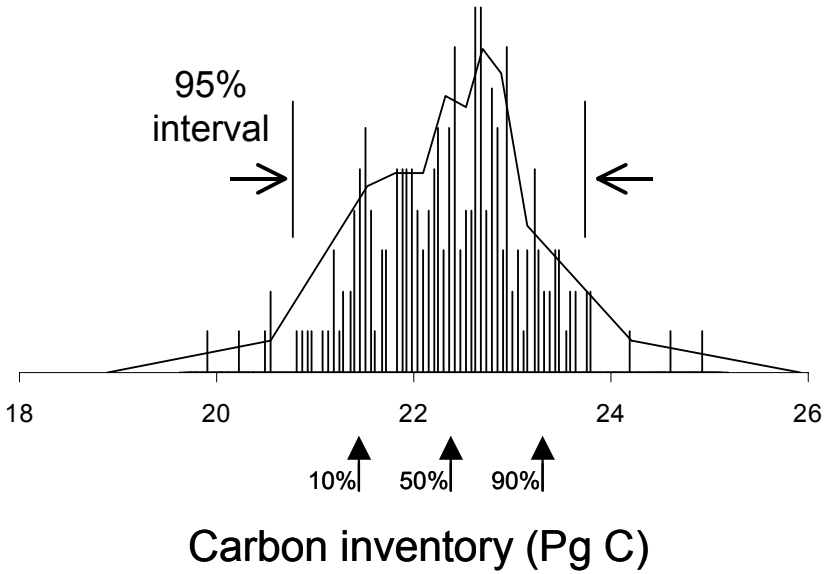
Multi-tier concept in NACP

Example Data Elements	1st Tier Mapping and Remote Sensing	2nd Tier Extensive Inventory (FIA and NRI)	3rd Tier Medium-Intensity Sample (new)	4th Tier Intensive sites (e.g., AmeriFlux)
Land cover class	X	X	X	X
Leaf area index	X	X	X	X
Live biomass	X	X	X	X
Land cover change	X	X	X	
Wildfire disturbance	X	X	X	
Climate variability			X	X
Soil CO_2 flux			X	X
Methane flux			X	X
Dissolved organic C				X
Ecosystem CO_2 flux				X

from: Wofsy, S.C. and R.C. Harriss. 2002. *The North American Carbon Program (NACP).* Report of the NACP Committee of the U.S. Interagency Carbon Cycle Science Program. Washington, DC: U.S. Global Change Research Program.

Confidence in Carbon Estimates at Regional Scale

Live biomass	Good
Woody debris and litter	Fair
Soil organic matter	Poor
Wood and Ag Products	Fair

