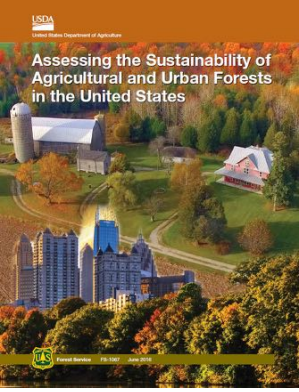



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Assessing the Sustainability of Agricultural and Urban Forests in the United States: Introduction

Guy Robertson
Forest Service Research & Development
August 11, 2016




 Forest Service


Research & Development

Credits

Editors: Guy Robertson & Andy Mason
Authors: Greg Liknes, Andy Lister, David Nowak, Charles Perry, Steve Rasmussen,* Michele Schoeneberger, Chris Woodall
(And many thanks to our numerous reviewers and the folks at layout and printing)



*Nebraska Forest Service, otherwise all contributors USFS R&D

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Why are you here?

- I'm mainly interested in urban forestry.
- I'm mainly interested in agroforestry and trees on agricultural lands.
- I'm interested in landscape scale management and the unifying role of trees across different land uses.
- I don't know. Quit asking me questions.



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Context and Rationale for Report

Companion report to the National Report on Sustainable forests

		<p>Next Report due in 2017</p>	<p>Comprehensive forest sustainability assessment of conventional* forests in the United States</p> <p>(*i.e., lands meeting FIA definition of forest)</p>
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This report focuses on the “Forests Left Out” of the National Report (i.e., non-FIA forest)



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Rationale for Report (cont.)

- Need to better understand a vast and valuable resource
- Help lay the groundwork for a comprehensive, wall-to-wall, inventory of trees & forests in the United States
- Facilitate landscape scale ecosystem management spanning jurisdictions and land-use types
- Unify our approach to measuring and understanding trees & forests wherever they occur



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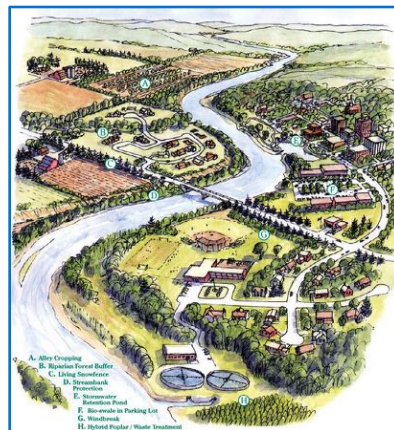
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What are agricultural and Urban Forests?

Forests and trees located in urban, peri-urban (“rurban”), and agricultural areas not meeting the FIA definition of forests

USFS Forest Inventory and Analysis (FIA) program definition of forests:

areas more than 120 feet (37 meters) wide and more than 1 acre (.4 hectares) in total extent with at least 10 percent forest stocking.



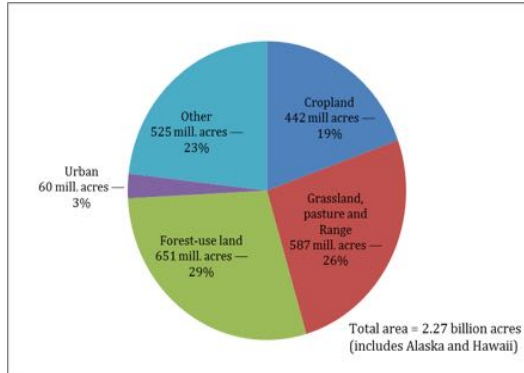
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Potential scale of resource

- 60 million acres of urban lands (138 million if “community lands” are included)
- Tree cover on urban lands currently estimated at approximately 35%

- Over 1 billion acres of cropland, pasture and range
- Tree cover estimates not available



Land use in the United States, 2002 (USDA Economic Research Service, <http://www.ers.usda.gov/publications/EIB14/eib14.pdf> [August 2015]).



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Importance of Agricultural and Urban Forests

Benefits similar to conventional forests but also many unique benefits

Greater than implied by area alone

- Proximity to human populations
- Proximity to agricultural production systems
- Concomitant ecosystem services

Role in unifying landscapes and maintaining ecosystem integrity

- E.g., Wildlife migration, aesthetics, riparian systems



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Measurement Challenges Associated with Agricultural and Urban Forests

1. Spatial configuration and fragmentation, for example:
 - Street and garden trees
 - Linear forests (windbreaks)
 - Heterogeneous distribution
2. Fragmented ownership
 - Parcel size
 - Diverse ownership types
3. Lack of forest management focus



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Current State of Knowledge About Agricultural and Urban Forests

Data needed to describe agricultural and urban forest at the national level is virtually nonexistent

- Extensive research and experience related to specific times or places does exist
- Including one-off studies and spatially restricted inventories
- But not commensurate with information on conventional forests at national scale
- In particular we have no nation-wide inventory of forest resources on agricultural and urban lands
- Ancillary data (e.g., employment numbers) not developed or identified



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Current State of Knowledge About Agricultural and Urban Forests

But the situation is improving

- Increased recognition of the value of trees and forests in different settings (e.g., “green infrastructure” and “ecosystem services”)
- Remote sensing combined with on-the-ground plot sampling are yielding cost-effective options for inventory
- Urban forest cover and extension of Urban FIA will allow for national level monitoring and reporting of urban forests
- Similar approach needed for agricultural lands
- Social and economic variables will continue to present challenges



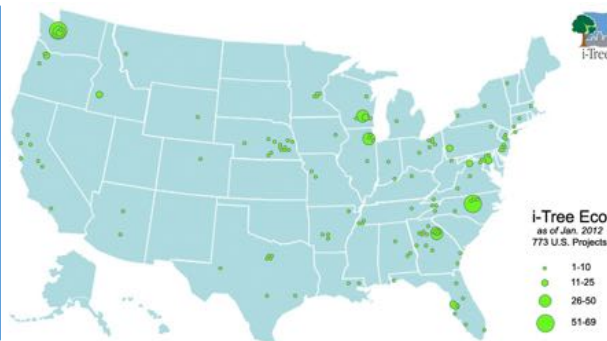
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iTree Eco Projects in U.S. (2012)

Localized sampling guided by common information framework and technology

Allows for broad-based, participatory measurement to produce consistent information



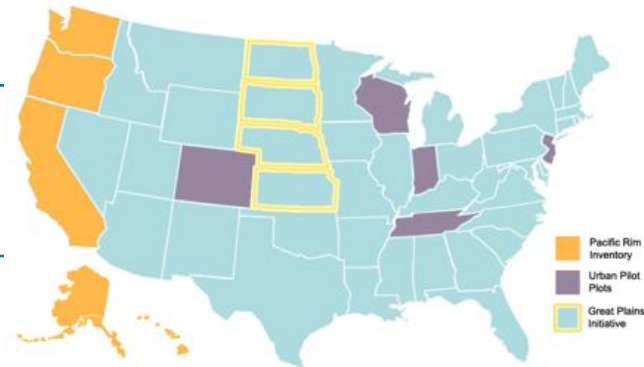
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FIA and FIA-type Extensions (2012)

Urban FIA

Great Plains Inventory
(FIA-type inventory
applied to all-lands)



Pacific Rim Urban Forest Inventory (2010–2012); Urban Forest Inventory and Analysis Pilots (as of 2013); Great Plains Tree and Forest Invasives Initiative Inventory (2008–2009).



