Landsat Happenings in the US Forest Service: *Just how important is Landsat to the USFS?*

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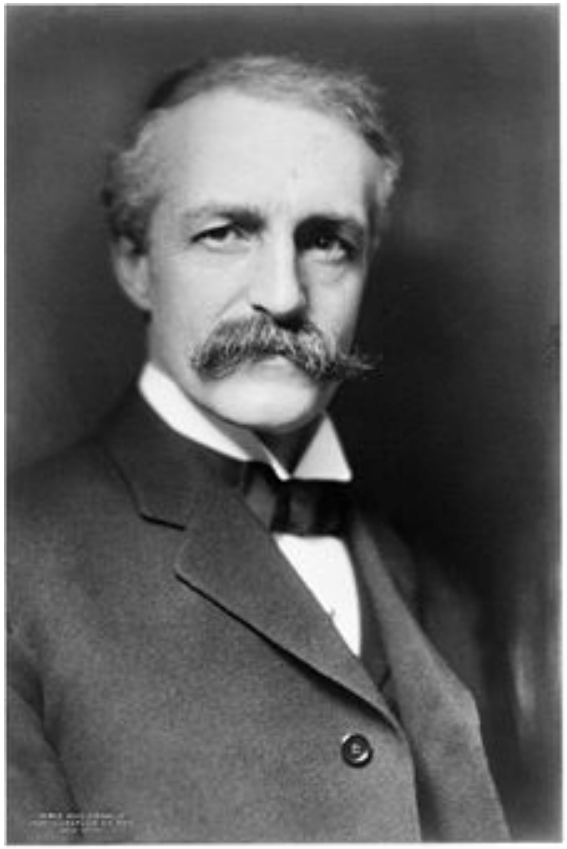
Landsat Science Team Meeting, Boise ID – 15-17 June 2010

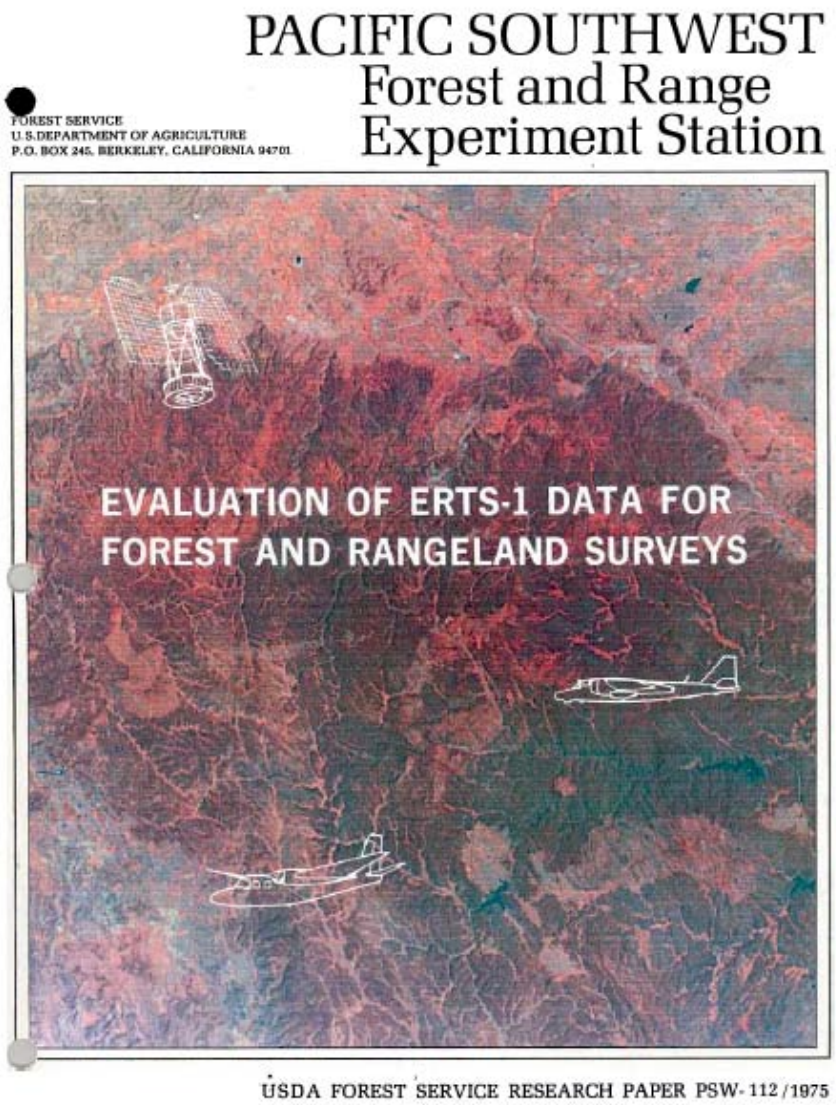
Contributions from:

Ken Brewer, John Coulston, Sean Healey, Eileen Helmer, Andy Hudak, Robert Kennedy, Paul Maus, Ron McRoberts, Gretchen Moisen, Mark Nelson, Janet Ohmann, Todd Schroeder, Brian Schwind, Nancy Thomas, and others