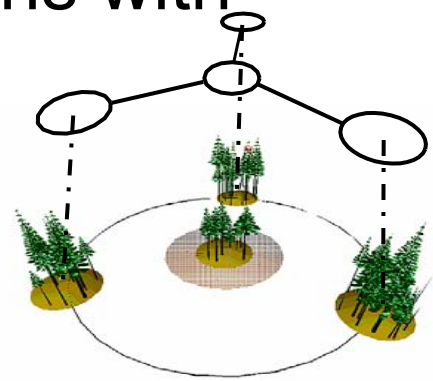


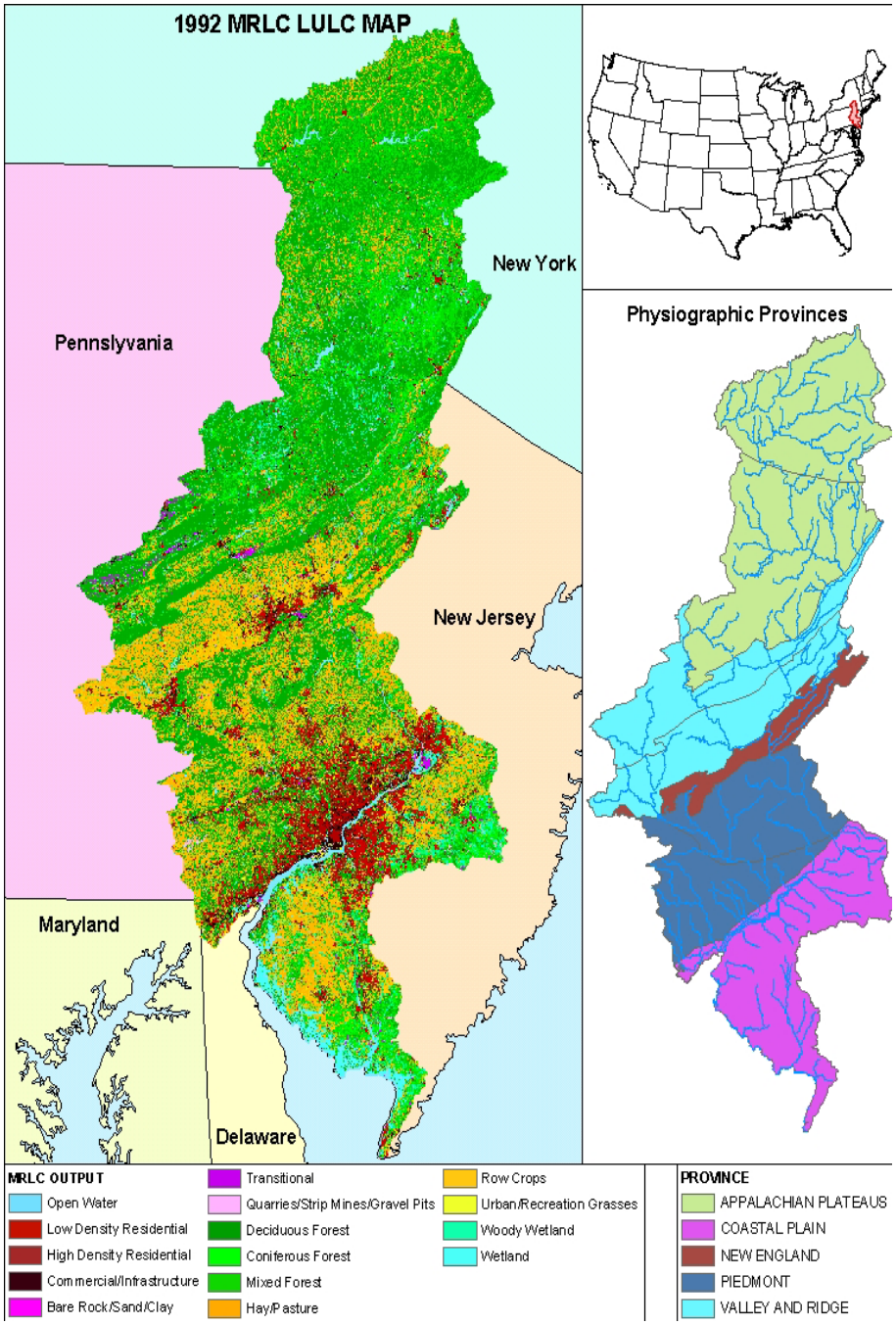
Uncertainty analysis suggests that estimates of forest C stocks are within 10% of true value 80% of the time.

from: Heath, L.S. and J.E. Smith. 2000. An assessment of uncertainty in forest carbon budget projections. Environmental Science and Policy 3: 73-82.

Carbon stocks and fluxes in the Delaware River Basin

- Optimize regional monitoring capability for C stocks and fluxes, by:
  - Evaluating current FIA monitoring strategies vis-à-vis C stock and flux estimation
  - Developing methods for scaling intensive site measurements to FIA P2/P3 network
  - Validating process model predictions with detailed field measurements





Delaware River Basin

- 12,700 square miles

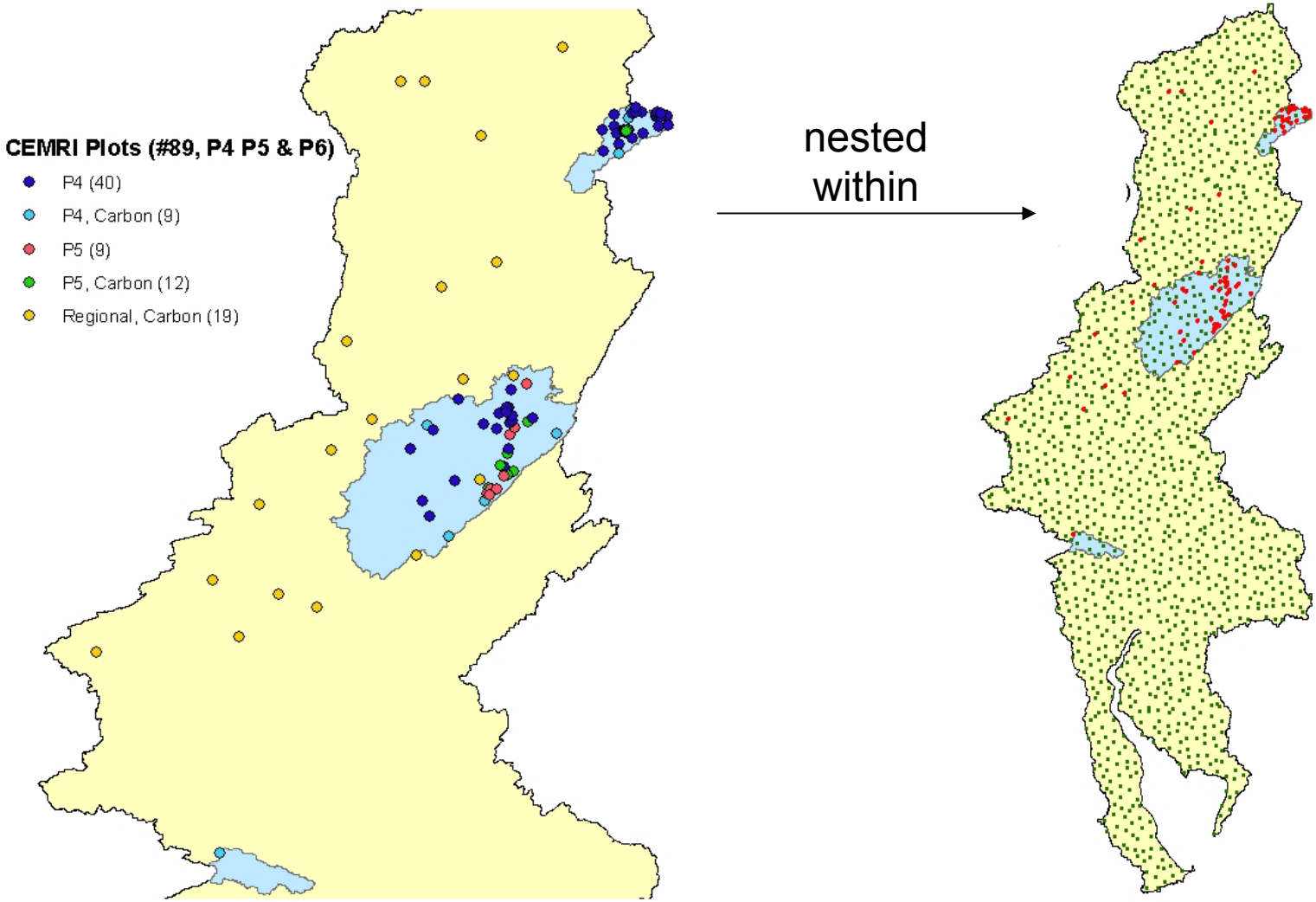
- 7.2 million residents
- 7.0 million additional people rely on water diverted from the Basin