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Note on Comprehensive Forest Sustainability Assessments Using C&I

Montréal Process Criteria & Indicators (MPC&I)

- 54 indicators arranged under 7 criteria
- Ecological, social, and economic
- Flexible application and interpretation
- Touchstone for development of a rational and explicit monitoring framework

MPC&I is broadly applicable to agricultural and urban forests (with substantial modifications), but it is only loosely applied in this exercise



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Outline for Rest of Webinar

- **Agricultural Forest Resources**
--Michelle Schoeneberger, *USDA National Agroforestry Center*
- **Urban Forests**
--David Nowak, *Forest Service Forest Inventory and Analysis*
- **Inventory Options**
--Charles Perry and Greg Liknes, *Forest Service Forest Inventory and Analysis*



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United States Department of Agriculture

Michele Schoeneberger
Andy Lister
Steve Rasmussen

Agricultural Forest Resources



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Michele Schoeneberger
Andy Lister
Steve Rasmussen

Agricultural Nonforest Tree (ANT) Resources



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Prairie States Forestry Project (1934-1942)

The Dust Bowl (1930-1940):

- ~ extreme & prolonged weather event
- ~ large-scale land-use conversion
- ~ fluctuating crop prices

200 million ~Trees in Support of Agricultural Lands

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Value of Agricultural Tree Resources



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Agricultural Nonforest Trees (ANTs)

- Naturally occurring tree(s)
- Trees deliberately managed and planted for targeted services.
 - Wood lots (generally captured w/in FIA)
 - **AGROFORESTRY**



North Dakota's rural landscape displays riparian forests and planted windbreaks.



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Agroforestry

(www.nac.unl.edu)



....the right trees in the right places for the right jobs.



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Benefits of Agroforestry



- Protect crops, livestock, buildings & roads
- Diversify farm economy
- Protect water, soil & air quality
- Provide key wildlife resources (**POLLINATORS!**)
- Improve nutrient cycling
- Enhance recreation opportunities
- Improve aesthetics
- Provide physical/visual barriers

→ *Providing key climate change adaptation & mitigation services to enhance the food security and resiliency of U.S. agricultural operations & lands.*



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Agroforestry: USDA Program Support

USDA programs, such as EQIP and CRP, provide support for technical and financial assistance.



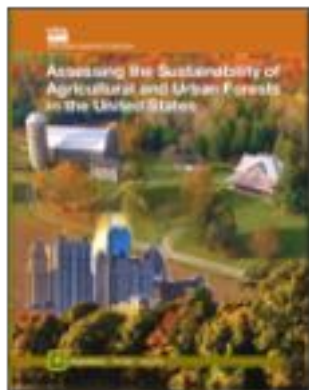
Finding Agroforestry in the 2014 Farm Bill. 2016 *Inside Agroforestry*
www.nac.unl.edu



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Inventory – Providing the Whats for the “Whys”



“Wise management is essential to sustain and enhance the values associated with agricultural and urban ‘forests’

....and wise management, in turn requires good information.”



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Inventory for the Whats & Whys

BENEFITS

- Diversify farm enterprise
- Protect crops, livestock, buildings & roads
- Improve utilization of nutrients
- Improve water/air/soil quality
- Enhance/protect wildlife habitat
- Mitigate greenhouse gas emissions



1. ANT RESOURCE TYPE/EXTENT
2. SERVICE(S)
3. CONDITION
4. CONTRIBUTION
5. VALUE \$\$



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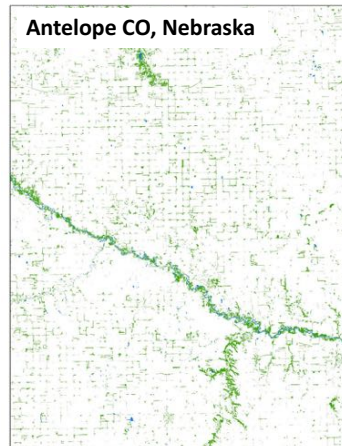
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Inventory for the Whats & Whys



North Dakota's rural landscape displays riparian forests and planted windbreaks.

Antelope CO, Nebraska



(D. Meneguzzo & G. Liknes, USFS NRS)



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Agroforestry: Why inventory?

Carbon Sequestration Potential (Nebraska farm - 50 yrs)

Option	Ha	%total	MT CO ₂
Conservation tillage only	254	100	9,203*
	No-tillage		9,203
Conservation tillage & windbreaks	241	95	8,712*
	13	5	7,416
	Windbreaks		16,128

*COMeT (Brenner et al.)

Schoeneberger, Brandle & Zhou



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Great Plains Initiative (GPI)

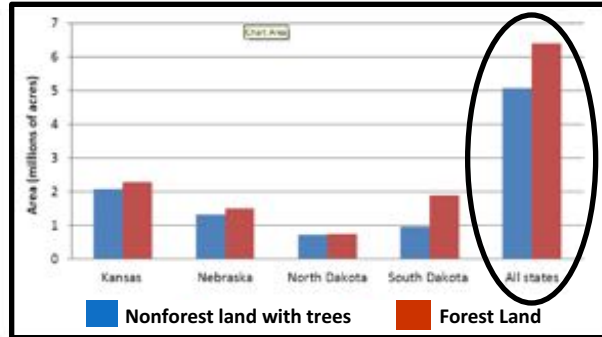
- Collaborative effort between State forestry agencies (KS, NE, SD & ND) and the FS National Inventory & Monitoring Applications Center
- 2008-2009 wall-to-wall (but one-off) study to provide insight regarding nonforest trees in the Plains (esp in regards to Emerald Ash Borer & other threats)
- GOAL: to characterize tree resources using FIA-compatible methods so that data can be integrated to gain an all-lands understanding



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Great Plains Initiative (GPI)



FIA forest land area and nonforest treed land area for KS, NE, SD & ND and all 4 states combined.

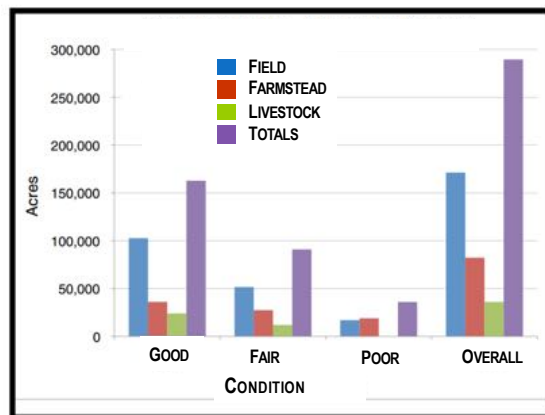
For more information contact: Dacia Meneguzzo, FIA, Northern Research Station



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Great Plains Initiative (GPI)



Kansas windbreak health by function.

For more information contact: Dacia Meneguzzo, FIA, Northern Research Station



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Great Plains Initiative (GPI): Financial Impacts of Windbreaks in NE

Field Windbreaks (most with ash)

- 93,000 acres
- 100 million linear feet (19,127 miles)
- 974 thousand acres protected
- Crop protection benefits = \$79 million/yr

Farmstead Windbreaks (most with ash)

- 81,000 acres
- 59 million linear feet (11,139 miles)
- 59,000 homes protected
- Total energy saved/yr = ~ \$24 million/yr

**Total Benefits/yr
\$102 million**

Nebraska Forest Service, 2016

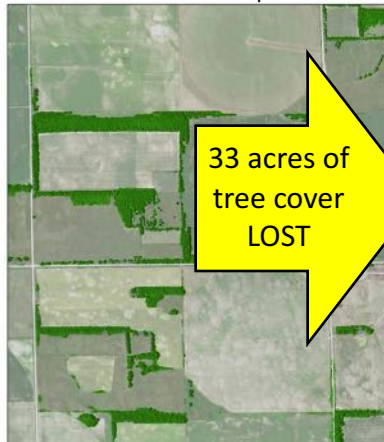


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Inventory for the Whats & Whys

