Forest Biomass Change Detection Using Lidar in the Pacific Northwest

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Master of GIS Capstone Proposal

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PENNSTATE World Campus

Outline

- Relevance of accurate biomass measurements
- Previous Studies
- Project Objectives
- Study area
- Data / Methods
- Preliminary Results
- Predicted Results
- Take Away Points

Forests act as a carbon sink

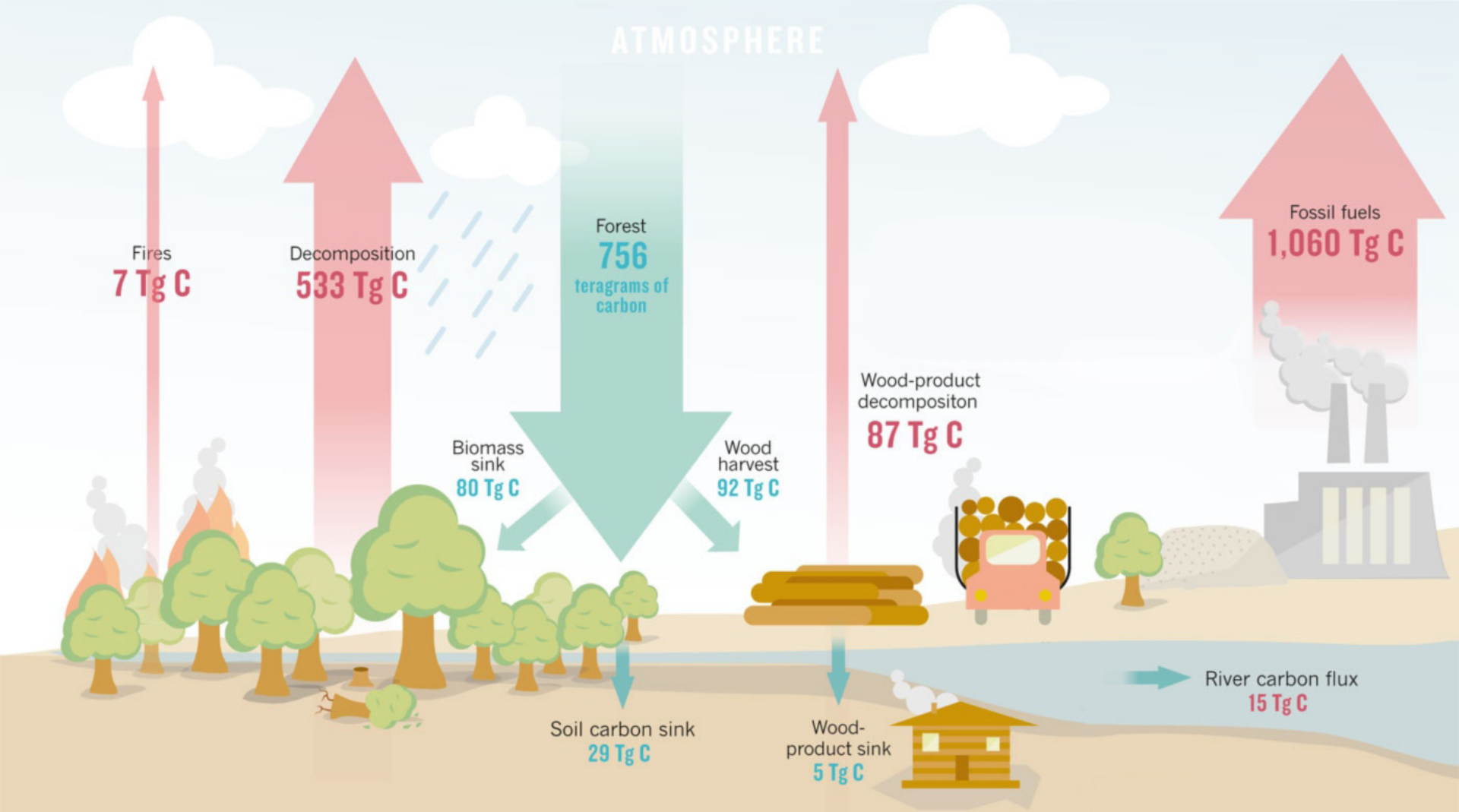


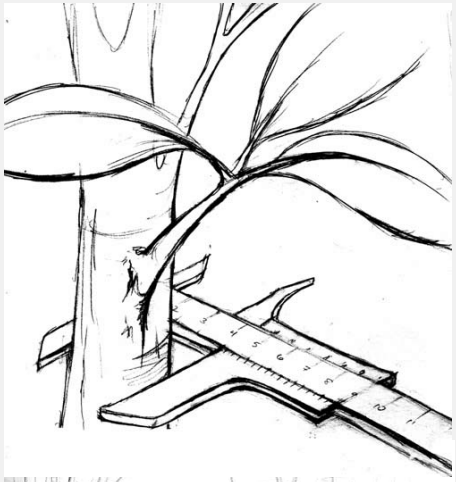
Image: Carbon cycle in Europe from 1990 - 2005
Source: S. LUYSSAERT ET AL. GLOB. CHANGE BIOL. 16, 1429–1450 (2010)

Above Ground Biomass (AGB) measurements help quantify carbon stocks

Above Ground Biomass (AGB):
All living biomass above the soil including stem, stump, branches, bark, seeds and foliage

Carbon Mass (kg C) = 0.5 * AGB

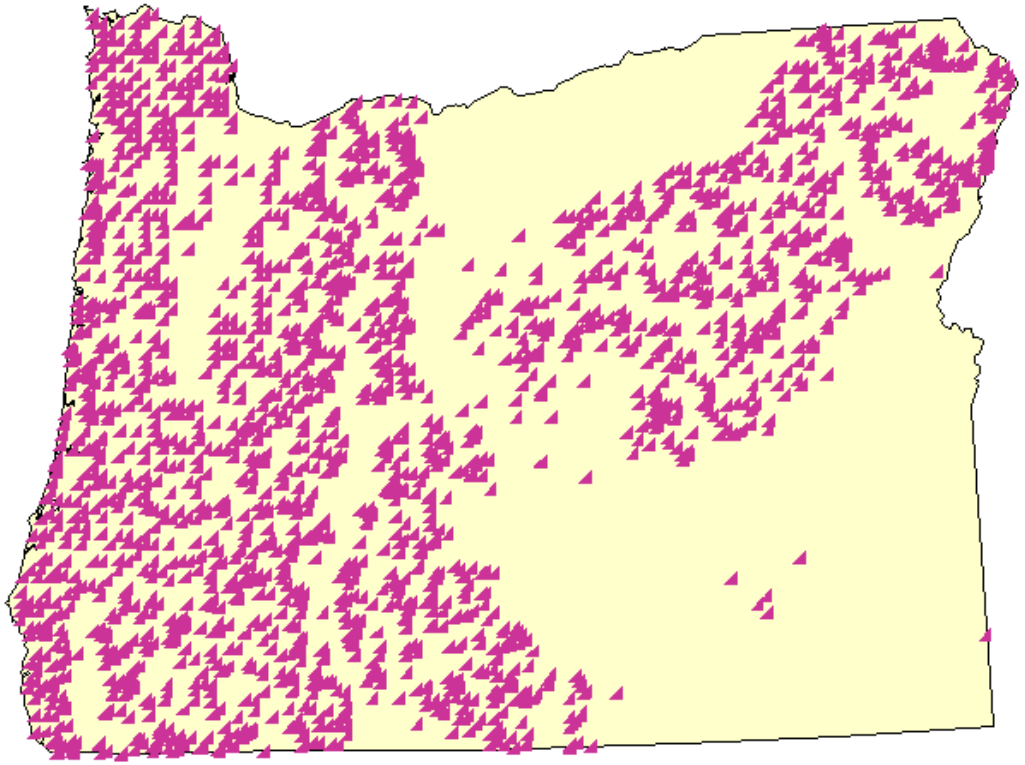
Traditional biomass sampling: time and cost intensive



Traditional field collection techniques (Hoover, 2008)

Forest Inventory Analysis (2015 FIA Annual Report)

