Forest Monitoring in the United States
Evolution and Impact in a Changing World

W. Brad Smith
Associate National Program Manager, FIA
The Inventory Vision
since 1928

Provide an integrated inventory and monitoring program capable of providing current, scientifically reliable indicators of sustainable forestry

Common definitions, standard protocols, and core consistency across spatial scales over time

1934 Michigan field crews
U.S. inventory operations cover 300+ million hectares of forest across 12 time zones ... and over 100 degrees of latitude!

From the Arctic Circle to the Tropic of Capricorn.

From the Virgin Islands to Palau, west of Sidney

How do you sample uniformly over such a large area?
Soccer provides a solution… or more specifically triangle tessellated hexagons.

The hex cell grid allows equal spacing of samples regardless of latitude.

The systematic grid allows flexible analysis using spatial layer overlays of the client’s choice to summarize data.

Plot intensity
- 1X
- 2X
- 3X
- 1/16 of Base

Cell = 2,500 ha

Base hexagon positioned over the conterminous United States

Subdivided into smaller hexagons

Sampled by year

Measure Year
- 2011
- 2012
- 2013
- 2014
- 2015

U.S. Forest Inventory and Analysis Overview 2015
A 4-point cluster plot with nested elements for efficient sampling.

**Subplot:**
- 24.0 ft radius
- Azimuth 1-2 = 360°
- Azimuth 1-3 = 120°
- Azimuth 1-4 = 240°
- Distance between subplot centers is 120.0 ft horizontal

**Macroplot:**
- 58.9 ft radius
- 18.0 m

**Microplot:**
- 6.8 ft radius center is 12.0 ft horizontal at 90° azimuth from the subplot center
- 2.1 m
- 3.7 m

Total area 0.4 ha
Total area of subplots 0.07 ha
Quality by Design

Accuracy

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>+/- 1% per million hectares</td>
</tr>
<tr>
<td>Volume</td>
<td>+/- 3% per 100 million cubic meters</td>
</tr>
</tbody>
</table>

Quality Assurance (QA)

- 20,000 forest plots measured annually across the U.S.
- 1,600 or 8% of these plots are randomly revisited the same year to verify measurement quality
**Inventory Budget for U.S.**

*Euro basis*

The U.S. inventory costs about €1.5 million per year per 6 million hectares of forest or the average forest area of an EU country.

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
<th>Cost per 6 million ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partners contribute</td>
<td>€6.9 million annually</td>
<td>€138,000</td>
</tr>
<tr>
<td>FIA contracts</td>
<td>€10.0 million annually</td>
<td>€200,000</td>
</tr>
</tbody>
</table>
FIA beyond the plots

Survey of all wood-using mills

FIA has collected data on all primary wood mills in the U.S. since 1947

The U.S. Census Bureau has collected data since 1796

Monitoring shows that mill waste in 1953 was 95% unutilized ... today 5% is unutilized.

Logging Utilization Studies

Monitoring of active logging operations to provide data on product distribution and unused wood

Also being used for taper data for volume and biomass studies

Studies indicate up to 30% of aboveground harvest material is currently left in the forest
Ownership and Biomass

Forest Ownership Studies

Began in 1953 and FIA has conducted 4 National Ownership studies since 1978

Provides data on the goals and objectives of the nation’s 10 million private forest landowners

Forest Biomass Reporting

FIA has reported U.S. forest carbon to IPCC annually since 1994

A new study is in progress to improve biomass estimation for a broader range of customers
**Forest Health**

**Invasive Species Monitoring**

Percent of forested subplots invaded by at least one monitored invasive plant

**Health Risk Monitoring**

FIA data is used to assist the Forest Health Protection Program (FHP) in modeling and evaluating areas at significant risk of insect and disease mortality
Forest Fuel Monitoring

FIA data shows where fuels are building... Integrating a humidity index and the West will look far worse than the East.

Recent fire trends

Continued monitoring will be crucial to evaluating the effects of fuel treatments and the interval at which fuels return.
Forest cover- then and now

1873 Census forest cover map

Change since 1873 Census map

FIA product in the current National Atlas of the U.S.
FIA Reporting Spans Spatial Scales

- Local
- Sub-State region
- State
- Regional/National

- Global
- Multi-national Process
- National multi-sector
In depth analysis of forestry related events...
The main events: 2005-2009

Housing starts decline 75%

1,000 mills close

... more forest-related jobs lost than the U.S. auto industry that received a government bailout!