2009 aerial image and tree cover
classification output



33 acres of
tree cover
LOST

2012 aerial image – yellow circles show
where tree cover has been removed

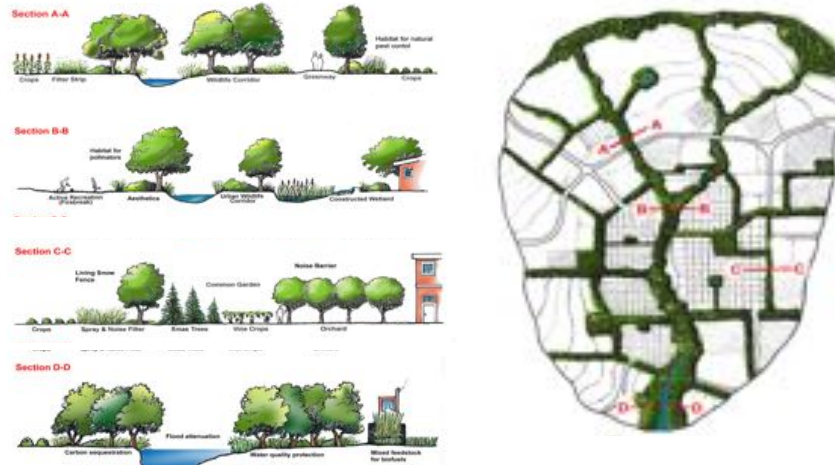


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Section in Nebraska (D. Meneguzzo & G. Liknes, USFS NRS)

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Designing ANTS to work from Site-to-Landscape Scales



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ANT Resources – Linking functions and objectives across lands and people



- ❖ Stormwater management
- ❖ Recreational trails
- ❖ Wildlife corridors
- ❖ Water quality
- ❖ Bioenergy



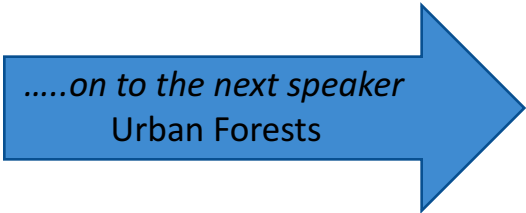
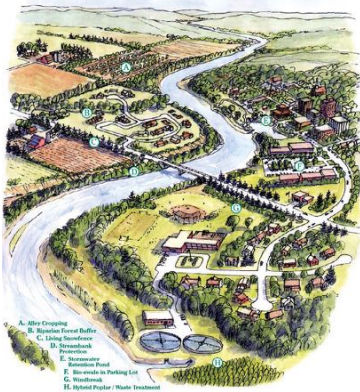
Agroforestry - to connect the rural and urban and forest areas
 ...helping to meet the many objectives we demand across these lands.



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ANT Resources – Linking functions and objectives across lands and people



Agroforestry - to connect the rural and urban and forest areas
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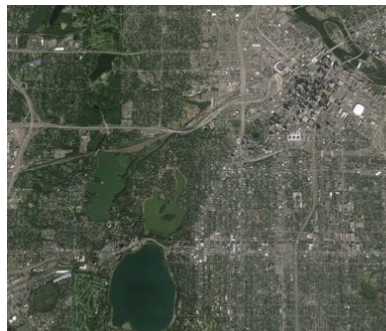
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United States Department of Agriculture

David Nowak

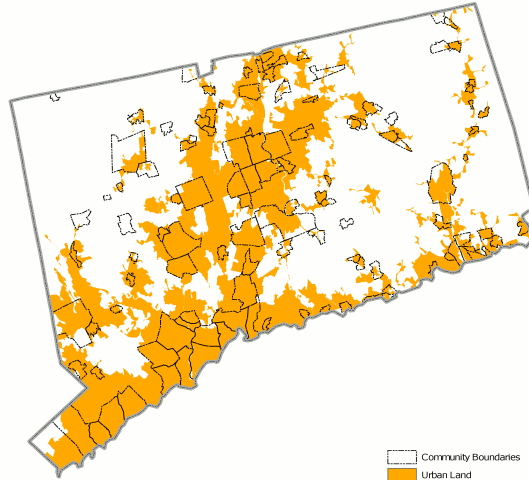
Urban Forests



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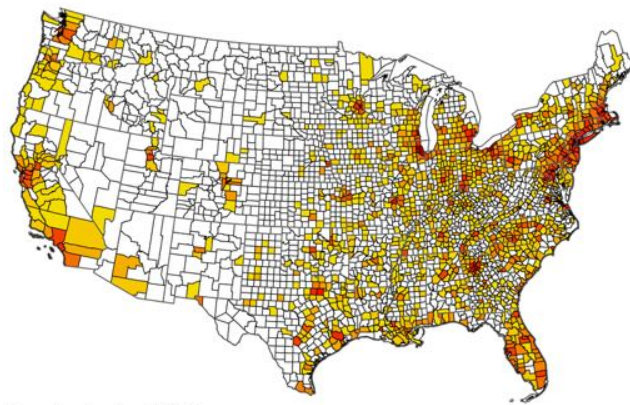
Urban and Community Land



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Urban (1990): 2.5%



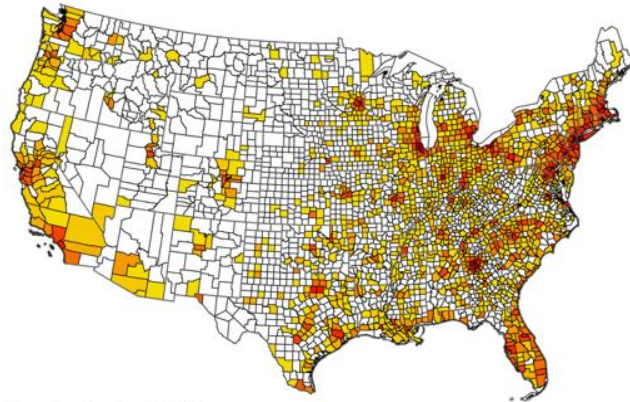
Percent urban land (1990)



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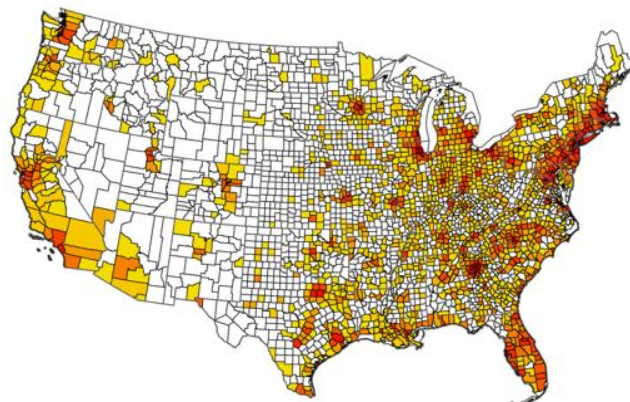
Urban (2000): 3.1%



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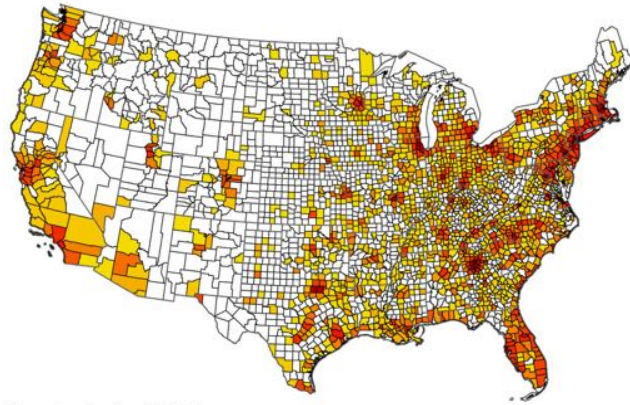
Urban (2010): 3.6%