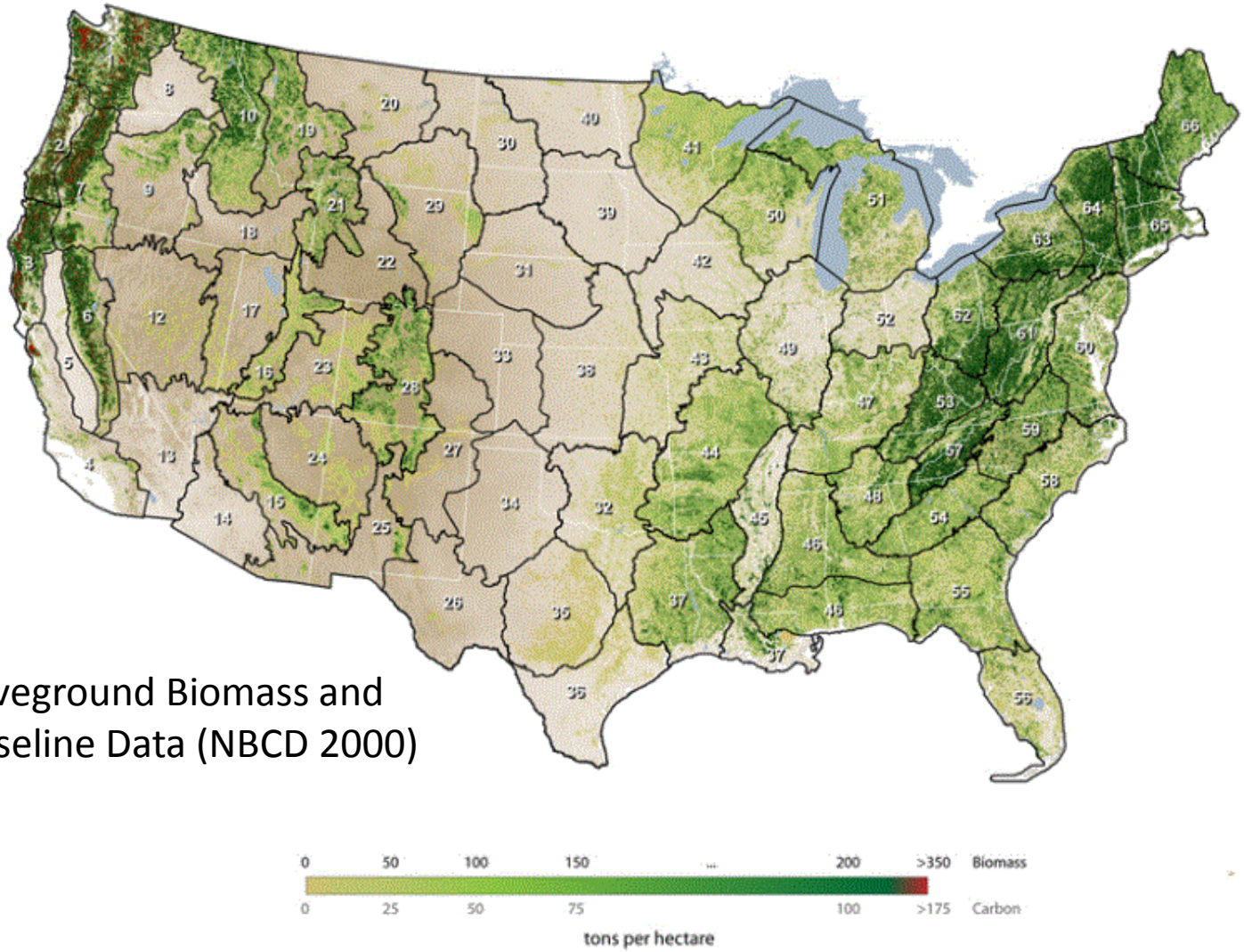
The Forest Inventory and Analysis (FIA) Program is continually updated



Oregon FIA Plot locations

Image source: http://andrewsforest.oregonstate.edu/pubs/webdocs/reports/regionl/gifs/nwfia.htm

FIA data can be integrated with remote sensing to estimate biomass



NACP Aboveground Biomass and Carbon Baseline Data (NBCD 2000)

Image source: Kellndorfer, J. et al, 2013

Satellite data is appropriate for modeling biomass over large domains

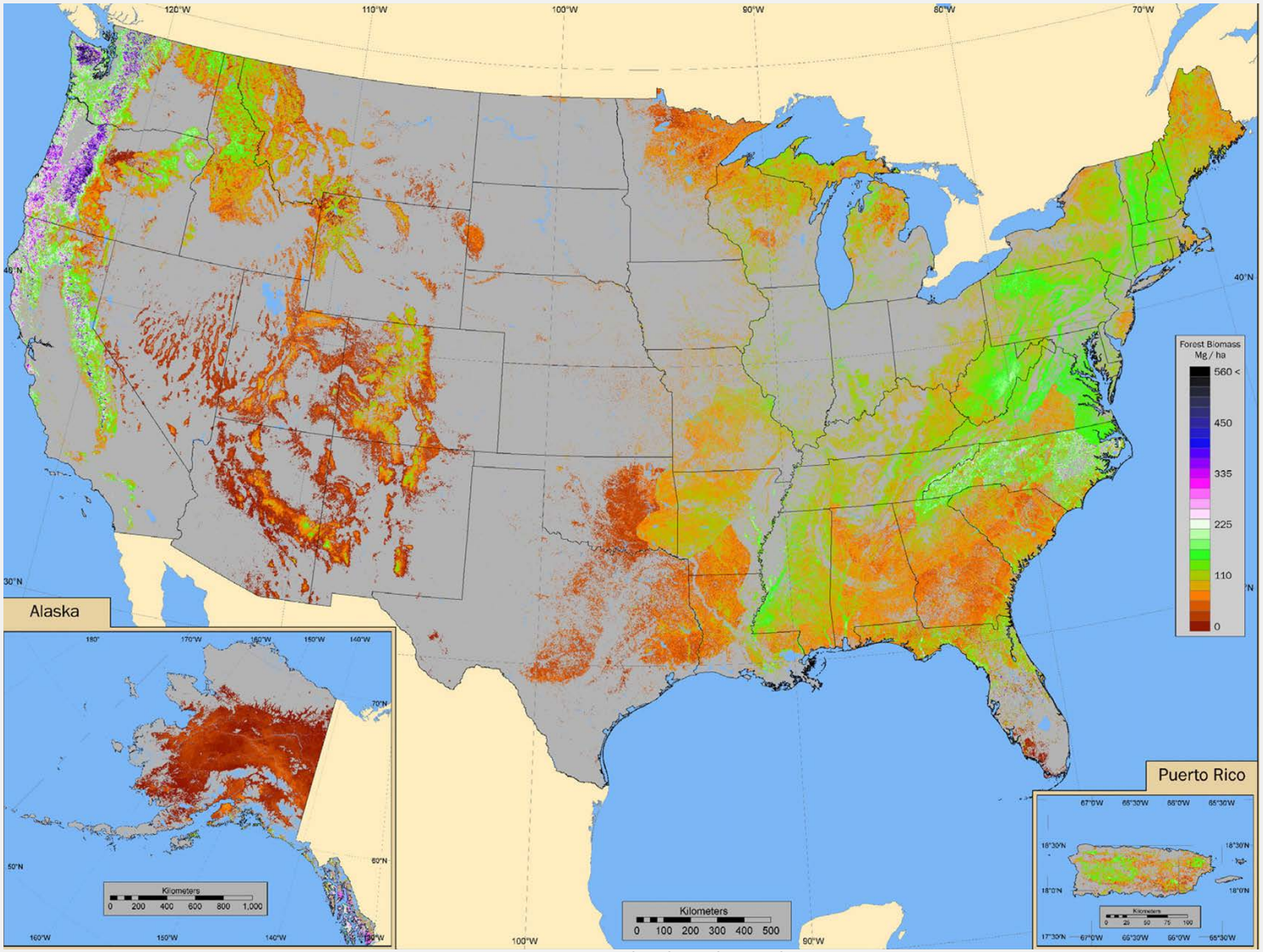


Image source: Blackard et al, 2008

Lidar supports estimates with finer spatial resolution

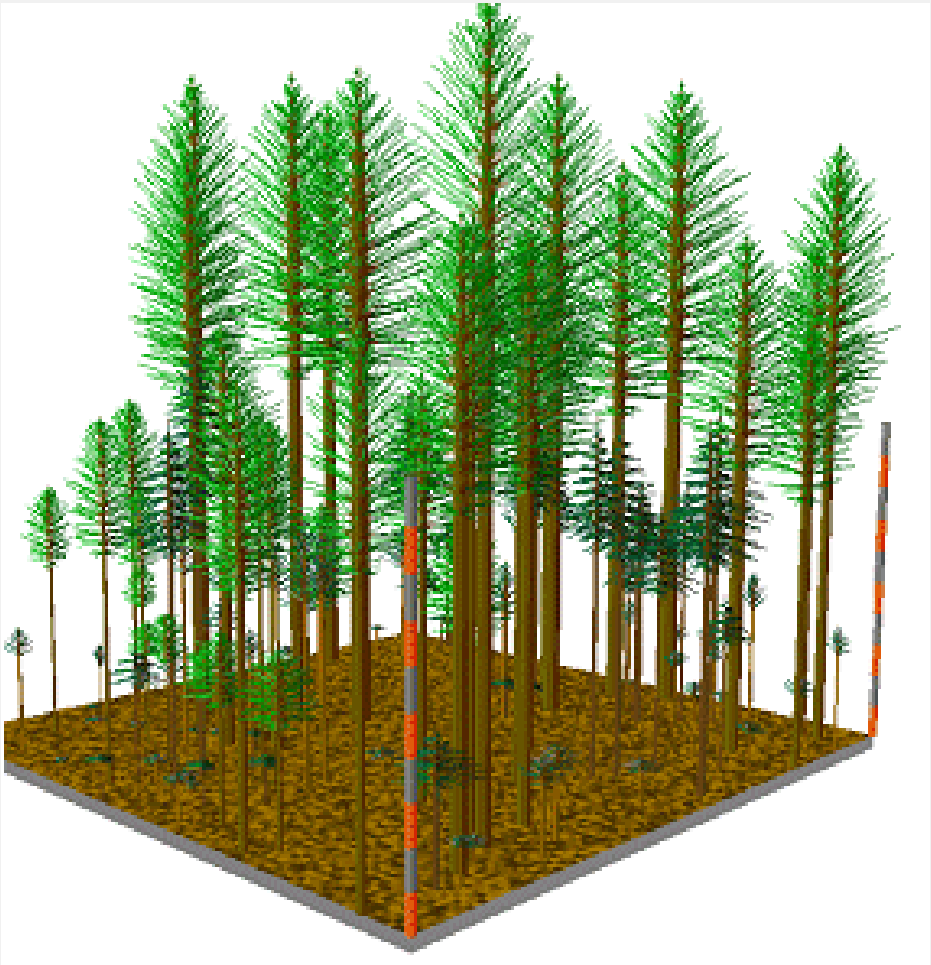


Image source: http://www.irmforestry.com

Methods include:

Plot level

- Groups/stands of trees
- Crown-distributed approach

Tree level

- Individual trees
- Stem-localized approach

This study aims to:

Test a lidar-based method for above ground biomass (AGB) estimation

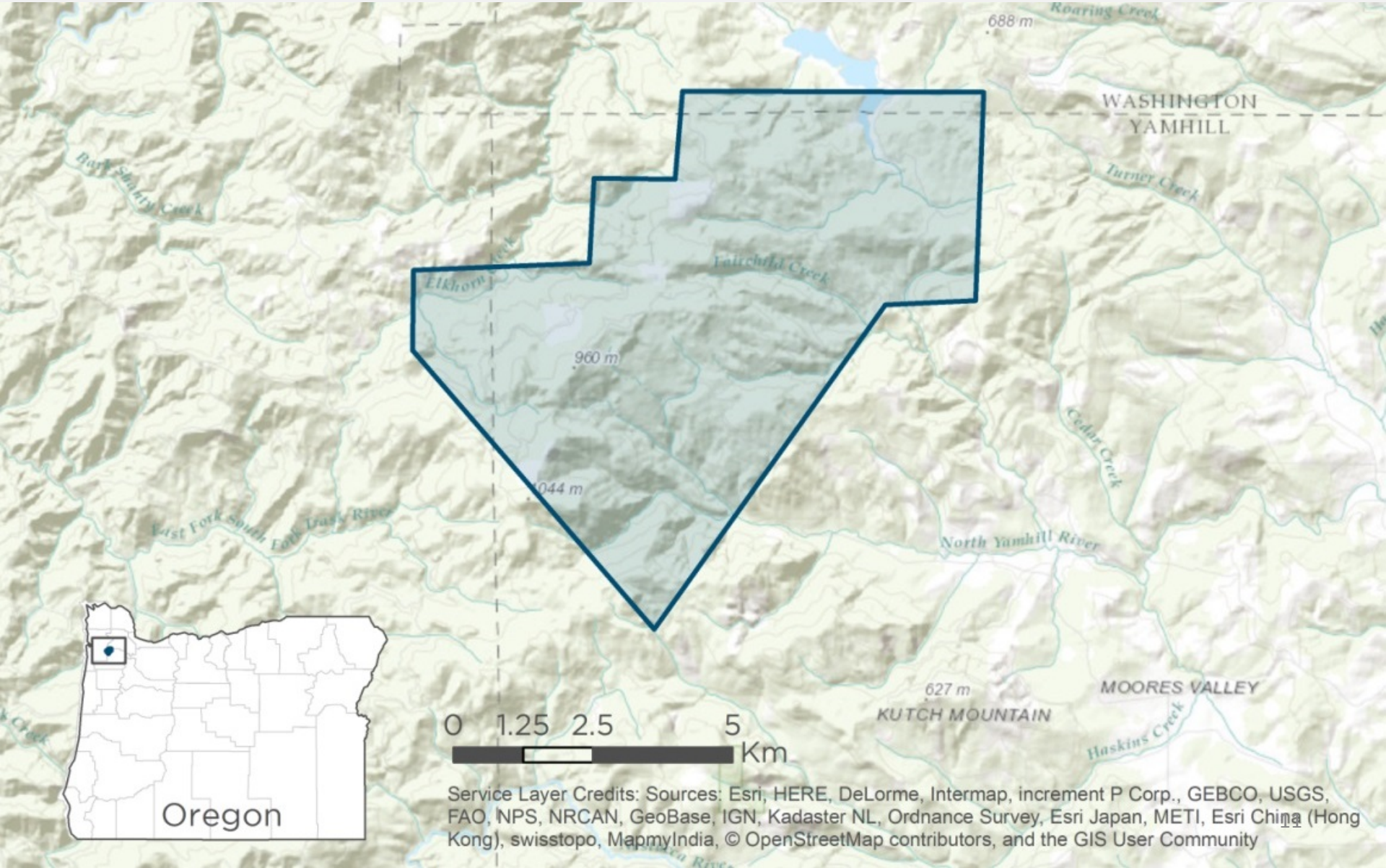
Compare results to past studies in the same area

Detect change over a 6 year period

2006 - 2012

Study area: 53 km^2 in NW Oregon

EPA Level II Ecoregion: Coast Range



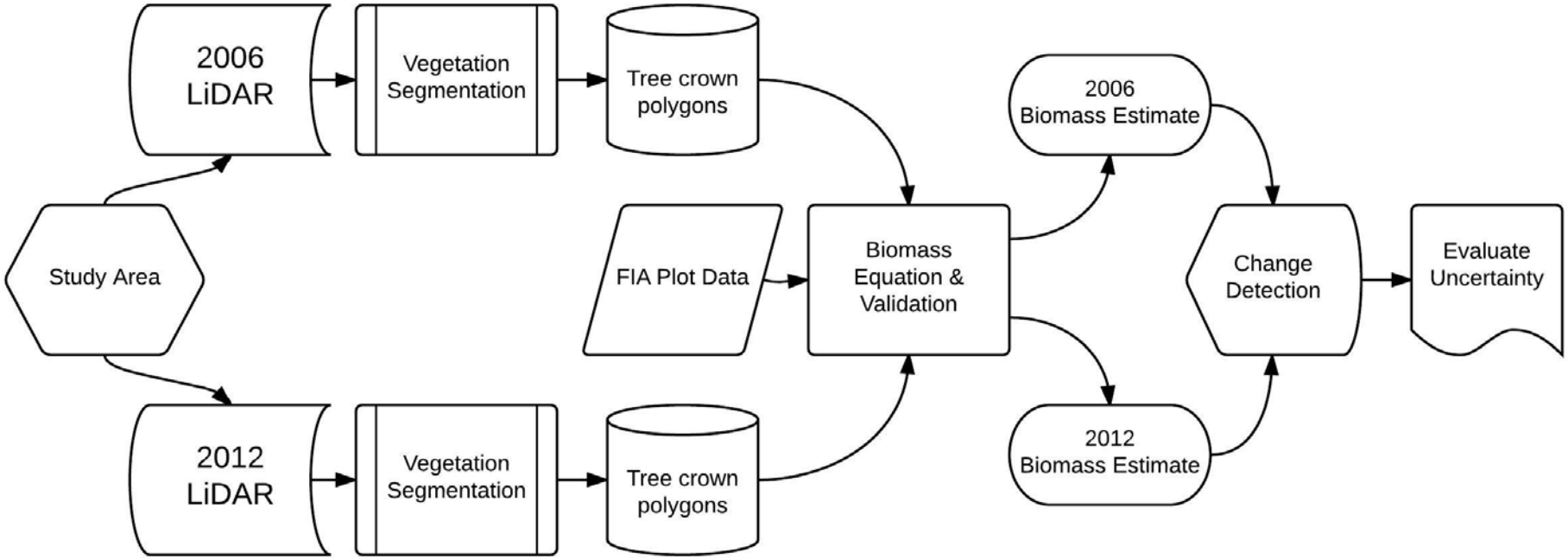
Actively managed forest provides opportunity for change detection

Image source: WSI, 2012

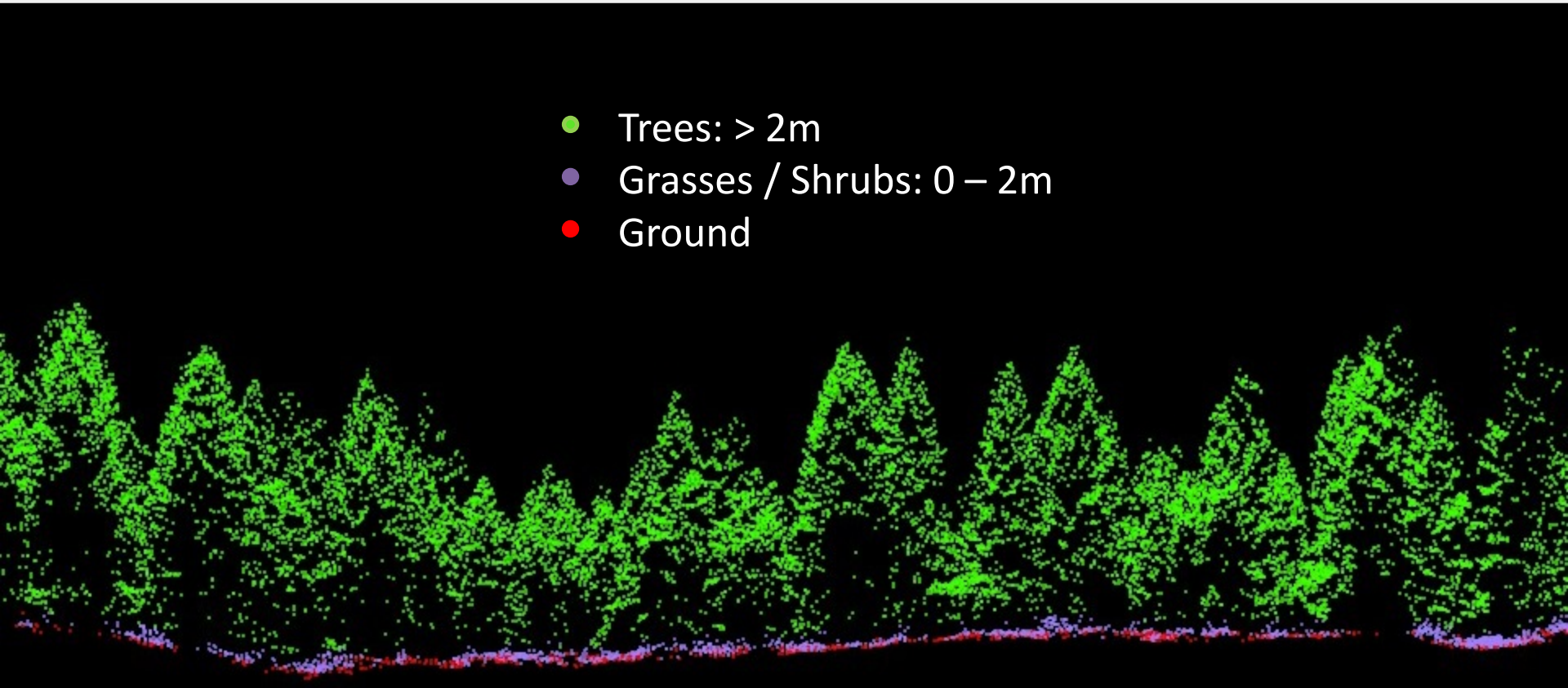
Two lidar data sets were collected 6 years apart