1 million jobs lost
Pocket summary of the status and trends in the nation’s forests

English measure

Metric measure

AVAILABLE on FIA website in 5 other languages

Spanish
French
Russian
Chinese
Portuguese
Moving forward
A new Forest Atlas

CONTENTS

WHERE DO TREES GROW AND WHY?
Ecological Provinces or Biomes
Current Extent of Forests
Important Tree Species Ranges
Types of Forest Communities

WHAT LIVES IN THE FOREST?
Wildlife Habitat
Forest Birds
Forest Fish and Aquatic Species
Forest Mammals

WHAT SHAPES THE FOREST?
Native Plants, Insects, Diseases
Non-native Plants, Insects, Diseases
Wildland Fire as a Natural Disturbance
Wildland Fire Management
Providing Quality Wood Products While
Sustaining Our Forests
Planted Forests
Our Changing Forests

HOW WE BENEFIT FROM FORESTS
Clean Water
Wilderness
Nature-Based Outdoor Recreation
Agroforestry
Urban Forests
Carbon Stocks
Wood Products in Everyday Life
Forest Industries Keep America Working

OUR FUTURE FORESTS
Who Owns the Forests
America’s Private Forest Owners
Public Forest Ownership
Forests and the Carbon Cycle
Forests on the Move

http://forest-atlas.fs.fed.us/

FIA is working with ESRI to produce additional online products

U.S. Forest Inventory and Analysis Overview 2015
Felled Tree Biomass Study

- **10 species in the West** *(250 trees thru 2014)*
- **20 species in the East** *(450 trees thru 2014)*

Species representing 75% of the nation’s forest volume

- Cooperator/Technical assistance
  - 6 Universities
  - 4 Industries and NGOs
  - U.S. Forest Products Laboratory
  - Forest Management Service Center

Compatible component measures will allow maximum user flexibility
Land Cover/Land Use Studies

National Land Cover Dataset (NLCD)

FIA data used to validate the tree cover layer of this multi-class dataset

Image Change Estimation (ICE)

A new FIA project to classify the land use, land cover, and change for all FIA plots (forest and non-forest) on the NAIP schedule (~ 375,000 plots or every 5km, every 3 years)
Using the entire FIA plot grid for Image Change Estimation (ICE)

375,000 total grid plots

FIA will have field samples on 75% of total land area
Image Change Estimation (ICE)

Georgia example

Legend
- Reforestation/Afforestation
- Partial Tree Harvest
- Clearcut Harvest
- Development
- Other

Agent of Change (% of total)

- Reforestation: 5.84%
- Partial Tree Harvest: 5.18%
- Clearcut Harvest: 5.38%
- Development: 2.12%
- Other: 0.48%

Most harvest area replanted (not same area but reflective of trend)
Linked remote-sensing products dramatically reduce variability in vegetation estimates for difficult-to-reach environments such as interior Alaska.

A swath of high-resolution lidar 3-D forest canopy measurements near Tok, Alaska.

An approach with LIDAR and Landsat together reduced estimates of residual variability for biomass by up to 36 percent relative to using Landsat alone.
Monitoring Urban Land

new national legislation includes urban tree monitoring
Urban influence is growing

The new inventory will be designed to be compatible with the existing FIA forest inventory in non-urban areas.
Urban FIA plot design:
- 0.002 ha, 14.6 m radius: tree sample
- Four 2 m radius micro plots sapling sub-sample
- 1/6 Acre Subplot, 48’ Radius: standard FIA plot
- Four 6.8’ radius microplots sapling sub-sample
- 0.02 ha, 14.6 m radius: tree sample
- Four 2 m radius microplots sapling sub-sample
Initial surveys - 8 cities
Extend Owner Survey to urban areas

- Different focus
- Different questions
- Same foundational sampling frame
- Same processing engine
- Can be integrated with other FIA data
Many processes - similar questions
International Projects

North American Forestry Commission (Canada, US, Mexico)
- Revised FAO ecozone map
- Built North American Database

Review FRA CFRQ variables for Montreal Process and submit issues to the Global Advisory Group (AG)

Participate in ECE activities including Global Objectives on Forests study

Reviewing and providing assistance on new national inventory and carbon monitoring programs in Brazil and Peru

Other NFIs: Viet Nam, Ecuador, Honduras, Bangladesh
Consistent with Koppen climate map (FAO requirement)
Consistente con Koppen mapa climático (requisito de la FAO)
Conformément à Koppen carte climatique (exigence de la FAO)

Consistent with existing North American maps (NA requirement)
De acuerdo con los mapas existentes de América del Norte (requisito NA)
Conformément aux cartes nord-américaines existantes (exigence NA)

- Bailey Ecoregions (Level 2)
- Omernick Ecoregions (Level 2/3)

Koppen

Bailey Level 2

Omernick (CEC) Level 3
All criteria met and final map 90+% Bailey/Omernick compliant