Gifford Pinchot, 1st Chief

Landsat & USFS: Historical Perspective



Gifford & Teddy

Landsat & USFS: Historical Perspective

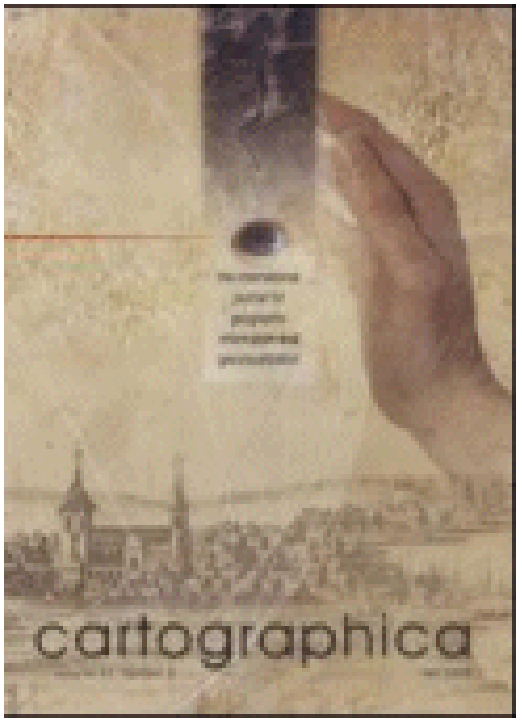
The CALVEG ("Classification and Assessment with Landsat of Visible Ecological Groupings") system was initiated in January 1978 by the Region 5 (California) Ecology Group of the U.S. Forest Service.

Detailed mapping involving a long and productive relationship with Strahler and Woodcock; many classic pubs of applications of advanced research (G-O model, segmentation, neural net)

Landsat & USFS: Historical Perspective

How Institutional Cultures Affect Results: Comparing Two Old-Growth Forest Mapping Projects - ROBERT A. NORHEIM

This paper explores the institutional and geographic factors that affected the outcome of two old-growth forest mapping efforts undertaken in 1989–1990 in the Pacific Northwest region of the United States: USFS and Wilderness Society



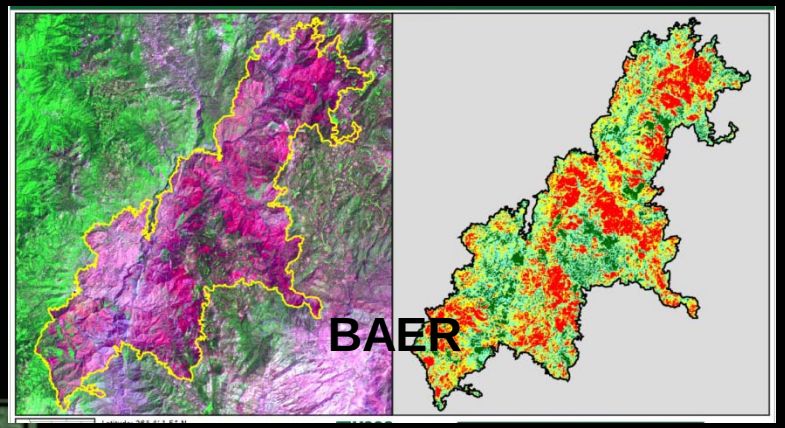
This controversy led to my job: thank you Landsat!

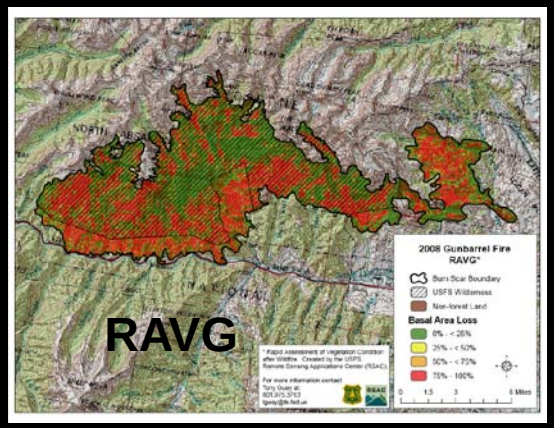
More Recent & Current Landsat Happenings in the US Forest Service (examples)

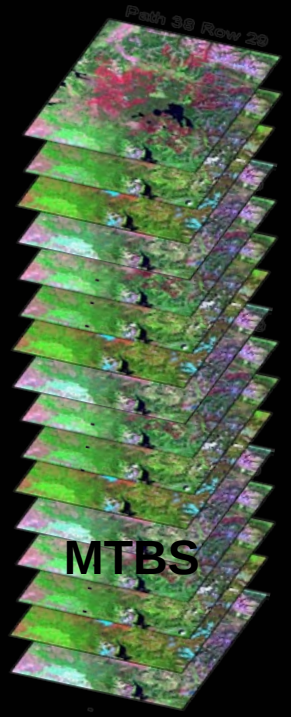
- Fire mapping & modeling
- Insect & disease
- Wildlife habitat
- Statistical estimation of forest conditions & change
- NLCD tree cover
- Regional assessments
- Partnership with NASA Applied Sciences Program