	2006 Lidar	2012 Lidar
Acquisition:	Feb. 6, 2006 – Feb. 7, 2006	Sept. 23, 2012 – Oct. 4, 2012
Sensor:	Optech ALTM 3100	Leica ALS60
Platform:	Cessna Caravan 208	Cessna Caravan 208
Projection:	UTM10, Meters	UTM10, Meters
Density:	8 pulses/m^2	8 pulses/m^2
Accuracy:	0.03 m RMSEz	0.04 m RMSEz
Format:	LAS 1.2	LAS 1.2
Provider:	Watershed Sciences, Inc.	Watershed Sciences, Inc.

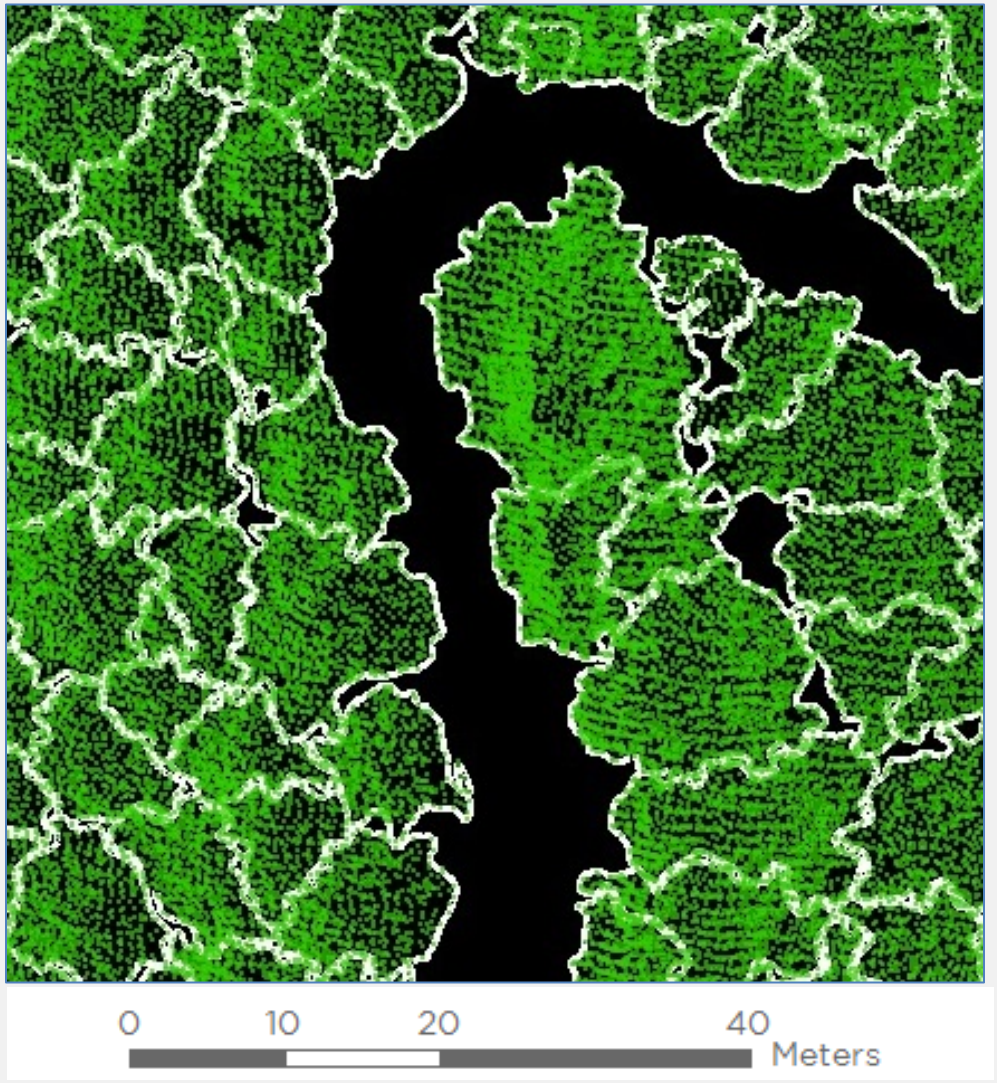
The same biomass estimation technique will be run on both data sets



First, vegetation is classified in the lidar point cloud



Vegetation points are run through segmentation algorithms



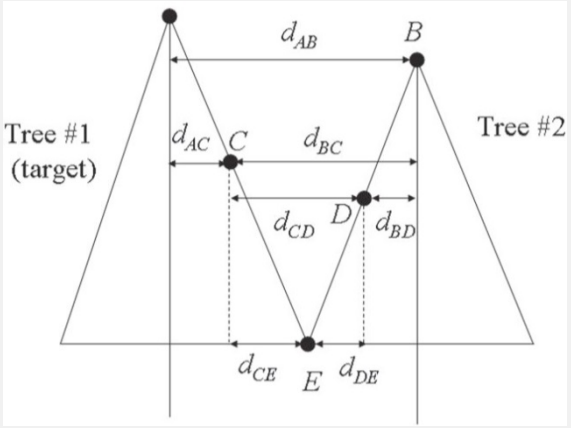
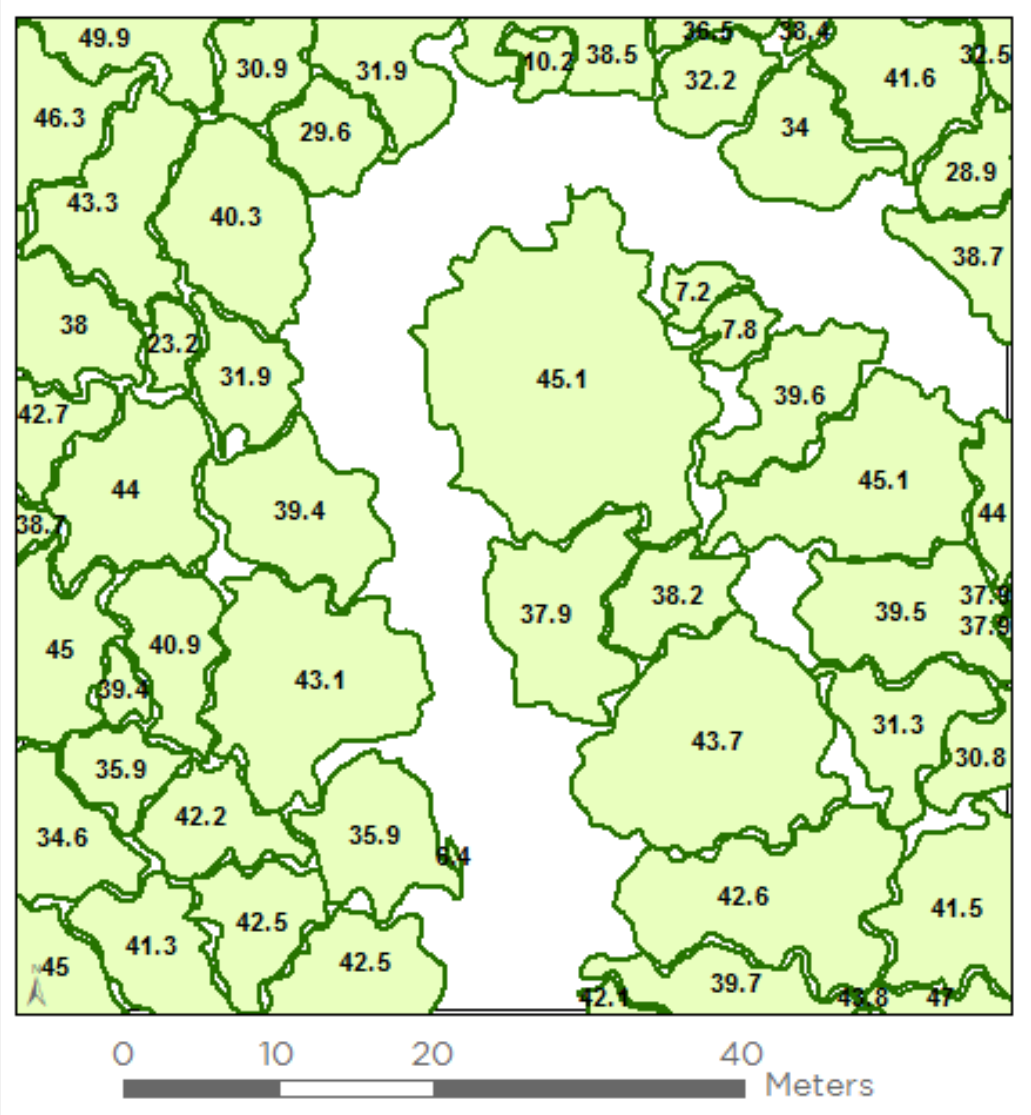


Image source: Li et al, 2012

Automated tree segmentation tools written by senior scientists at Quantum Spatial, Inc.