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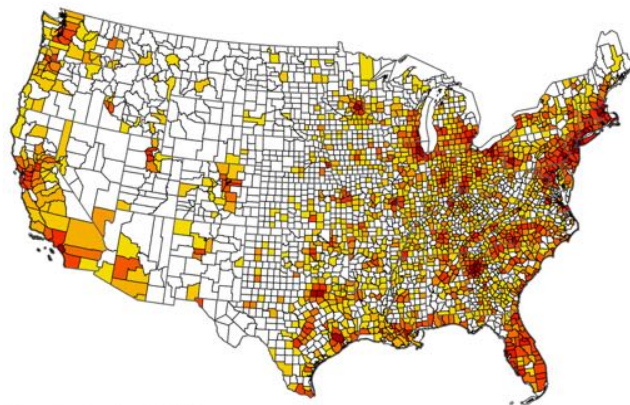
Urban (2020): 4.4%



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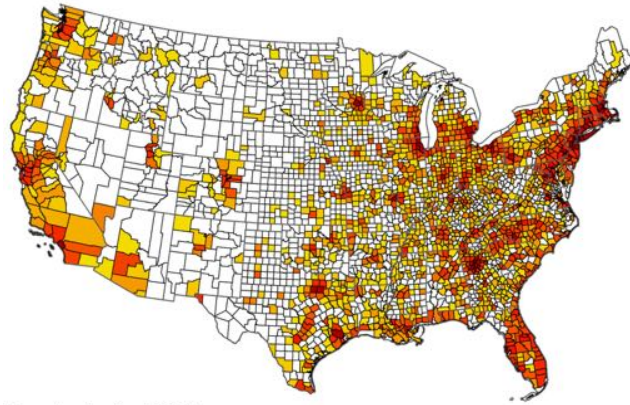
Urban (2030): 5.2%



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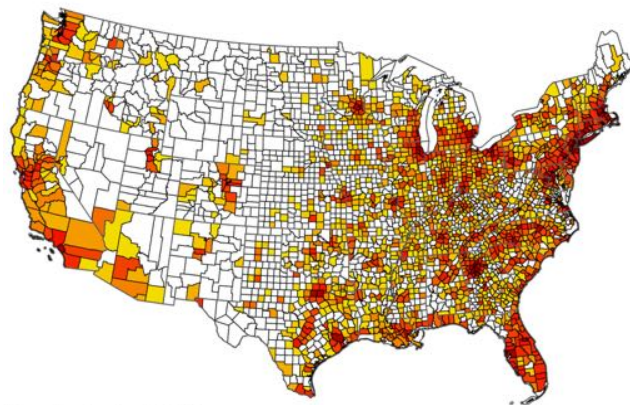
Urban (2040): 6.3%



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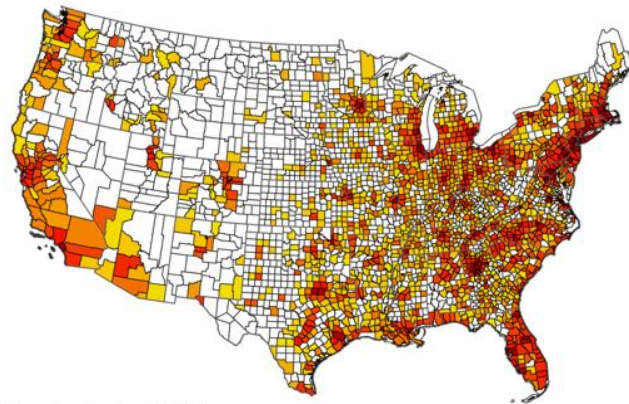
Urban (2050): 7.4%



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Urban (2060): 8.7%



Percent urban land (2060)



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Projected urban land increase (2010-2060):

- +2 million acres / year
- Urban land (conterminous U.S.)
 - 2010 = 67.8 million acres (3.6%)
 - 2060 = 163.1 million acres (8.7%)
 - Increase greater than size of Montana
- Urban population increase
 - Approximately 90% urban population (2060)

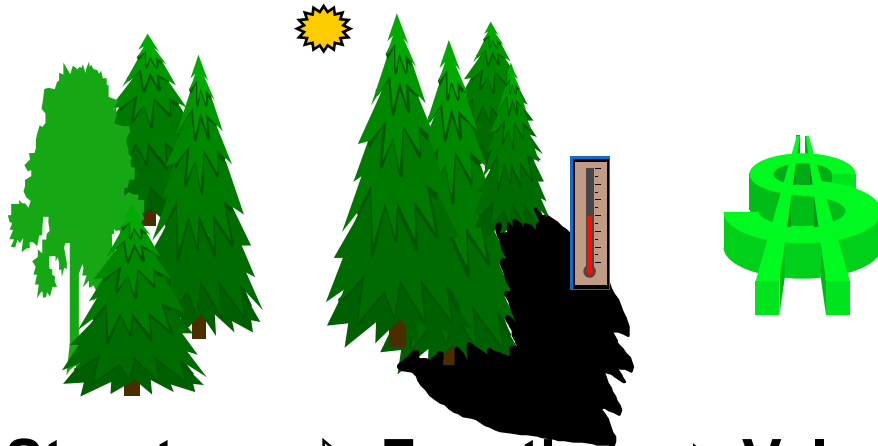
Delaware land area = 1.2 million acres



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Structure is Critical



Structure → **Function** → **Value**



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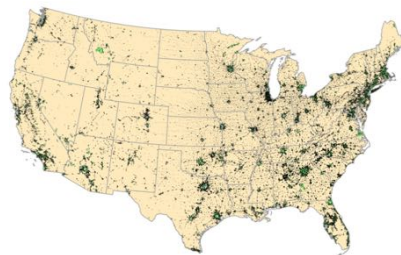
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~80% of U.S. urban land is within forested areas

Tree Cover



Urban / Community Land

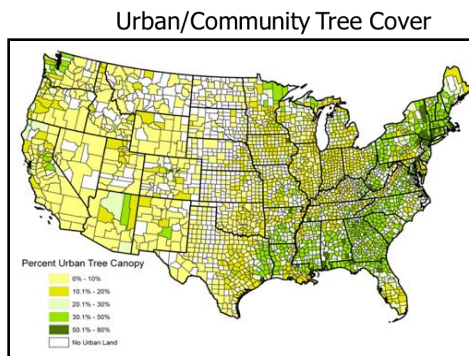


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Tree Cover in the United States

State	Percent Tree Cover		
	State	Urban	Rural
Connecticut	72.6	66.5	75.9
Massachusetts	70.8	64.5	74.4
New Hampshire	88.9	64.0	91.5
Maine	83.1	54.0	84.4
Rhode Island	70.3	54.0	82.0
Alabama	70.0	53.0	71.5
Vermont	81.5	53.0	82.3
Georgia	66.4	52.0	67.7
New Jersey	57.0	50.4	59.8
North Carolina	62.6	48.2	63.9
Idaho	37.9	13.0	38.2
New Mexico	19.1	12.0	19.2
Nevada	11.6	12.0	11.6
Montana	27.5	9.0	27.4
Wyoming	14.5	9.0	14.4
US(48)	34.2	35.0	34.1