Post-Fire Mapping Applications

- Burned Area Emergency Rehabilitation (BAER)
- Rapid Assessment of Vegetation Condition After Wildfire (RAVG)
- Monitoring Trends in Burn Severity (MTBS)



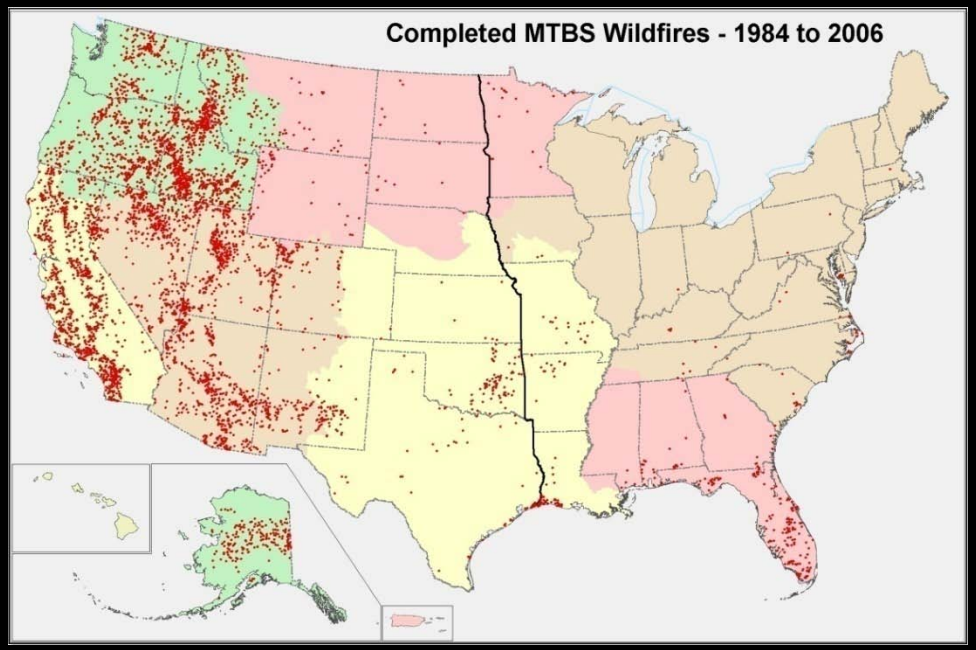


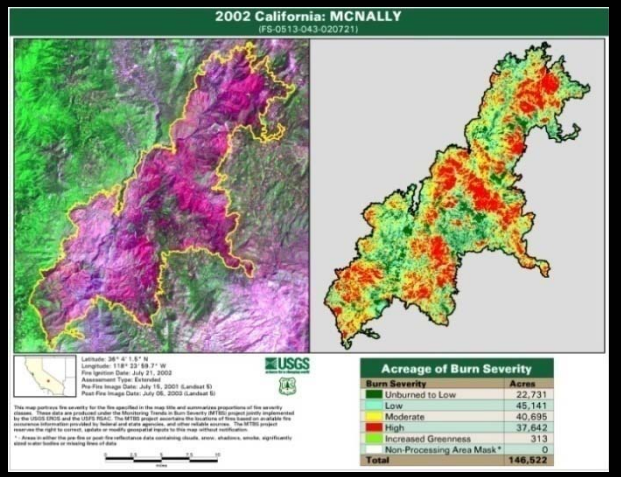


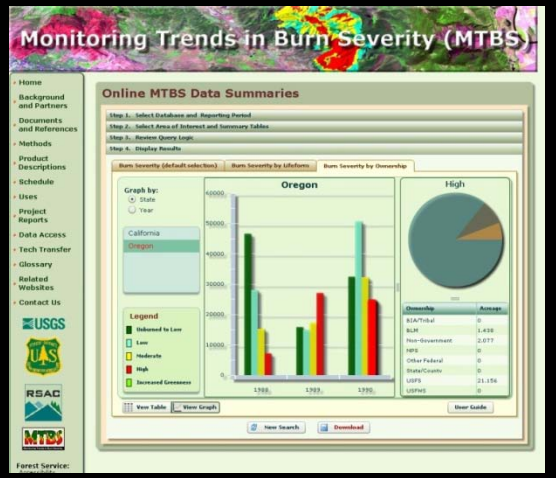
Monitoring Trends in Burn Severity (MTBS)

http://www.mtbs.gov

- Consistently map burned areas and associated severity of large fires on all US lands (1984-2010)







- Sponsored by Wildland Fire Leadership Council
- Implemented jointly by USFS RSAC and USGS EROS
- Strategy to monitor the effectiveness of NFP and HFRA
- Distribute geospatial data via web-based portals
- Over 6400 Landsat images processed covering 10K fires

FireLab
USDA Forest Service

USGS
science for a changing world

The Nature Conservancy
Protecting nature. Preserving life.