Height and crown area attributes are assigned to each tree



Tree top height (m)

A allometric equation for biomass was developed from regional FIA data

AGB (kg) = $(-55.53 * H) + (2.386 * H^2) + (5.062 * SqM) + (0.4238 * SqM^2)$

Variables:
H = Tree Height (feet)
SqM = Crown Area (square meters)

Conversion to Carbon:
AGB = Above Ground Biomass
Carbon Mass (kg C) = 0.5 * AGB

Source of equation:
Andrew Gray – USFS
(Personal Communication)

Source of data:
FIA plots within EPA level III ecoregion

Ground truth data indicated a linear relationship

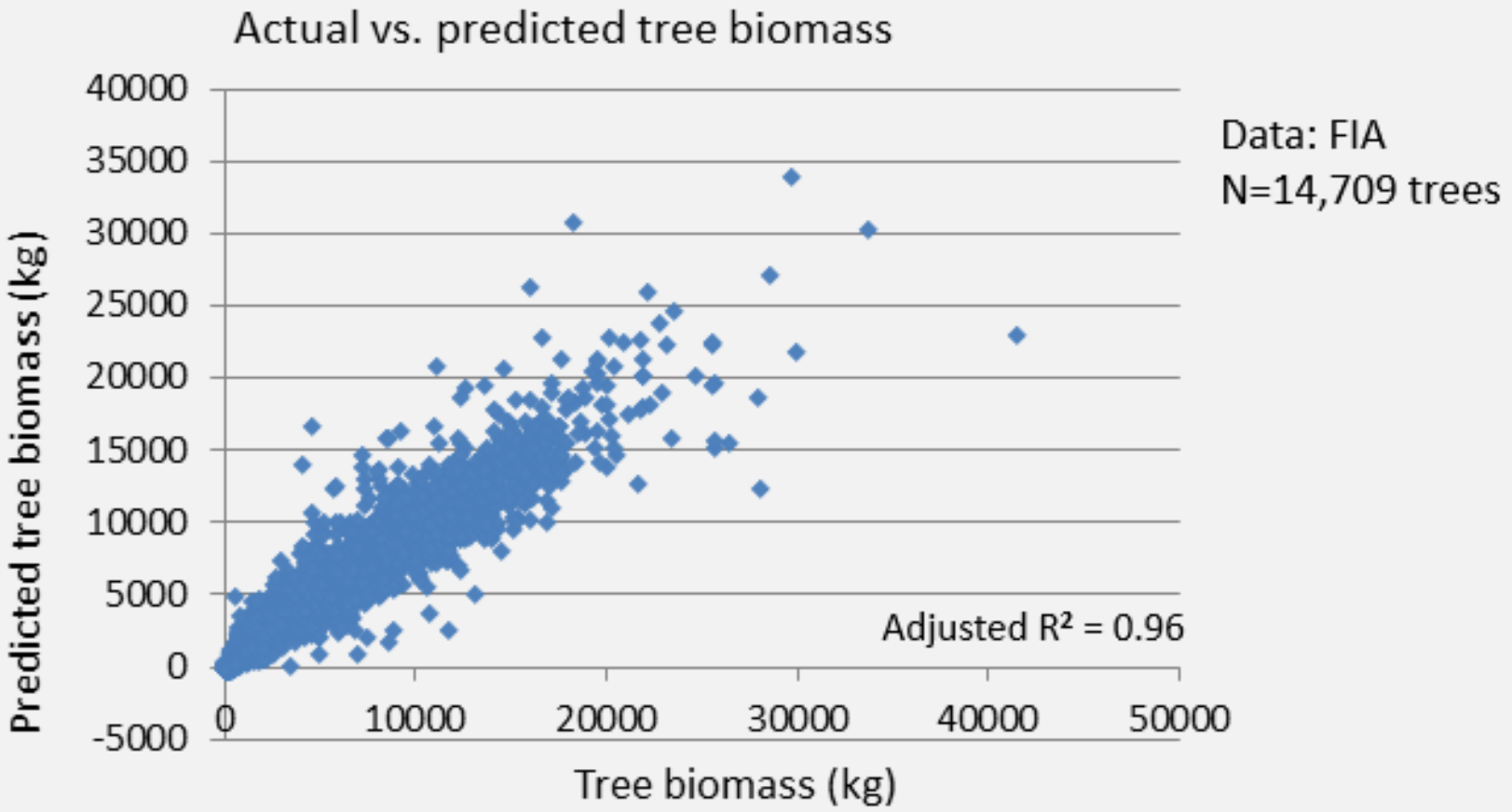
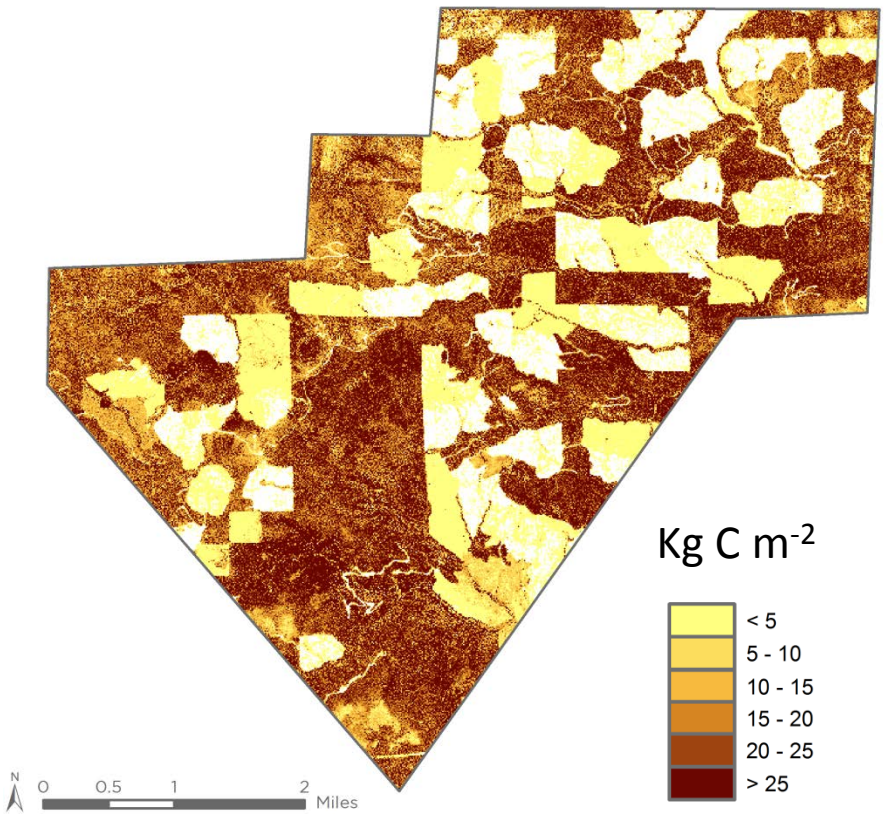
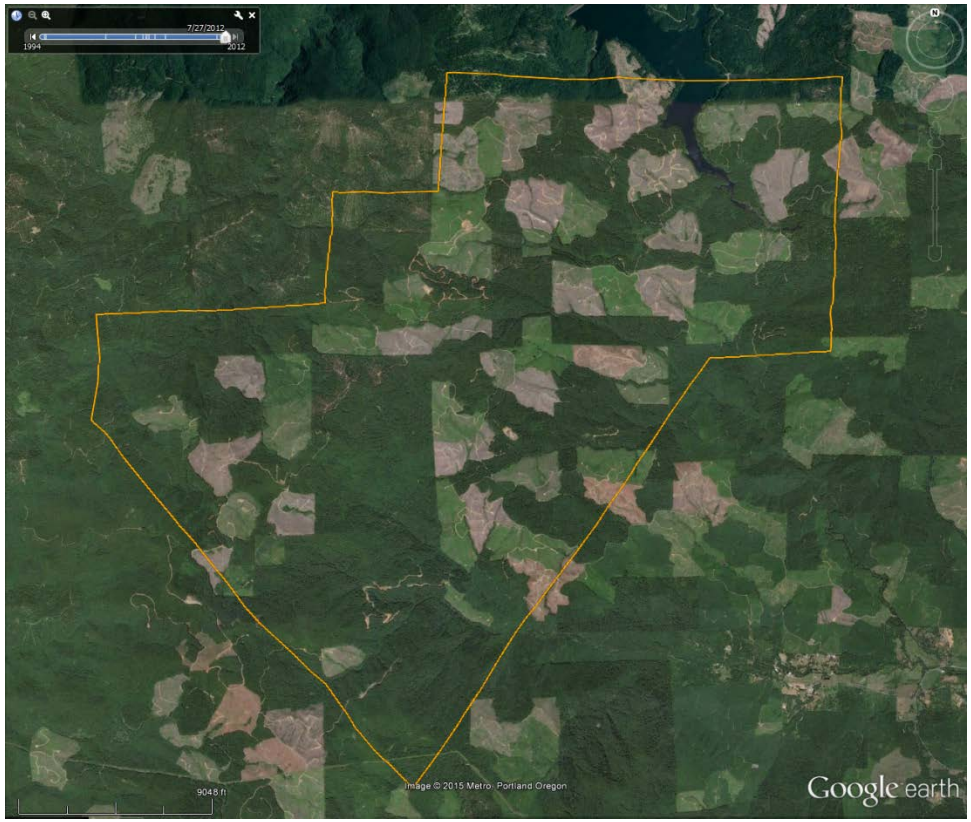