20.8 million acres of urban tree cover in US

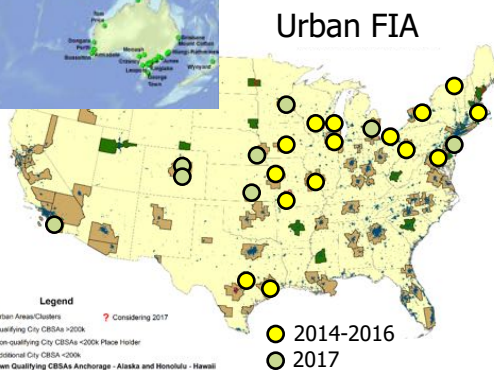
~4 billion urban trees



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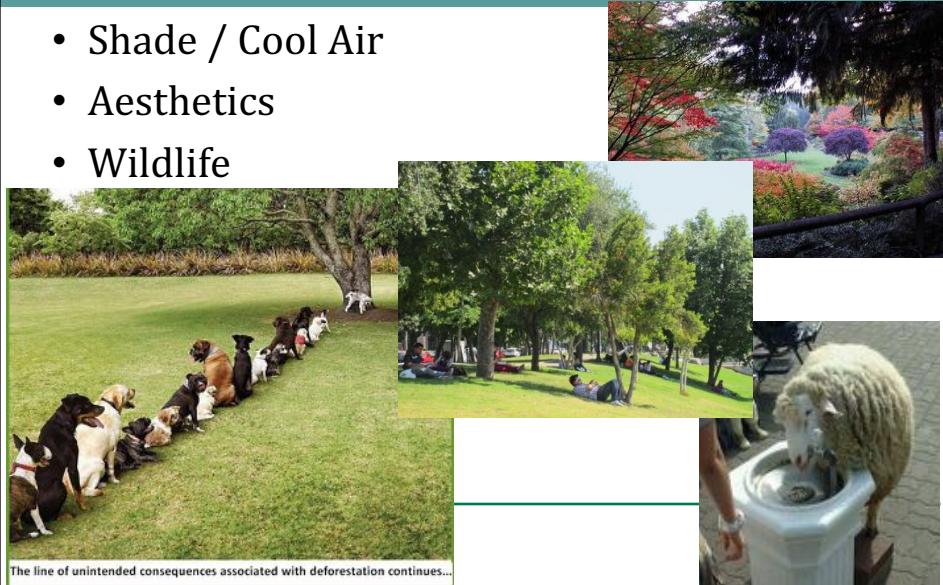
Measuring Structure



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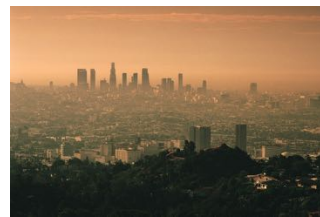
Tree Benefits - Tangible

- Shade / Cool Air
- Aesthetics
- Wildlife



Tree Benefits – Less Tangible

- Pocket book (\$)
 - Altered building energy use / altered emissions
 - Products (26M t wastewood/yr), jobs
- Human Health
 - Water quality
 - Air quality, UV radiation
 - Physiological changes
- Environmental Quality / Regulations
 - Air quality, water quality, carbon, air temperature
- Other
 - Biodiversity, neighborhoods, crime...



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US Urban/Community Annual Values

- Avoided energy use = \$7.8 billion
- Carbon sequestration = \$6.6 billion
- Air pollution removal = \$4.7 billion*
- Avoided emissions = \$2.2 billion
- Total = \$21.4 billion
 - \$590 per acre of tree cover

* Urban only



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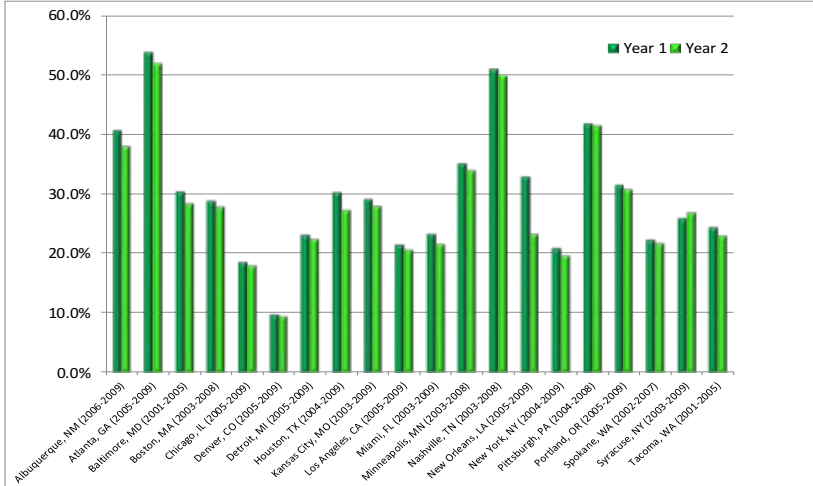
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Tree cover in cities is changing



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Tree Cover Change



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Tree Cover Change

- In the U.S., urban tree cover dropping:
 - 20,000 acres per year
 - 4.0 million trees per year



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Major Drivers of Change in the Future

- Development

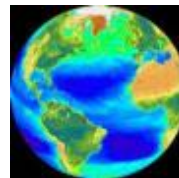


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Major Drivers of Change in the Future

- Development
- Climate Change



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Major Drivers of Change in the Future

- Development
- Climate Change
- Insects and Diseases



Emerald ash borer range (2013)

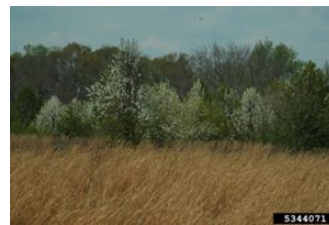


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Major Drivers of Change in the Future

- Development
- Climate Change
- Insects and Diseases
- Invasive species



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Begin with the end in mind

Forest inventory activities are evolving continuously. These advances are being extended to agricultural and urban forests.



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FIA conducts the US NFI to achieve *national* program goals. We need to estimate:



- The extent (area) of forest land;
- The volume, growth, and removal of forest resources; and
- The health and condition of the forest.


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Quick question: which of these is NOT part of FIA's definition of "forest land"?

- A. Stand area;
- B. Stand width;
- C. Land use;
- D. Land cover; or
- E. None. ALL are part of FIA's definition.



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Our traditional focus was on "forest land."

Land at least 37 meters wide and at least 0.4 hectare in size with at least 10% cover (or equivalent stocking) by live trees including land that formerly had such tree cover and that will be naturally or artificially regenerated. Trees are woody plants having a more or less erect perennial stem(s) capable of achieving at least 7.6 cm in diameter at breast height, or 12.7 cm diameter at root collar, and a height of 5 meters at maturity in situ. The definition here includes all areas recently having such conditions and currently regenerating or capable of attaining such condition in the near future. Forest land also includes transition zones, such as areas between forest and nonforest lands that have at least 10% cover (or equivalent stocking) with live trees and forest areas adjacent to urban and built-up lands. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if they are less than 37 meters wide or 0.4 hectare in size. Forest land

does not include land that is predominantly under agricultural or urban land use.

Oswalt, S.N., Smith, W.B., Miles, P.D. and Pugh, S.A., 2014. Forest Resources of the United States, 2012: a technical document supporting the Forest Service 2015 update of the RPA Assessment. Gen. Tech. Rep. WO-91. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 218 p.



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Many trees fall through the gap

Not an Acre Wrong land use Not 120' Wide

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But all trees:

- Sequester Carbon
- Provide Habitat
- Filter Water
- Stabilize Soils
- Provide Biomass
- Enhance Biodiversity
- Create Jobs

And some trees:

- Increase crop yields
- Protect livestock
- Conserve energy
- Improve health and safety

Handy trees should be tally trees!

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We also need to track land use and land use change for C attribution.

Forest land Croplands Settlements

Woodall et al. 2015. Recent Land Use Change is a Substantial Component of the Forest Carbon Sink in the eastern United States. *Scientific Reports*, 5.

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Let's leverage the ENTIRE plot network.


Forest Plots Non-Forest Plots

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An effective inventory system would meet several criteria.

1. Statistically valid national sample;
2. Published sampling and reporting protocols;
3. Established change process;
4. Comprehensive land use definition;
5. Public database with stable format;
6. Reporting on schedule;
7. Identify and fill gaps;
8. Interaction with user community; and
9. Institutional and budgetary permanence.