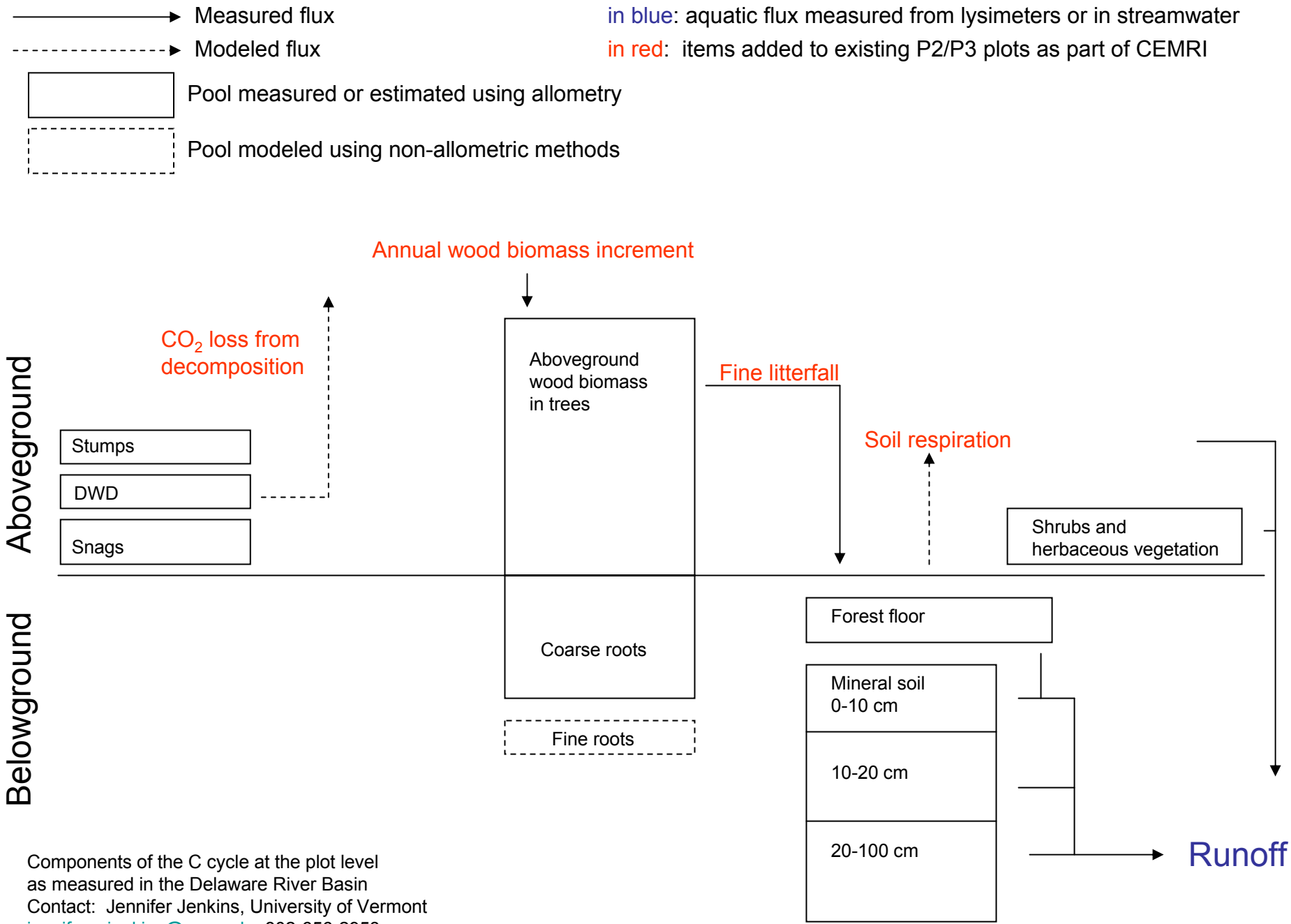
- 60% forested
- 24% agricultural
- 9% urban/residential