Chart: Gray, 2015

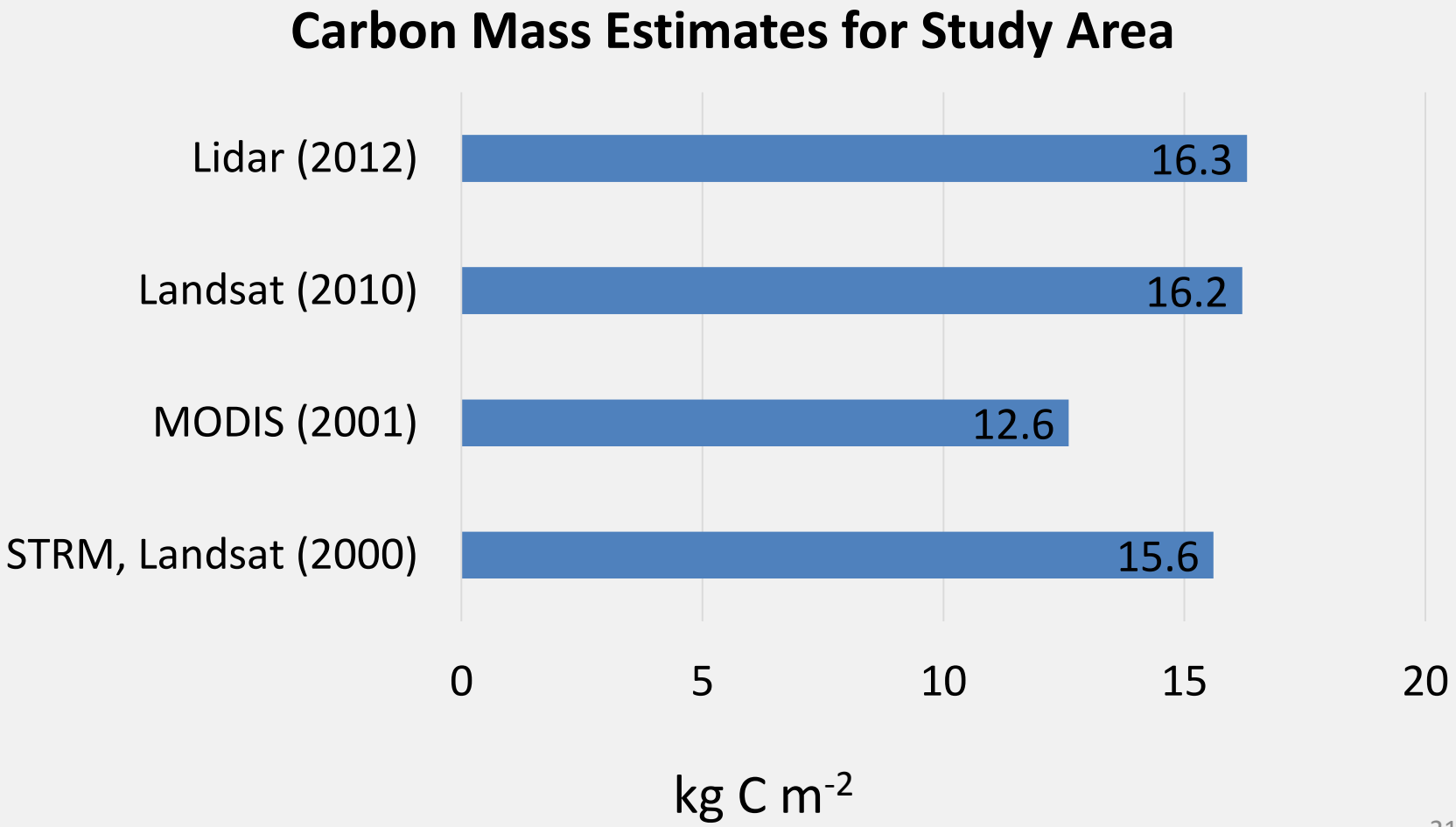
Preliminary Results (2012):
Mean Carbon Mass = 16.3 kg C m^{-2}





Aerial image: July 2012

Preliminary results align with past studies



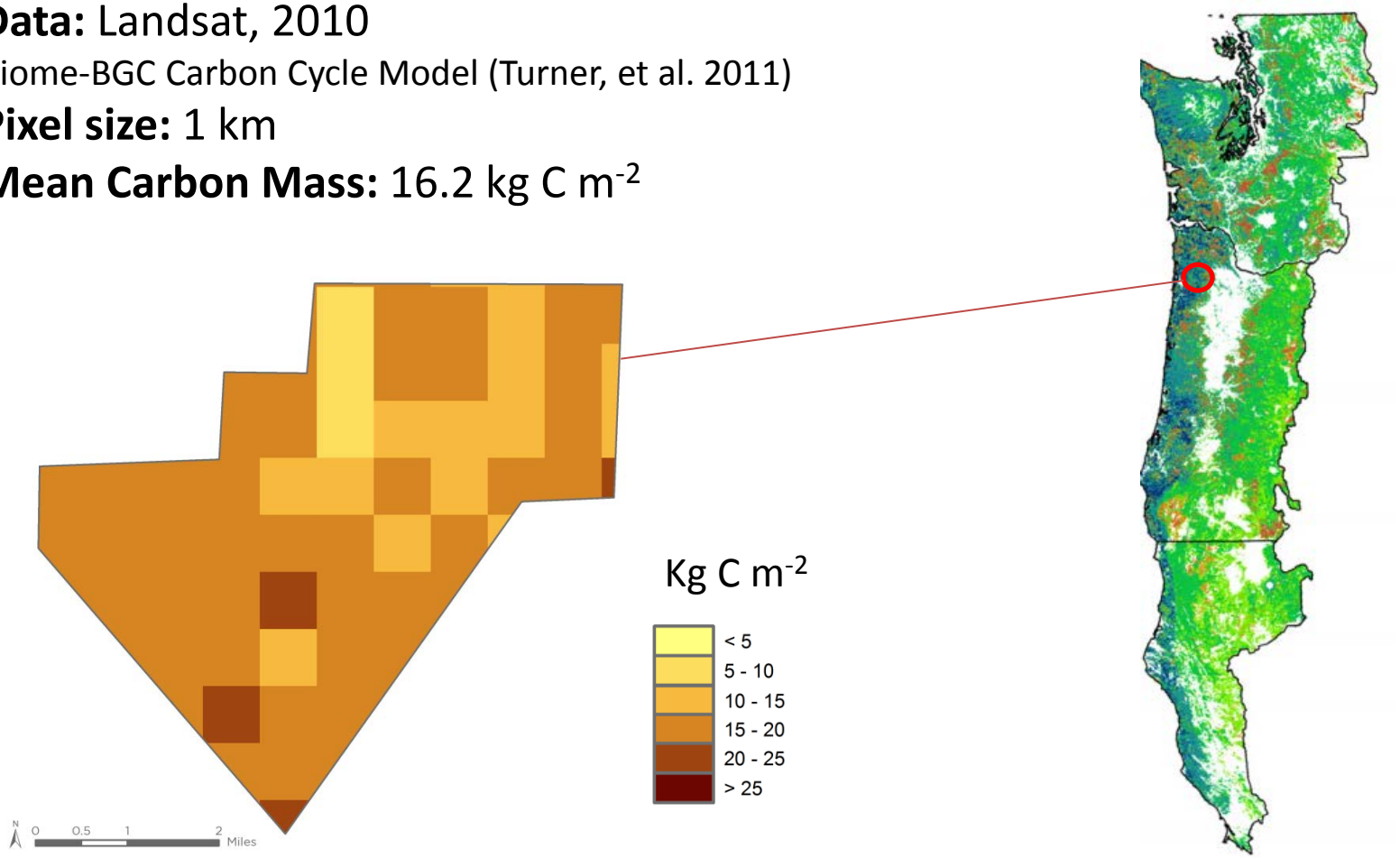
Carbon estimates from previous studies were clipped to the area

Data: Landsat, 2010

Biome-BGC Carbon Cycle Model (Turner, et al. 2011)