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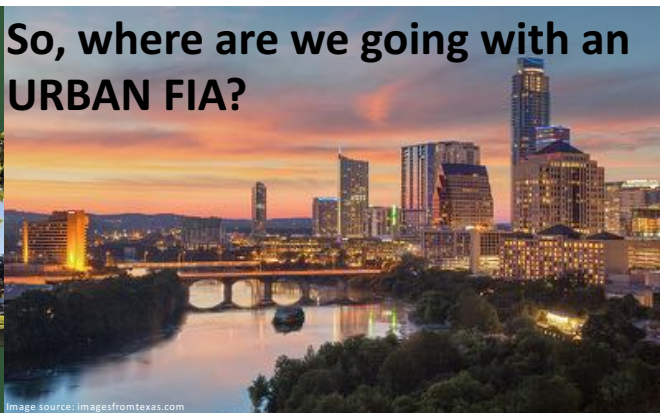
**Austin's Urban Forest
2014**




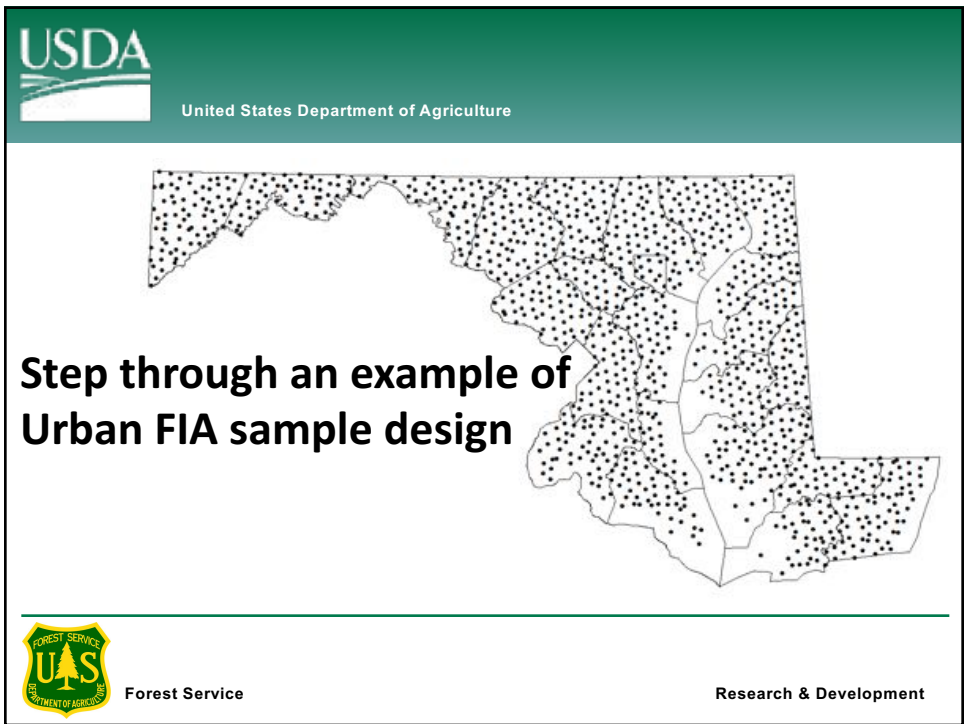
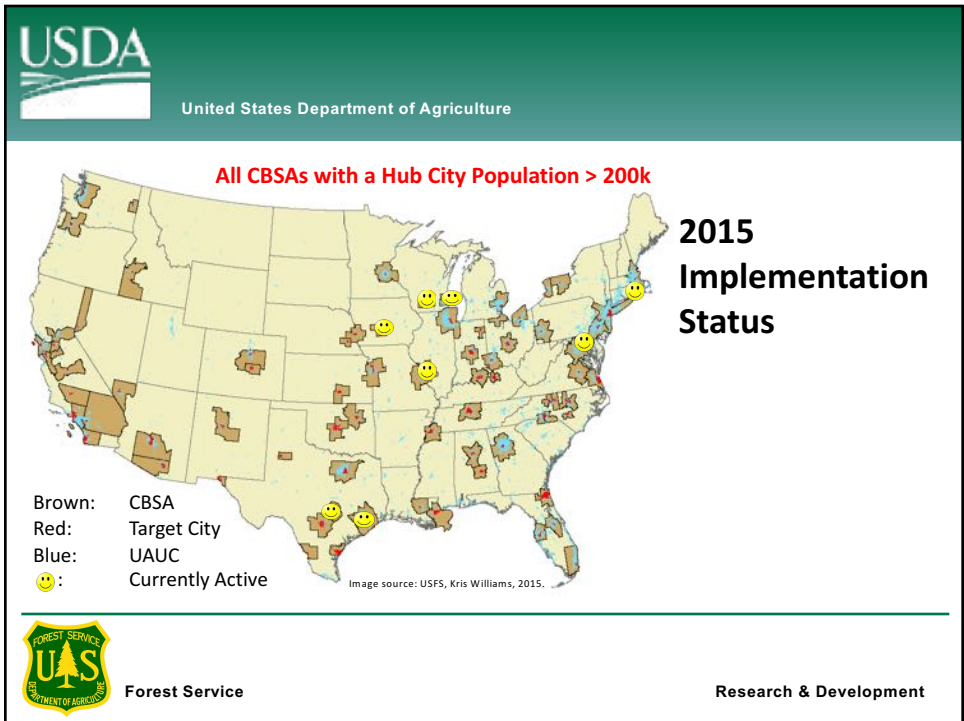
Forest Service
Northwest
Research Station
Resource Bulletin
RWS-155
Publication Date
February 2014

Image source: imagesfromtexas.com

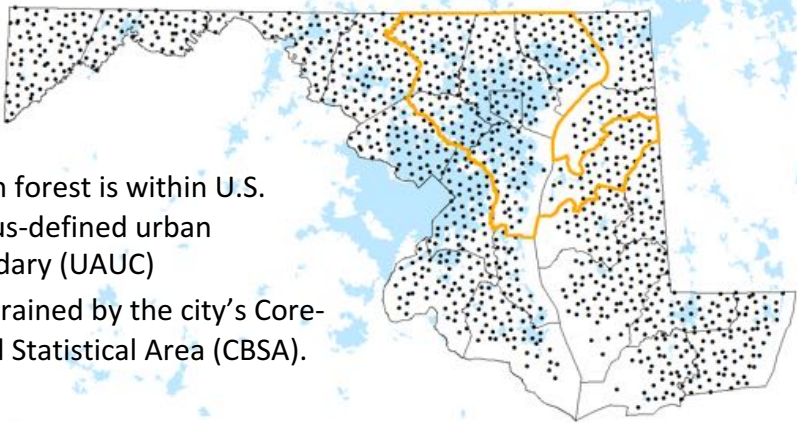
So, where are we going with an URBAN FIA?




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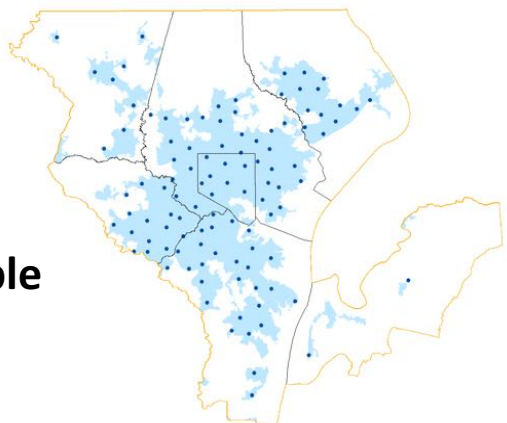
- Urban forest is within U.S. Census-defined urban boundary (UAUC)
- Constrained by the city's Core-Based Statistical Area (CBSA).