Scaling strategy

CEMRI carbon plot network

FIA P2/P3 plot network





Components of the C cycle at the plot level
as measured in the Delaware River Basin
Contact: Jennifer Jenkins, University of Vermont
jennifer.c.jenkins@uvm.edu, 802-656-2953

Dendrometer bands on all tally trees (i.e. > 5” dbh) are used to measure wood increment over periods shorter than standard FIA remeasurement interval.

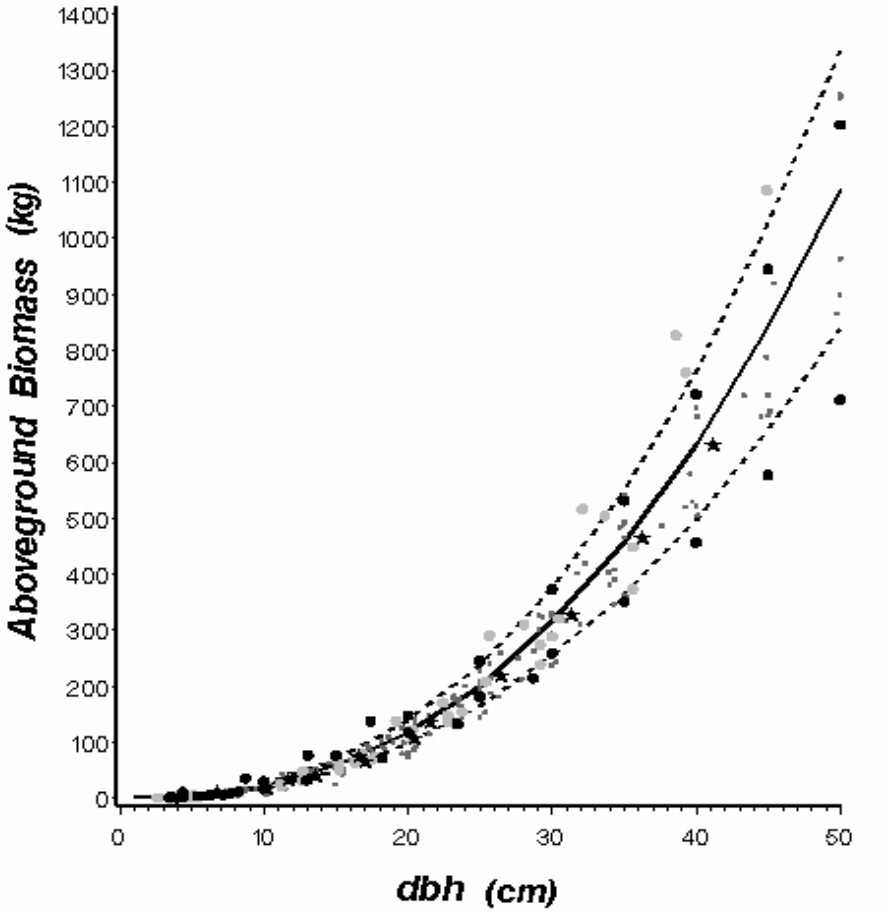
- Measurements are made annually.
- Diameter remeasurements made after three years for comparison.

Eight litterbaskets are placed on each plot (2 baskets per subplot) where they do not interfere with other indicator measurements.

Litterfall data are collected at one-two month intervals year-round.

Annual results are calculated per plot as the mean of these litter measurements.