LANDFIRE, also known as the Landscape Fire and Resource Management Planning Tools Project, is a multi-partner project producing consistent and comprehensive maps and data describing vegetation, wildland fuel, and fire regimes across the United States.

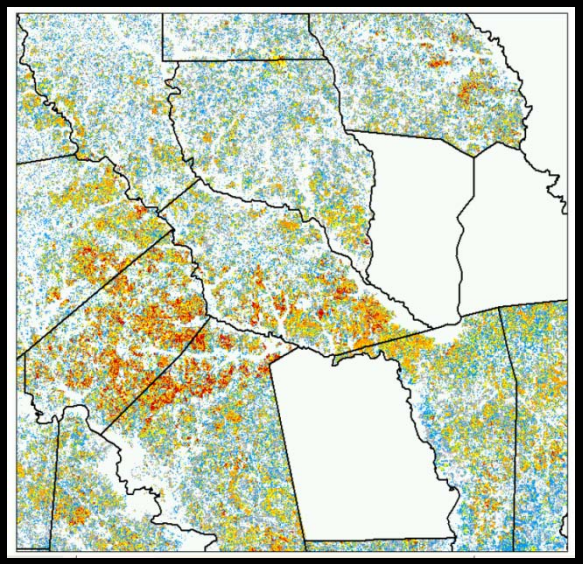
FAQ. What is the connection between LANDFIRE and Landsat satellite imagery? The Landsat program provides imagery that is critical for LANDFIRE's vegetation and fuel mapping effort.

Insect and Disease Risk Mapping

http://www.fs.fed.us/foresthealth/technology/

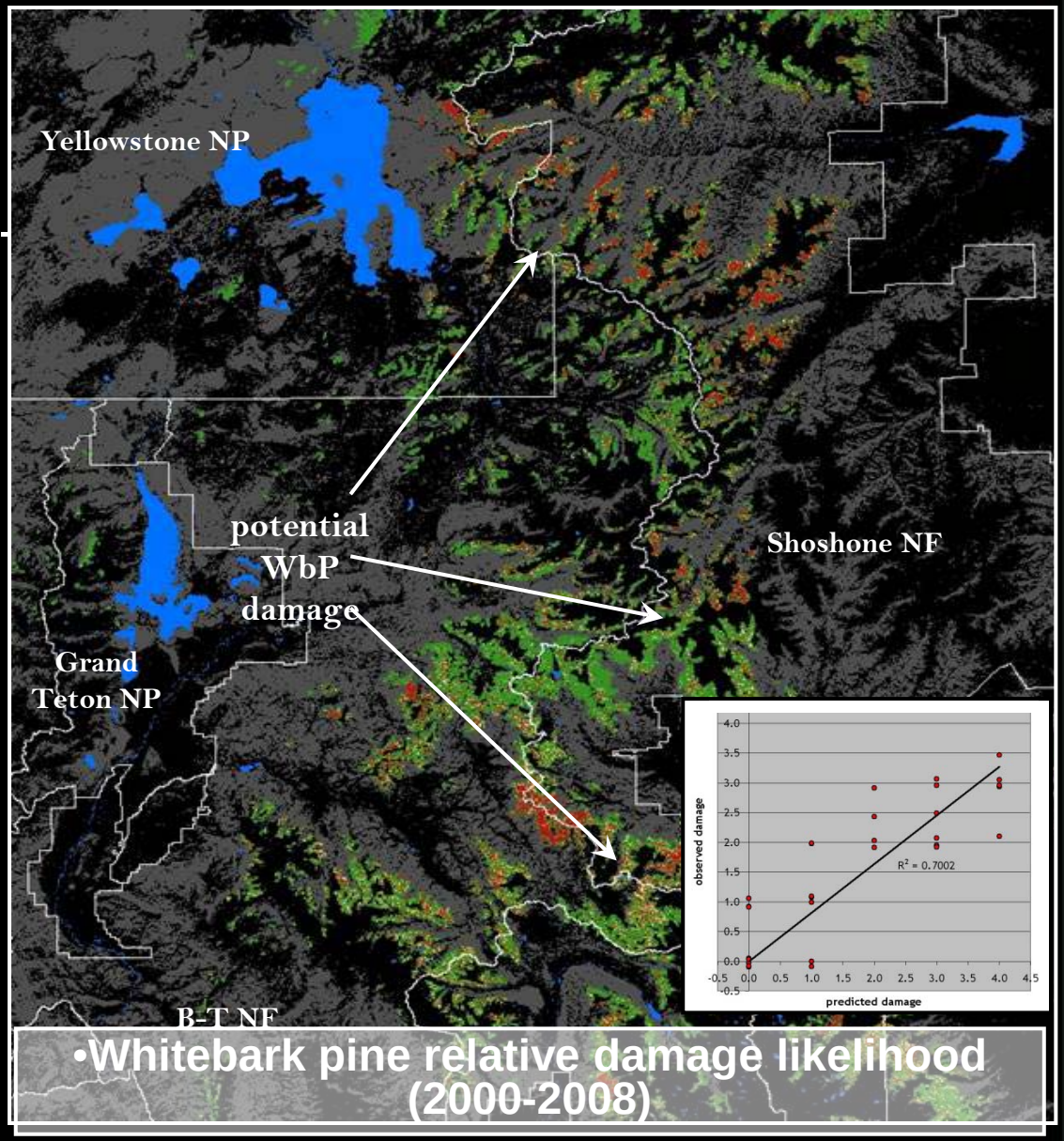
- Nationwide Insect & Disease Risk Map (RIDRM)
- Develop 30-meter risk layer for predicting forest insect and disease risk
- Uses Landsat with additional predictors variables & FIA plots to model risk