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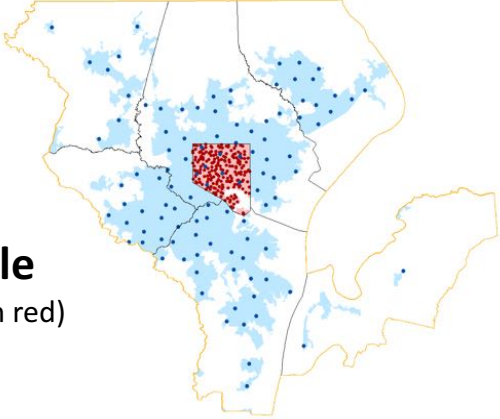
Baltimore, MD sample




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Baltimore, MD sample
(Baltimore City is the Hub city in red)



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Simplified plot design



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Urban Microplots:
6.8 ft. radius
13 - 12.0 ft. @ 270°
14 - 12.0 ft. @ 360°
From plot center

Urban Plot

1/6 Acre Subplot, 48' Radius:
tree sample

Four 6.8' radius Microplots:
sapling sub-sample

Plot Center:
48.0 ft. radius

Urban Microplots:
6.8 ft. radius
11 - 12.0 ft. @ 90°
12 - 12.0 ft. @ 180°
From plot center

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Inventory & Monitoring trees in agricultural landscapes

- Currently less developed than urban I&M
 - No ag complement to FIA's urban program
- Yet critically important
- Very large land area


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Remote Sensing provides context

- Can help answer
 - How much?
 - What is it doing?
 - How is it changing?
- High-resolution data sources
 - National Agriculture Imagery Program (NAIP)
 - Lidar
- Complement to field-based observations

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A new remote sensing effort

- Targeted task team at the Northern Research Station
 - Trees Outside Forests Image-based Inventory
 - Team TOFii
- Partnership with National Agroforestry Center (USFS)

MISSION

- To develop methods for efficient mapping of tree resources as well as for identifying and quantifying their ecosystem functions in agricultural landscapes*
- To create a baseline inventory that can be monitored over time*

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Mapping process





Image Segmentation Classification

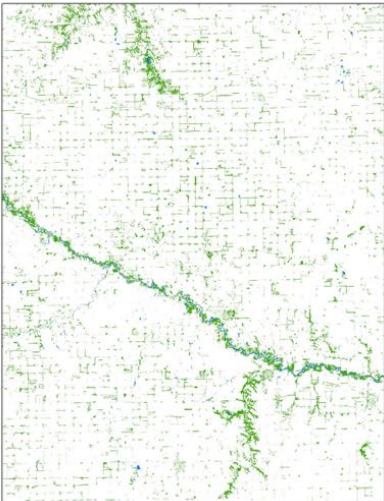
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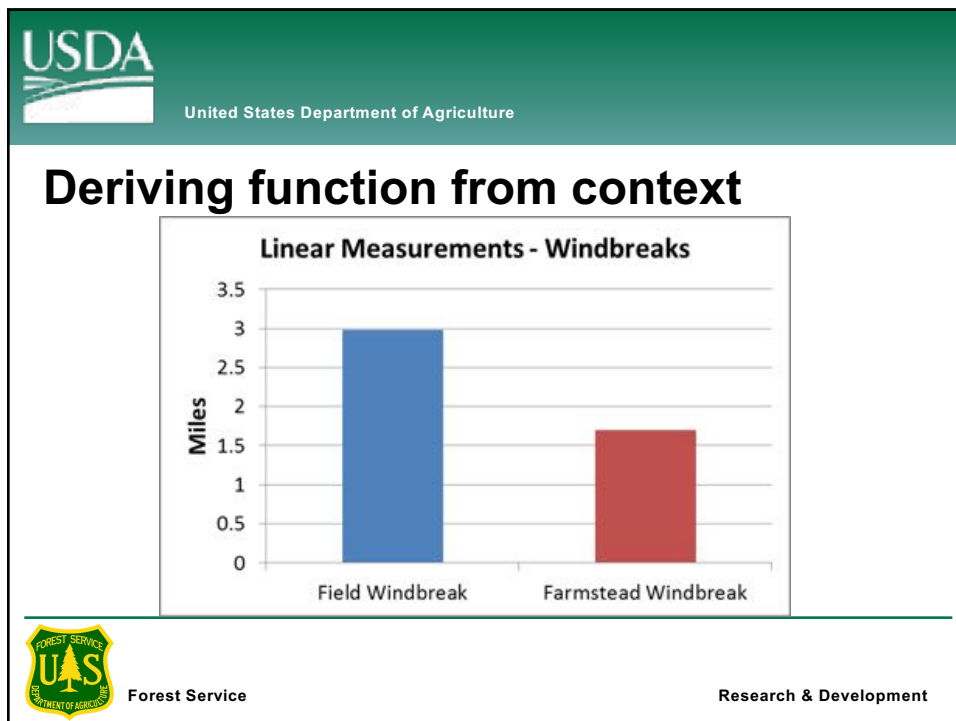
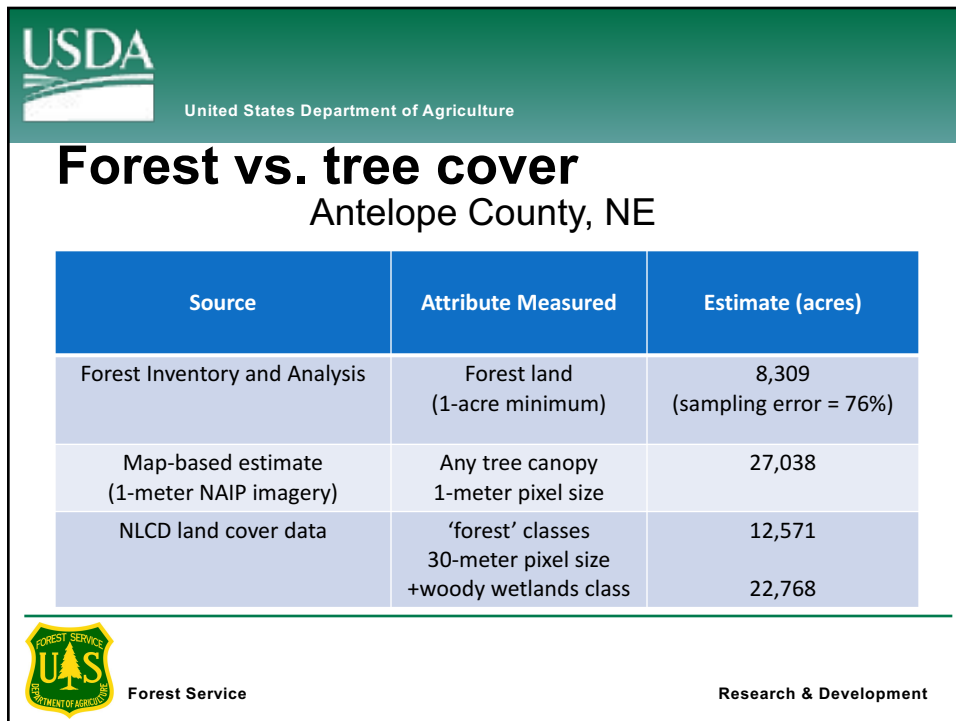
Sample Output