Biomass estimators

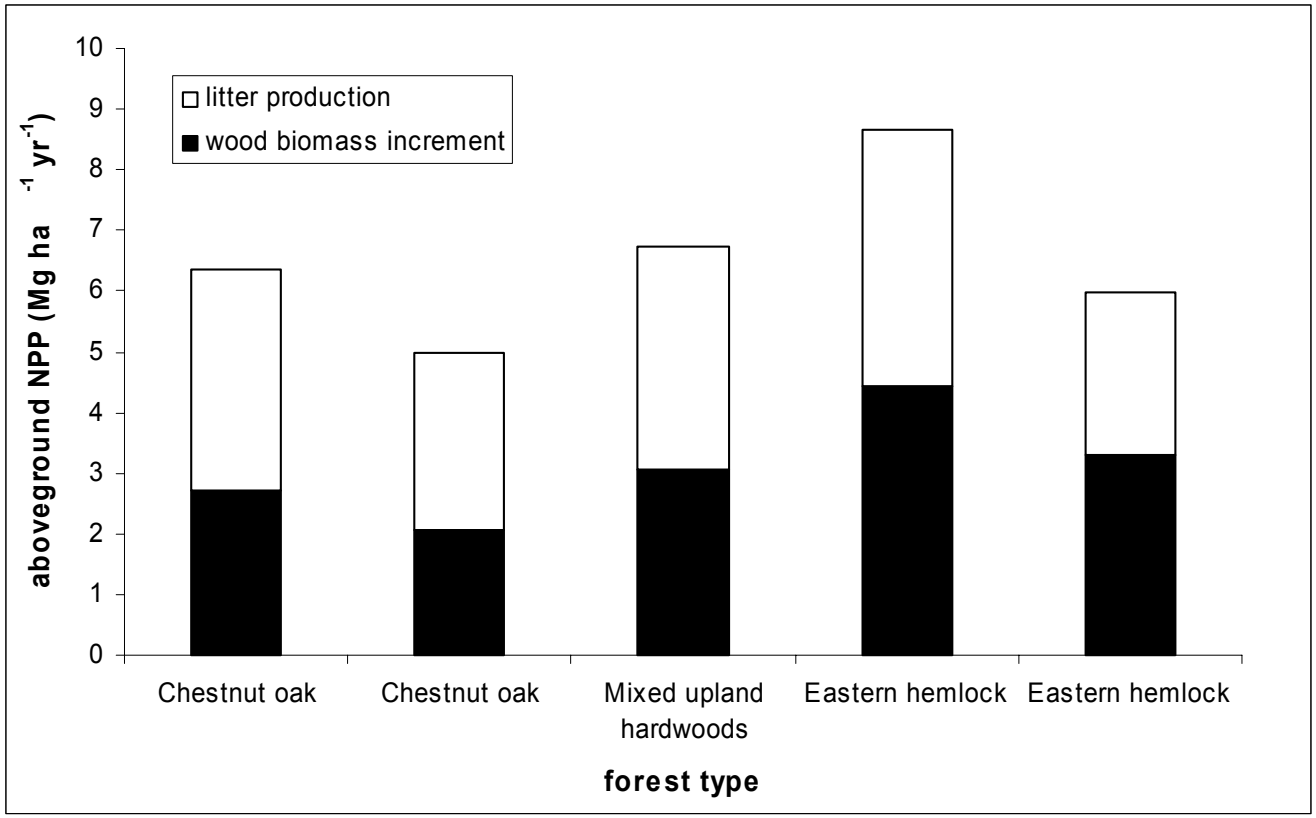


Pine species highlighted:
stars – pinyon
gray dots – loblolly
black dots – lodgepole
small dots – all other species

14 pine species (of about 35)
43 aboveground equations
26 authors

from: Jenkins, J.C., D.C. Chojnacky, L.S. Heath, and R.A. Birdsey. 2003. National-scale biomass estimators for United States tree species. *Forest Science* 49(1):12-35.