Southern Pine Beetle
30-meter Risk Model



Whitebark Pine Decline Assessment

- Assessed changes in whitebark pine across the GYA between 2000-2008
- WBP is key habitat for T&E species including grizzly bear
- Develop regression between field plots and changes in NDVI
- Used 5 path/rows covering the Greater Yellowstone Area



•Whitebark pine relative damage likelihood (2000-2008)

Studies of wintering habitat for the endangered Kirtland's Warbler

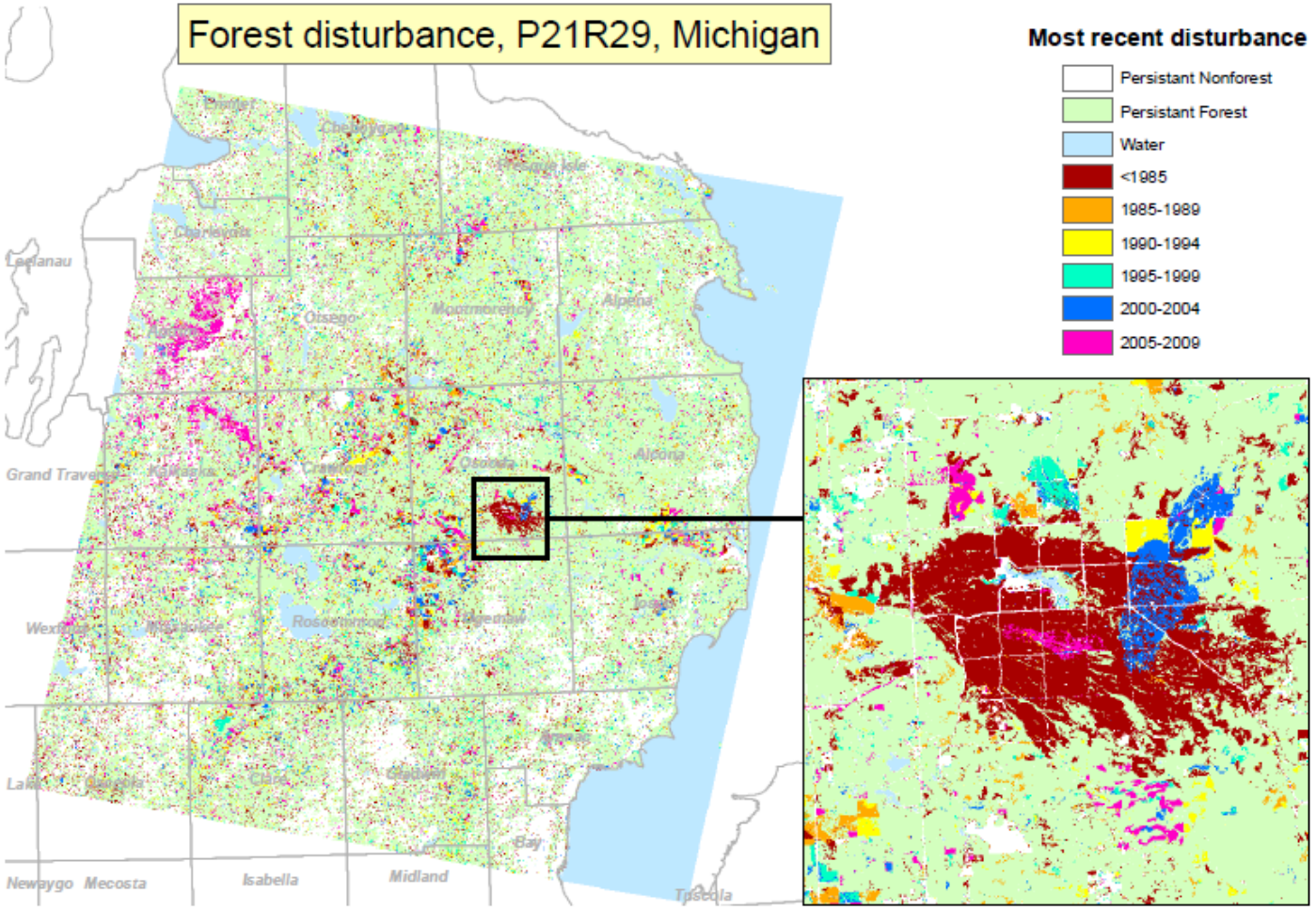
Kirtland's Warblers in anthropogenically disturbed early successional habitats on Eleuthera, The Bahamas. Wunderle, J. M. Jr., D. Currie, E.H. Helmer, D.N. Ewert, J.D. White, T.S. Ruzycki, B. Parresol, and C. Kwit. *Condor* 112(1):123-137.