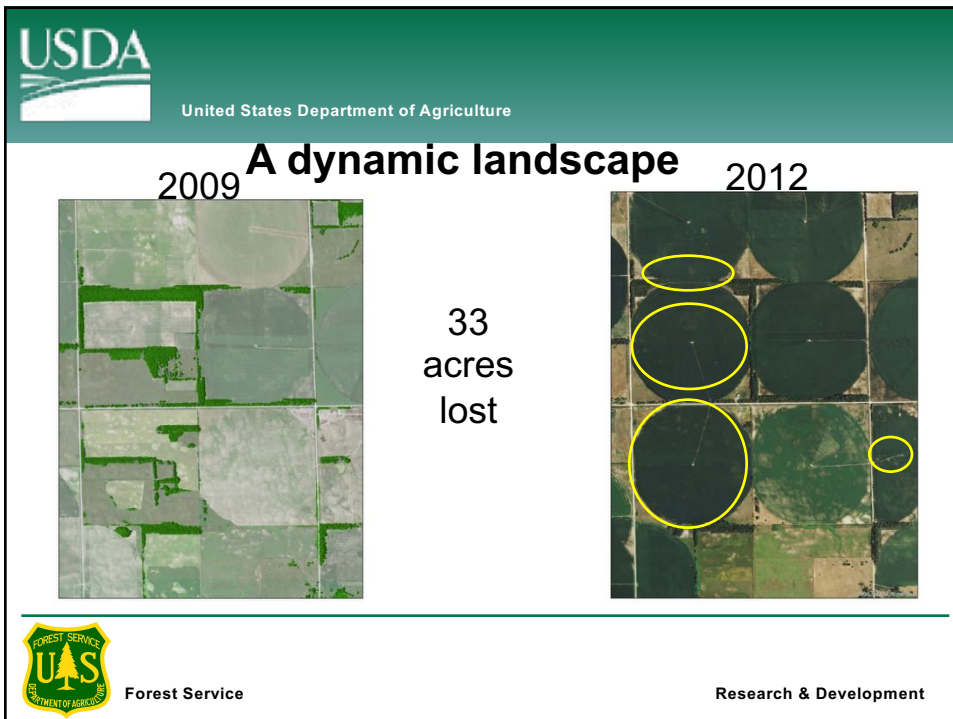
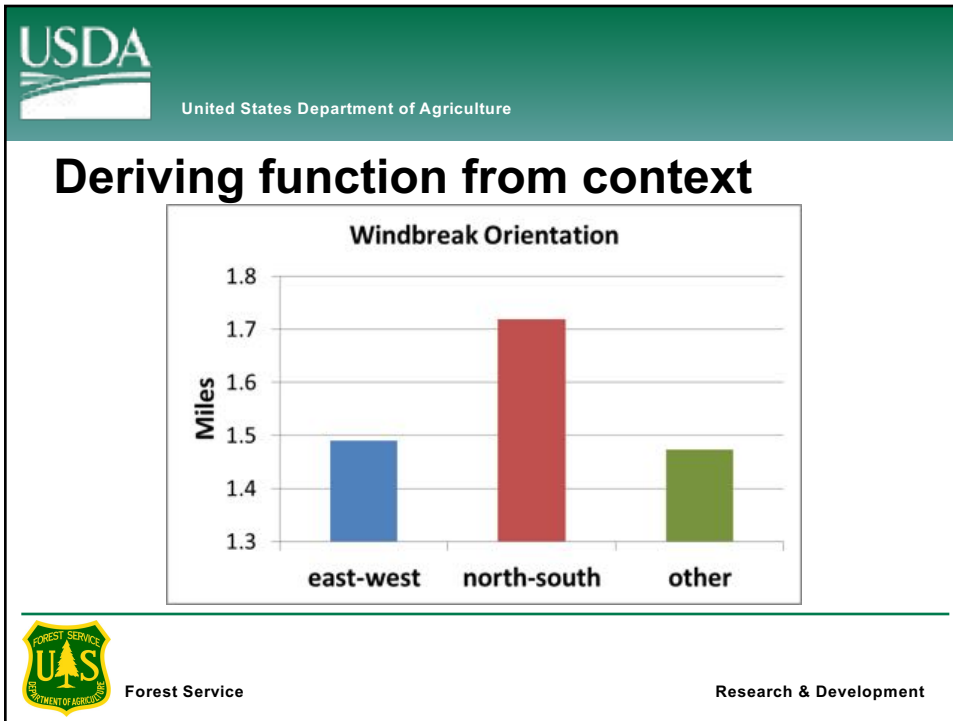
1-meter map of tree cover and water for Antelope County, NE

27,038 acres of tree cover




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A big technical challenge...



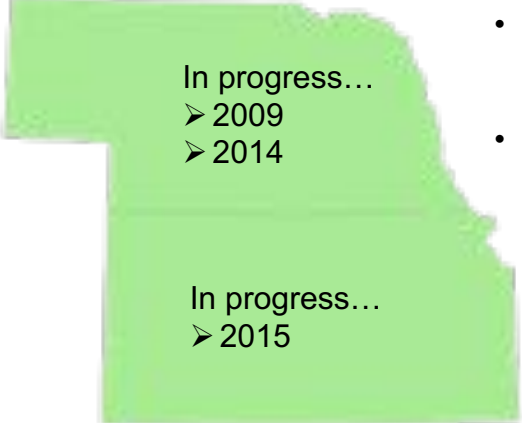
200 billion pixels
(+10% overlap)

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Working with partners



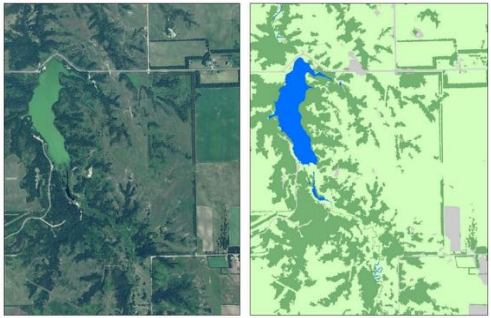
- National Agroforestry Center (USFS)
- University of Nebraska – Lincoln
- Kansas State University – Kansas Forest Service


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Questions?



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MPC&I-type criteria guide development...

3.3 Forest cover lost to development. Agricultural and urban forests are particularly prone to conversion to other land uses through the process of development. This indicator would measure the area of forests lost to this particular disturbance factor.

- **Status:** Core indicator. Change analysis associated with Indicator 1.1.a, although additional analysis to identify developed areas is needed.
- **Data sources:** Plot-based sampling and remote-sensing techniques used for Indicator 1.1a.


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and links to recent i-Tree developments.

6.1b Production of ecosystem services from agricultural and urban forests. Measures volume (in appropriate units) of ecosystem services derived from agricultural and urban forests. The potential range of these services is outlined in the previous chapters but could include, for example, water quality and flow regulation, wildlife habitat, or carbon sequestration. Comprehensive, quantitative measures are likely not feasible, but indicative information from analysis of inventory data and review of current literature can help describe the dimensions of the various ecosystem services associated with these resources.

- **Status:** Suggested for consideration. Substantial development required.
- **Data sources:** Inventory information developed in Criterion 1 combined with estimation techniques equating forest area or tree counts with supply of ecosystem services.

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Conclusions

- Advances in FIA (including Urban FIA) point to feasibility and need for wall-to-wall covering agricultural forests as well.
- Such an inventory provides a foundation for:
 - True landscape-scale management
 - The integration of disciplines and thinking across wildland, agricultural and urban land uses
 - A way to access the status and sustainability of all US forests



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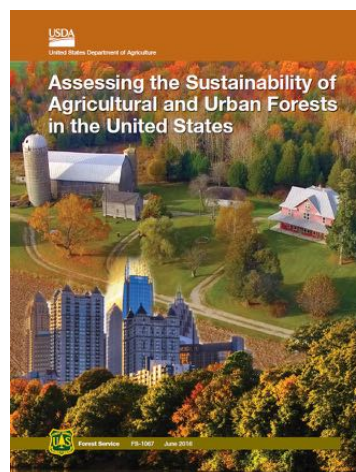
Thank you!

Copies of this report are available in downloadable format at:

<http://treearch.fs.fed.us/pubs/52278>

If you want a hardcopy version mailed to you please email me with your address

[Grobertson02\[at\]fs.fed.us](mailto:Grobertson02[at]fs.fed.us)



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