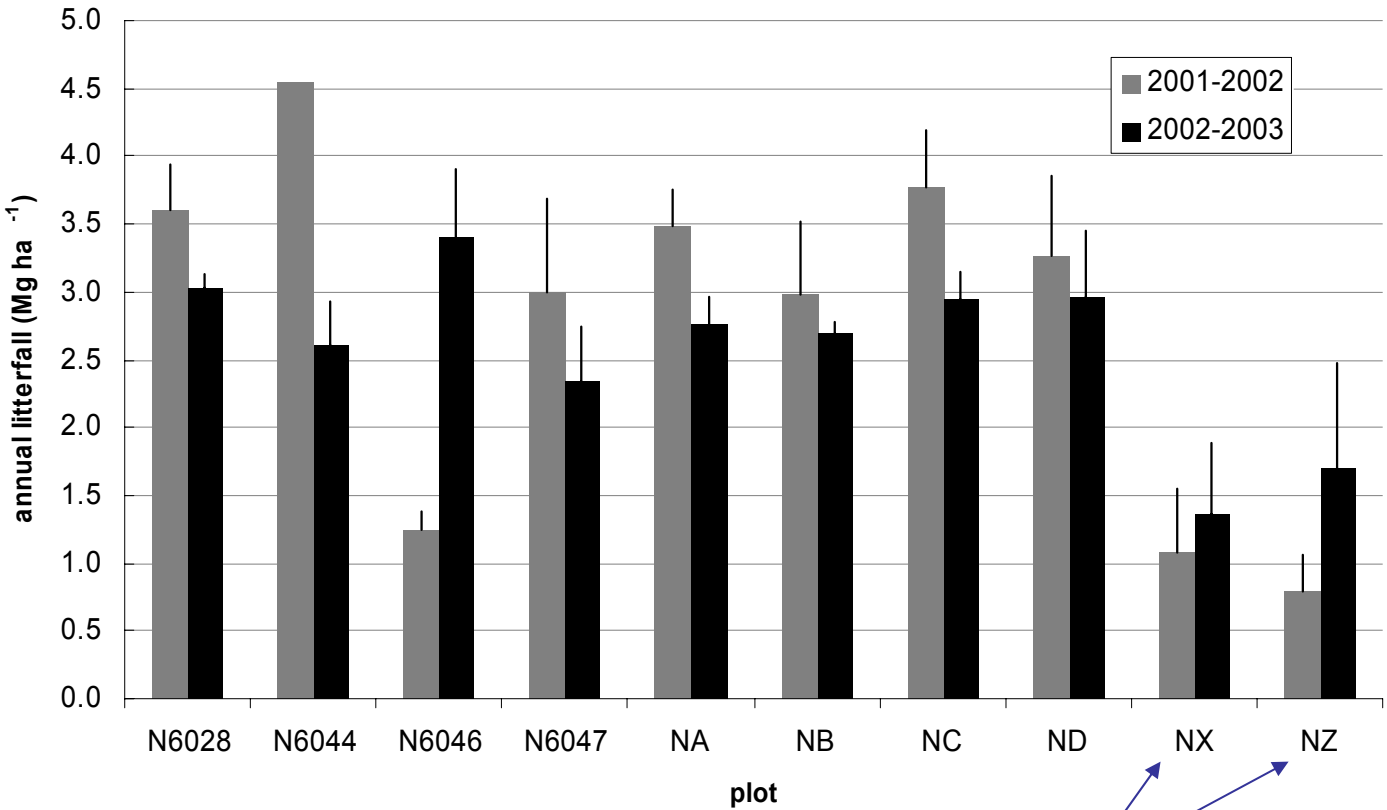
Aboveground NPP



- Litterfall can exceed wood production on an annual basis.
- Plot-to-plot and year-to-year variability can be substantial.
- This variability may not be critical at large scales.

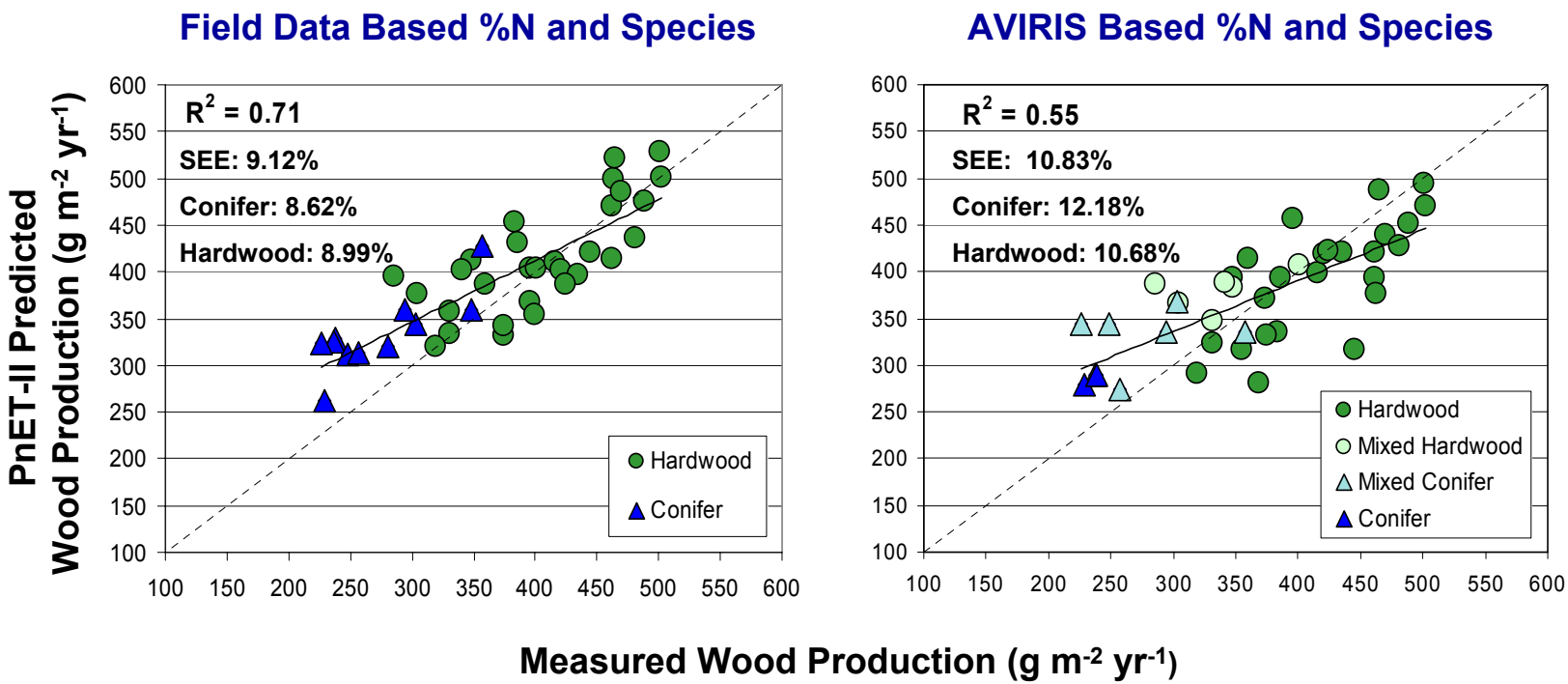
Comparison data: Wood production **1.4 Mg C ha^{-1} yr^{-1}** for 8 years at Harvard Forest (1993-2000) (Barford et al. 2001); **2.4 and 2.9 Mg C ha^{-1} yr^{-1}** average for 1998 and 1999 (respectively) in mixed hardwoods in Indiana (Ehman et al. 2002)