Mapping tropical dry forest height, foliage height profiles and disturbance type and age with a time series of cloud-cleared Landsat and ALI image mosaics to characterize avian habitat. Helmer, E.H, T.S. Ruzycki, J.M. Wunderle, Jr., S. Vogesser, B. Ruefenacht, C. Kwit, T.J. Brandeis and D.N. Ewert. 2010. *Remote Sensing of Environment.* In press.

Effects of common disturbances on early-successional plant communities on Eleuthera Island, The Bahamas. Larkin, C.C., C. Kwit, J.M. Wunderle, Jr., E.H. Helmer, M.H.H. Stevens, M.T.K. Roberts, and D.N. Ewert. In review.

Helmer

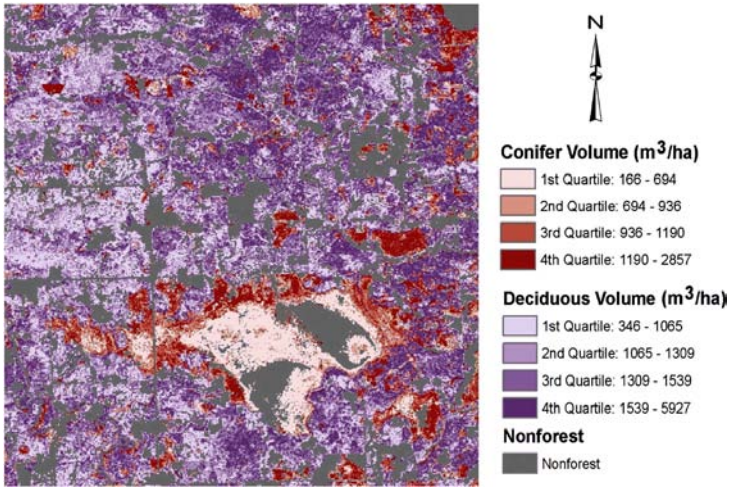
North American Forest Dynamics:
Supporting Kirtland's Warbler Conservation on the breeding grounds, northern Lower Michigan



(Nelson and Stueve In Prep.)

Estimation (FIA) : how much of multiple forest variables - stratification with Landsat plus field plot measurements

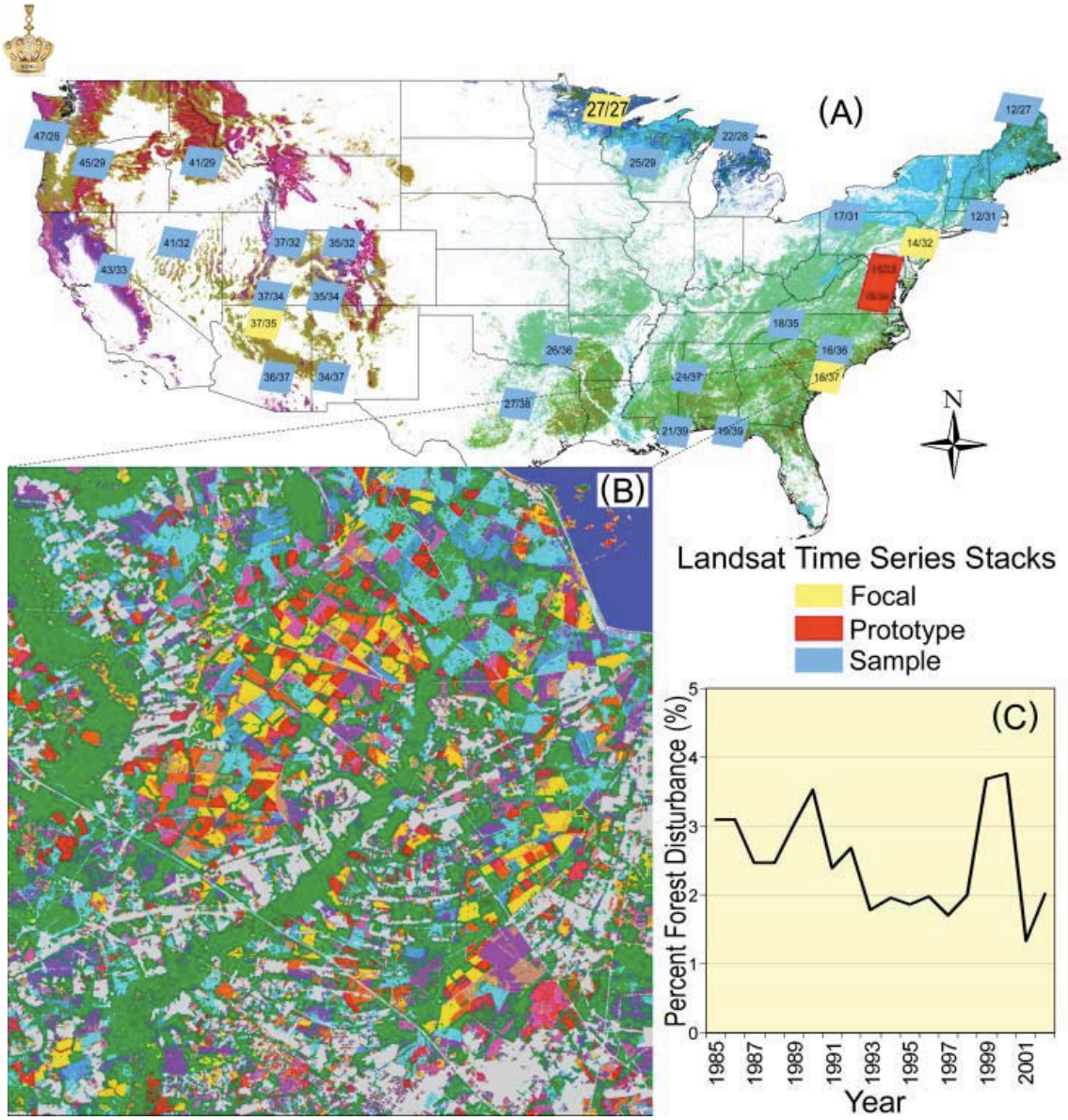
Real-world operational and financial advantages of Landsat-based stratifications