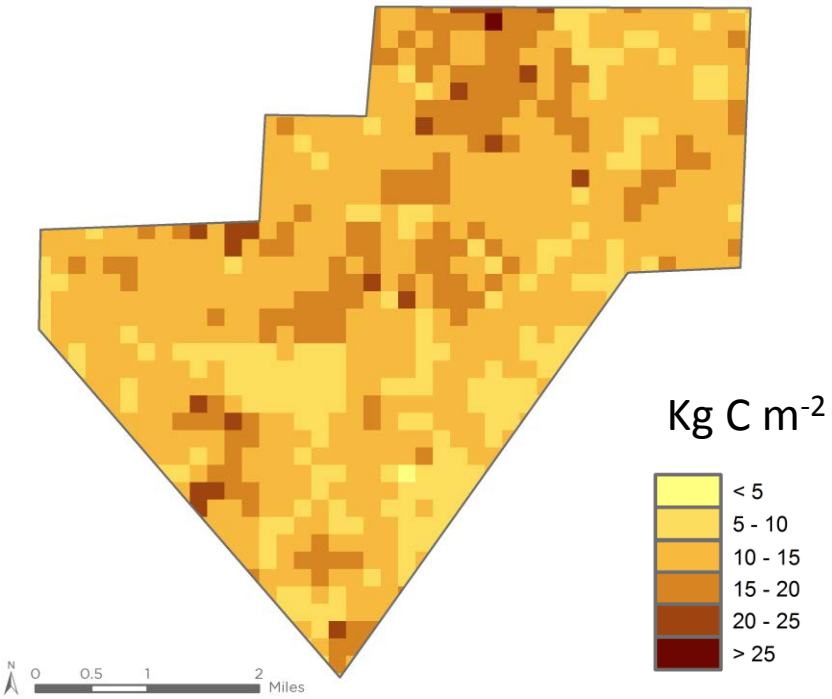
Pixel size: 1 km

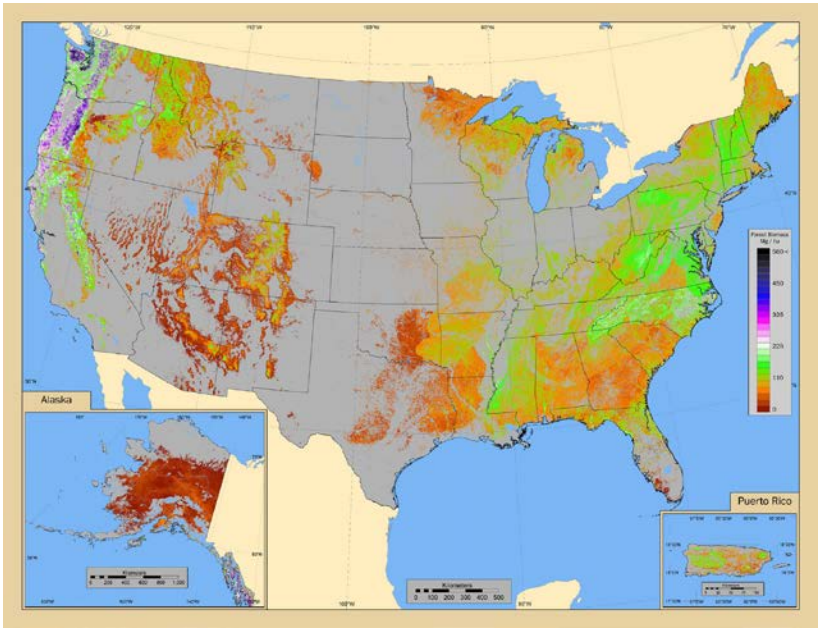
Mean Carbon Mass: 16.2 kg C m^{-2}



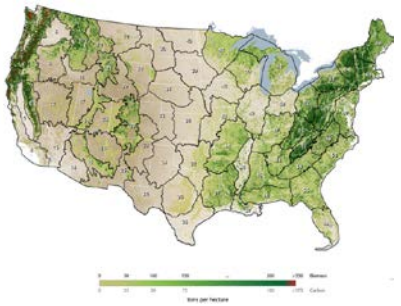
Tree-level data can be used to evaluate coarser resolution analyses

Data: MODIS, 2001
(Blackard et. al, 2008)
Pixel size: 250 m
Mean Carbon Mass: 12.6 kg C m^{-2}





Visual analysis shows significantly more tree cover in 2000

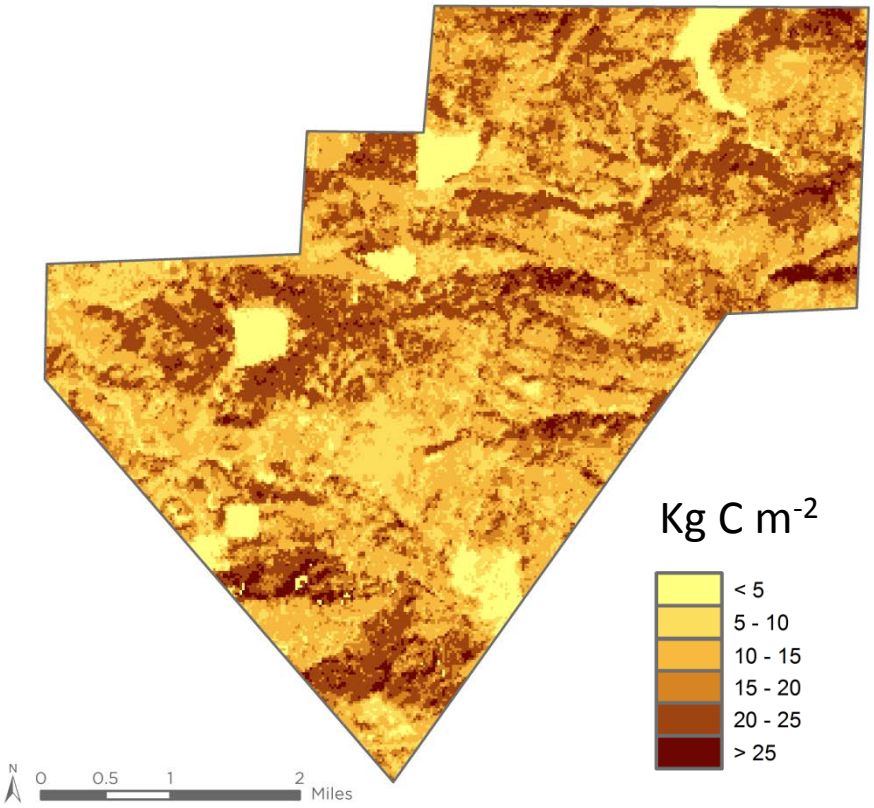


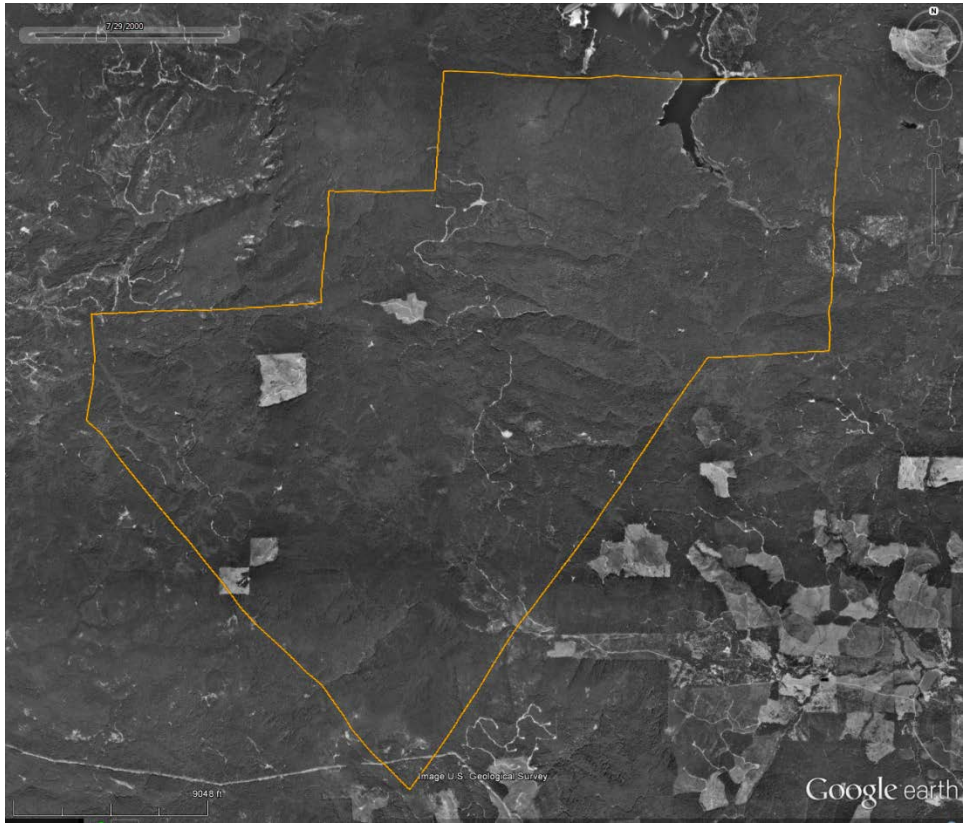
Data: Landsat, 2000

NACP Aboveground Biomass and Carbon Baseline Data (NBCD, 2000)