Interannual litterfall variability: Neversink watershed



recovering from clearcut in the 1990's

Modeling forest productivity: PnET-II

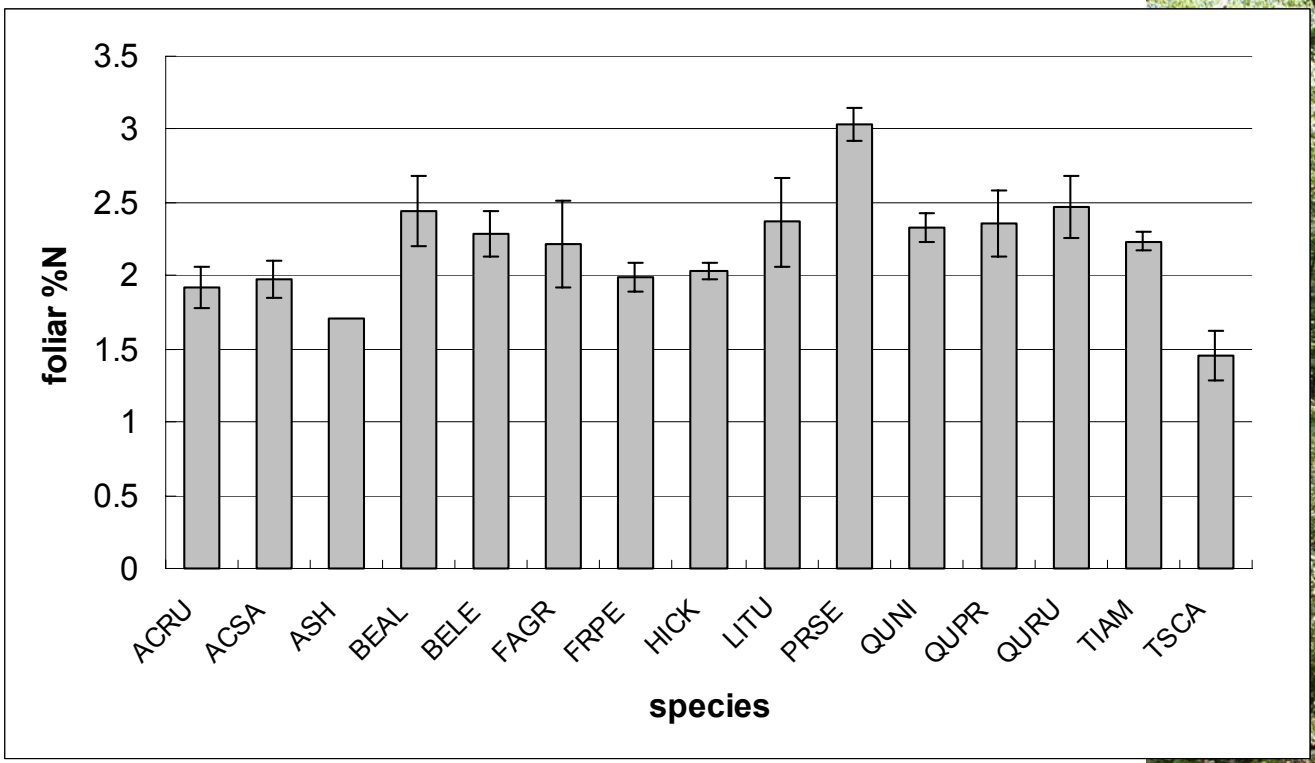


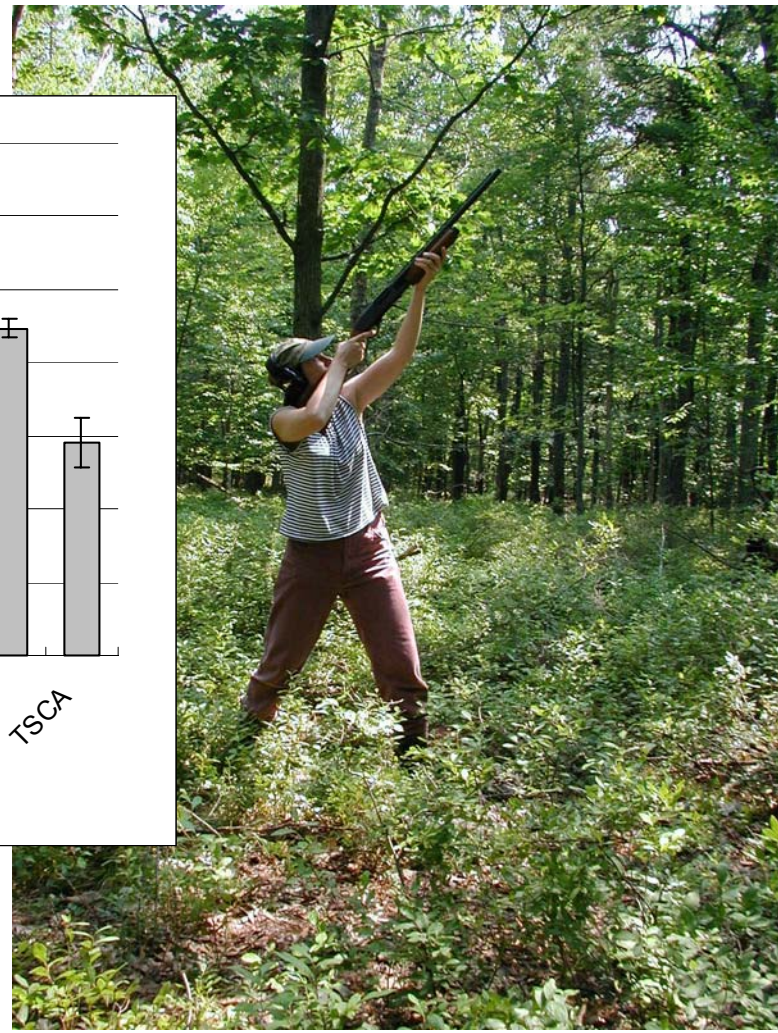
PnET-II predicts wood production accurately when field data are used for foliar N parameterization.