Todos los criterios se encontraron y mapa final 90+% Bailey/Omernick compatible

Tous les critères sont réunis et carte finale de 90+% Bailey/Omernick conforme

http://www.cec.org/Page.asp?PageID=924&ContentID=25137&AA_SiteLanguageID=1
Identifying FRA reporting issues

### Employment in Forestry and Logging reported to FRA 2015

<table>
<thead>
<tr>
<th>Country</th>
<th>2000</th>
<th>2005</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>75</td>
<td>70</td>
<td>55</td>
</tr>
<tr>
<td>Canada</td>
<td>86</td>
<td>70</td>
<td>52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>161</strong></td>
<td><strong>140</strong></td>
<td><strong>107</strong></td>
</tr>
</tbody>
</table>

1000 persons

### Total US and Canada Primary Forestry Employment 2013

(1000 persons)

<table>
<thead>
<tr>
<th>Pulp and paper product manufacturing</th>
<th>Wood product manufacturing</th>
<th>In-forest activities</th>
<th><strong>Total</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>437</td>
<td>454</td>
<td>111</td>
<td><strong>1,001</strong></td>
</tr>
</tbody>
</table>

**UNITED STATES Job Statistics**

**CANADA Job Statistics**
Establish compatible land cover and use classifications with focus on trees

<table>
<thead>
<tr>
<th>Level 1 Earth Cover class and percent of tree crown cover</th>
<th>PRIMARY USE CLASS*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forest land</td>
</tr>
<tr>
<td></td>
<td>Tree%</td>
</tr>
<tr>
<td>1- Treeland</td>
<td></td>
</tr>
<tr>
<td>10-24% sparse forest</td>
<td>13</td>
</tr>
<tr>
<td>25-60% open forest</td>
<td>14</td>
</tr>
<tr>
<td>60+% closed forest</td>
<td>15</td>
</tr>
<tr>
<td>2- Shrubland</td>
<td></td>
</tr>
<tr>
<td>0% treeless</td>
<td>20</td>
</tr>
<tr>
<td>1-4% sparse trees</td>
<td>21</td>
</tr>
<tr>
<td>5-9% open trees</td>
<td>22</td>
</tr>
<tr>
<td>3- Grassland (includes herbaceous)</td>
<td></td>
</tr>
<tr>
<td>0% treeless</td>
<td>30</td>
</tr>
<tr>
<td>1-4% sparse trees</td>
<td>31</td>
</tr>
<tr>
<td>5-9% open trees</td>
<td>32</td>
</tr>
<tr>
<td>4- Cropland</td>
<td></td>
</tr>
<tr>
<td>0% treeless</td>
<td>40</td>
</tr>
<tr>
<td>1-4% sparse trees</td>
<td>41</td>
</tr>
<tr>
<td>5-9% open trees</td>
<td>42</td>
</tr>
<tr>
<td>10-24% sparse forest</td>
<td>43</td>
</tr>
<tr>
<td>25-60% open forest</td>
<td>44</td>
</tr>
<tr>
<td>60+% closed forest</td>
<td>45</td>
</tr>
<tr>
<td>5- Developed land</td>
<td></td>
</tr>
<tr>
<td>0% treeless</td>
<td>50</td>
</tr>
<tr>
<td>1-4% sparse trees</td>
<td>51</td>
</tr>
<tr>
<td>5-9% open trees</td>
<td>52</td>
</tr>
<tr>
<td>10-24% sparse forest</td>
<td>53</td>
</tr>
<tr>
<td>25-60% open forest</td>
<td>54</td>
</tr>
<tr>
<td>60+% closed forest</td>
<td>55</td>
</tr>
</tbody>
</table>

Consistent and reduces double counting

FAO international classes for treed land

- **Forest** (tree cover >10% + >5m) - >10% cover potential
- **OWL** = other wooded land (tree/shrub cover 5-9% or <5m)
- **OLWT** = other land with tree cover >10% - includes urban
- **TOF** = trees outside forest (<10% cover)
Into our virtual future?

Scientists and field crews are already experimenting with body-mount 3D cameras on plots.

Old school?

New School?

Drone camera
2015 FIA Science Symposium

Pushing Boundaries –
New Directions in Inventory Techniques & Applications

December 8-10, 2015
Portland Marriot Downtown Waterfront

Portland, Oregon USA

TOPICS
- Tree biomass estimation
- Inventory challenges in Alaska
- Forest health indicators
- Forest carbon accounting
- Improving estimates of growth, removals, and mortality
- Land use/cover change monitoring
- Socio-economic dimensions of forests
- Urban Inventory

JOIN US!

Anticipated attendees 200
Presentations 136

JOIN US!
FIA Data Access

• Virtually all U.S. forest inventory data are available on the web at http://fia.fs.fed.us

• All national inventory databases provide output options of English or metric units

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QUESTIONS?