Pixel size: 30 m

Mean Carbon Mass: 15.6 kg C m^{-2}

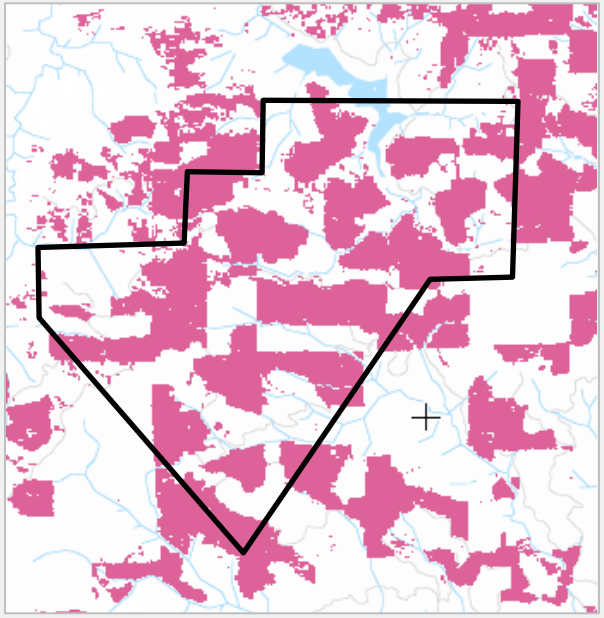




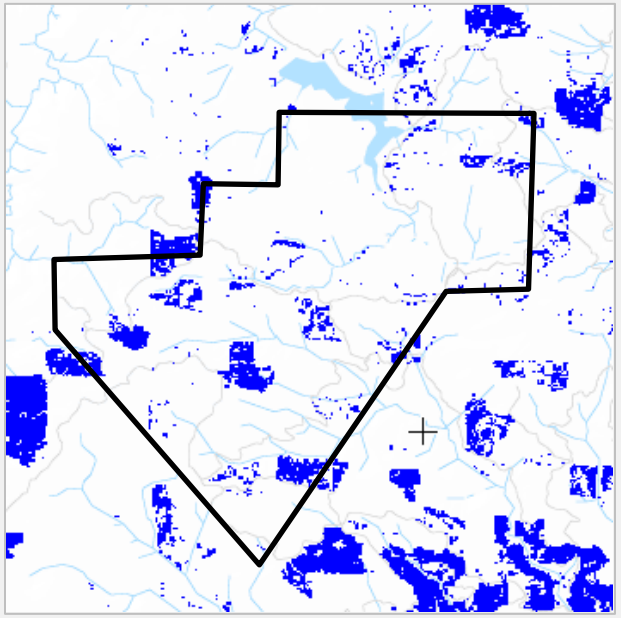
Aerial image from 7/29/2000

Planned evaluation using Global Forest Watch

Tree Cover **Loss**
2001 - 2014

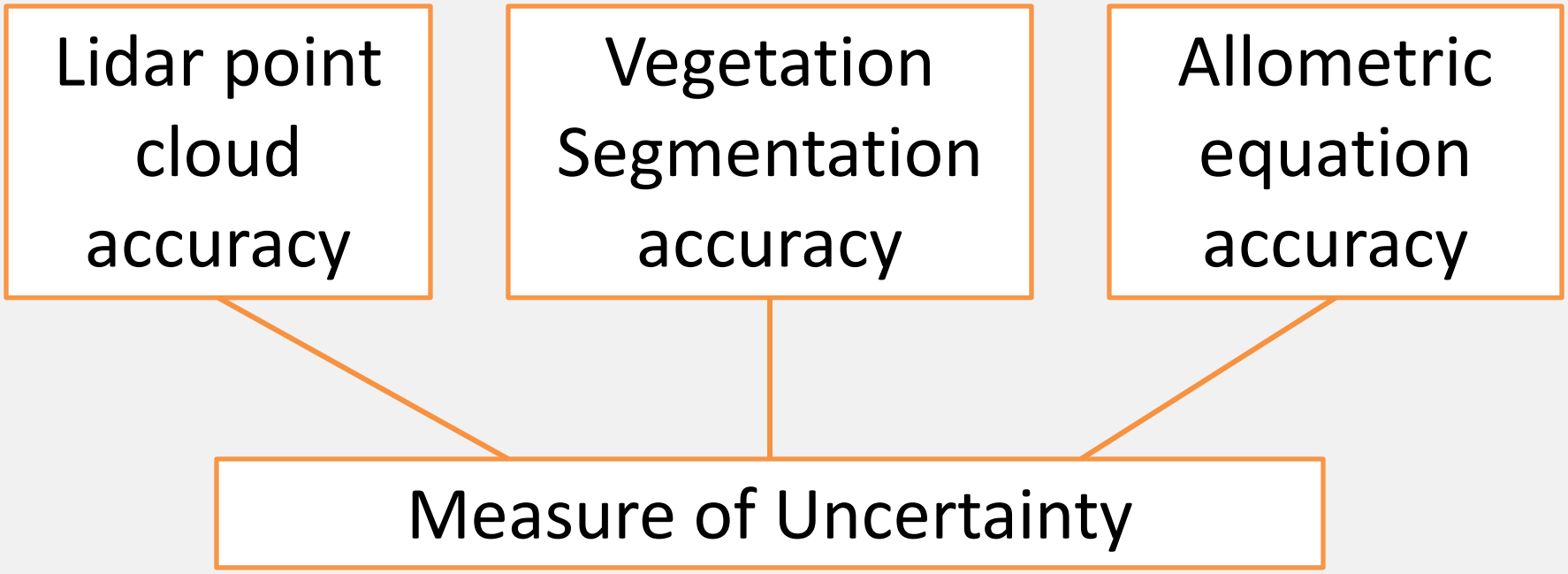


Tree Cover **Gain**
2001 - 2014



Source: Global Forest Watch. Retrieved 5 December, 2015 from http://www.globalforestwatch.org

3 Potential Sources of Error



Take away points

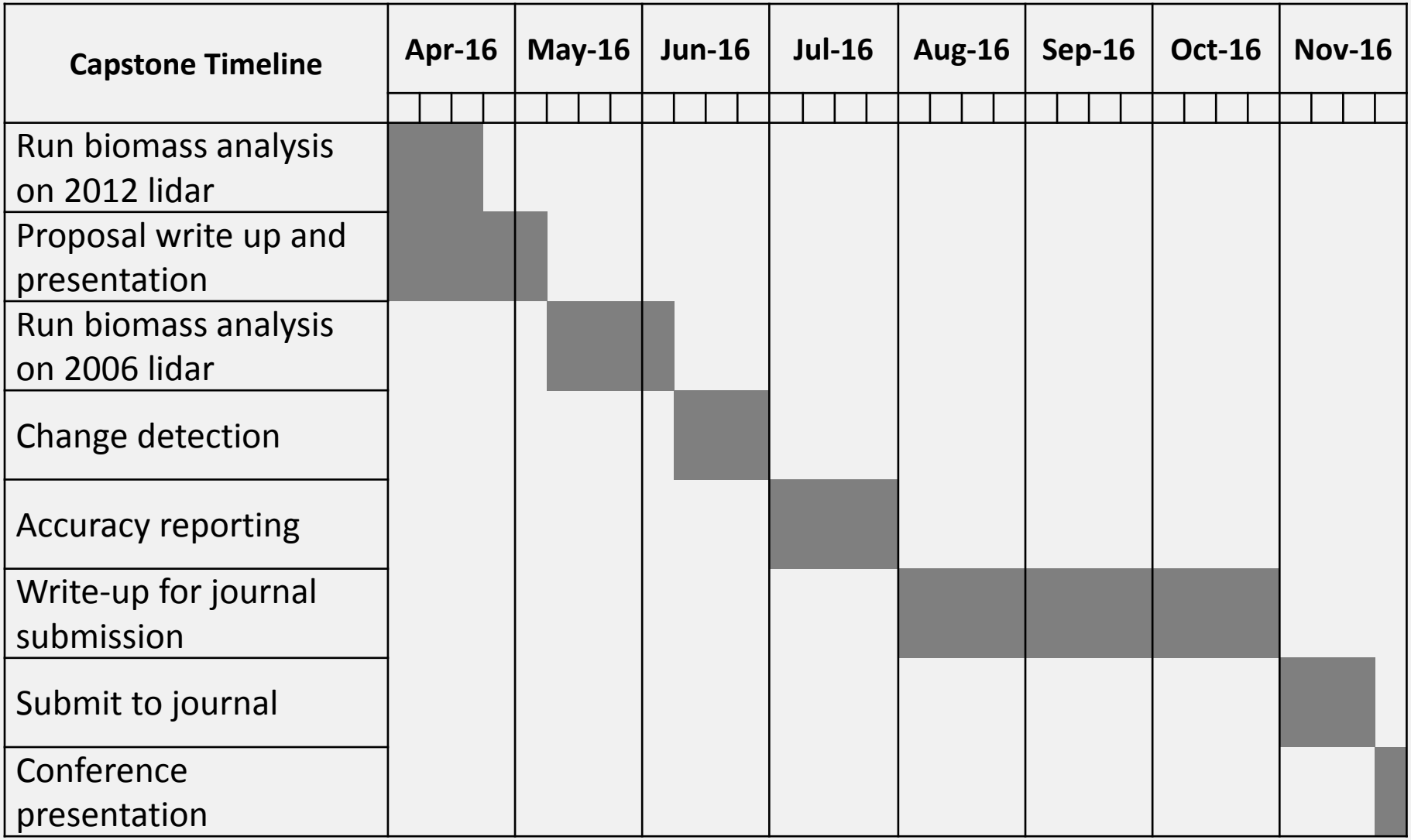
High resolution lidar is a good choice for tree level biomass calculation

Change detection with 2006 data will provide further insight

Potential end users of this product include:

Environmental organizations
Forestry companies
Urban forestry programs (e.g. Tree City USA)
Government and international programs

Capstone Project Timeline



Acknowledgements

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Mischa Hey – Quantum Spatial

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Questions

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