High-resolution satellite imagery can also be used to estimate foliar N, resulting in accurate predictions without field measurements.

(graphs and data from ML Smith 4/2000)

Foliar N by species for DRB

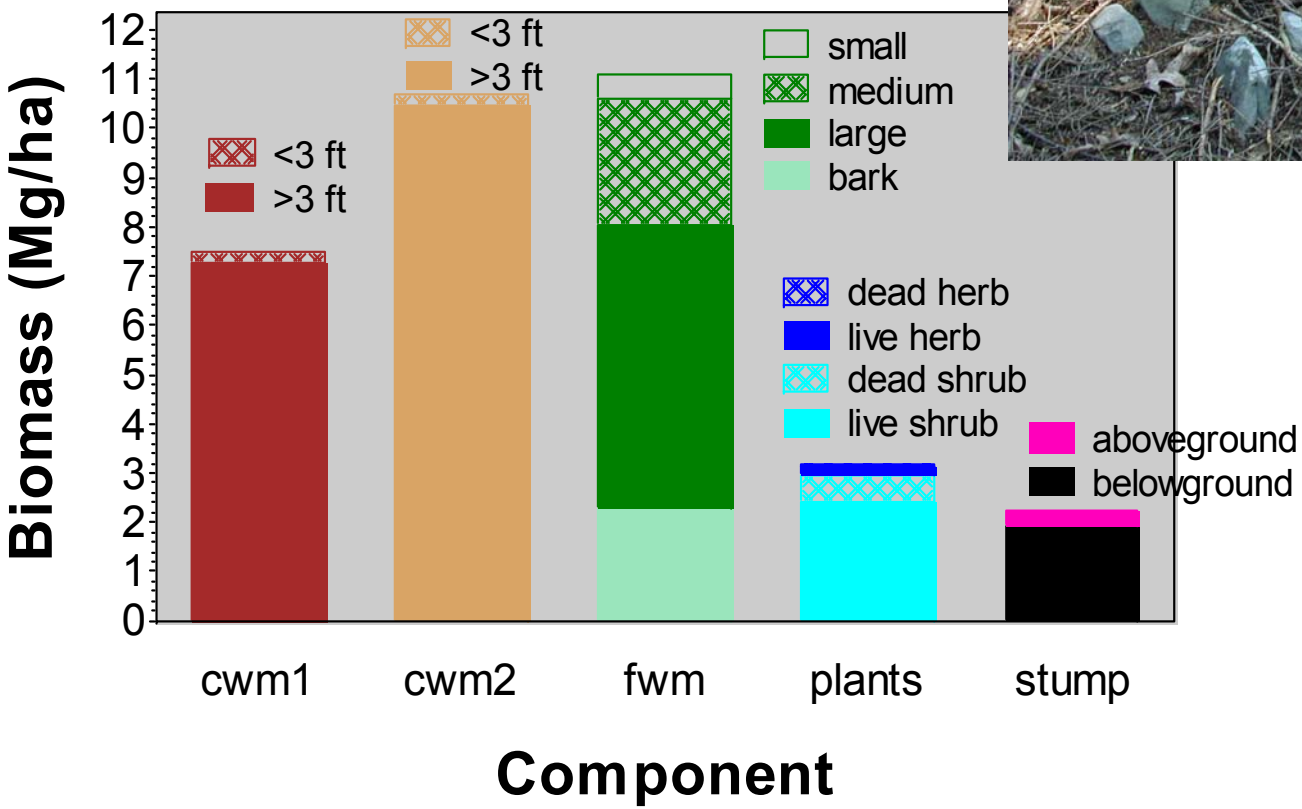




Down dead wood

Components not currently censused by FIA:

- Coarse woody debris < 3 ft in length
- Fine woody debris (bark component)
- Stumps



(Analysis courtesy D. Chojnacky)

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  - USDA Forest Service Northern Global Change Program
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  - David Chojnacky, USDA Forest Service
  - Kevin McCullough, USDA Forest Service