(McRoberts)

- Relative efficiency (RE): the factor by which field sample sizes would have to be increased to obtain the same variances without stratifications using remote sensing
- With Landsat REs ranged from about 1.5 to almost 6.0
- RE=2 for Minnesota – requires double sample size (addtl. 10,000 plots over a 5-year cycle at $750/plot would cost $7.5 million)
- Before Landsat-based approach, aerial photography: 6-8 full-time photo interpreters 2-3 years to construct comparable strata for Minnesota, whereas a GIS/RS technician can do it using Landsat in about 2-3 days.

North American Forest Dynamics (for NACP)

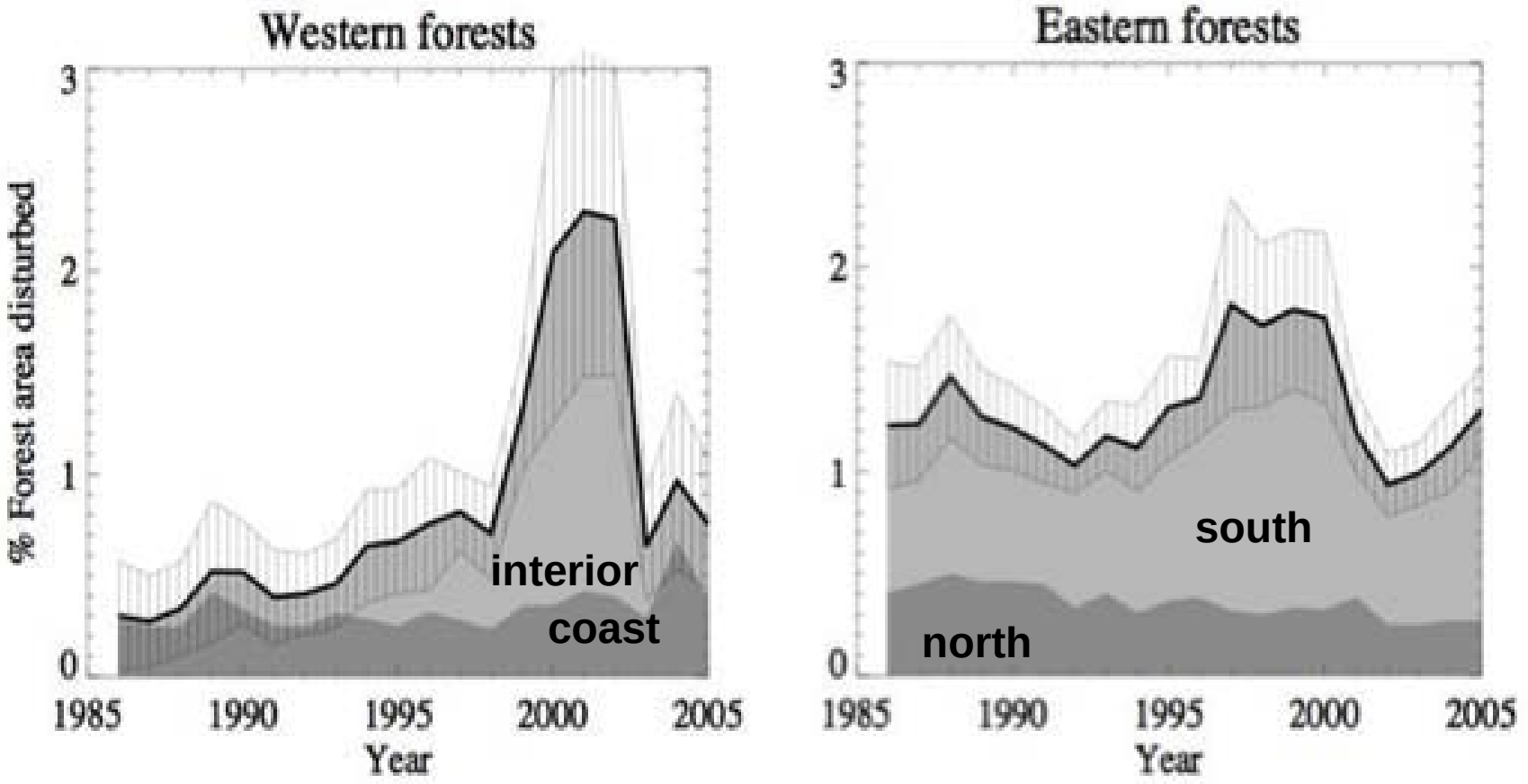


Estimation of forest disturbance rates (VCT)

NASA-funded to UMD, GSFC, USFS

(Goward, Masek, Moisen, Cohen, Huang, Wulder, Kennedy, Powell, Healey, and several others)

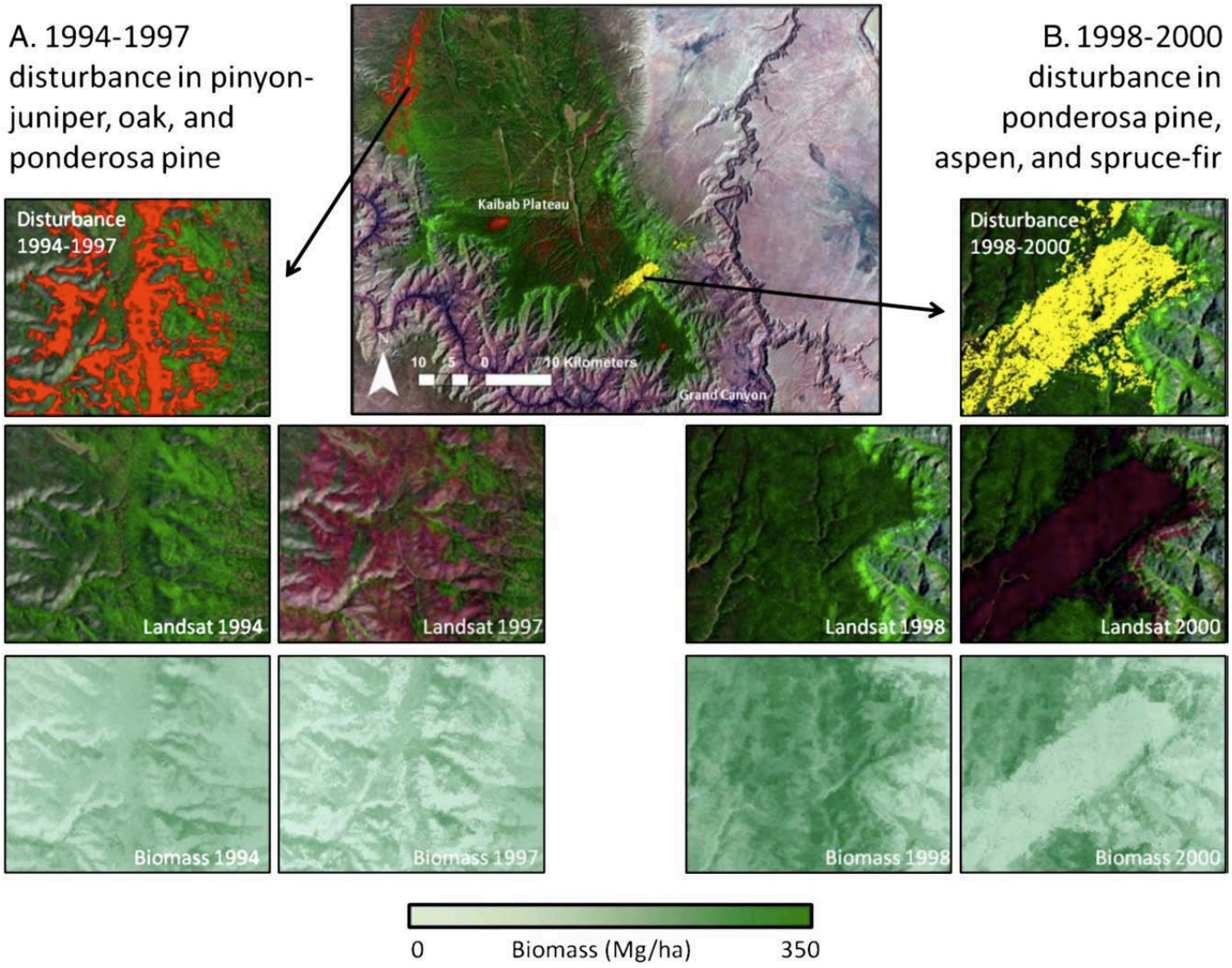
National Estimates of Forest Disturbance Rates



Natural and economic factors
Samples can dominate signal – need wall to wall

Kennedy et al.

National Estimates of Forest Biomass Change



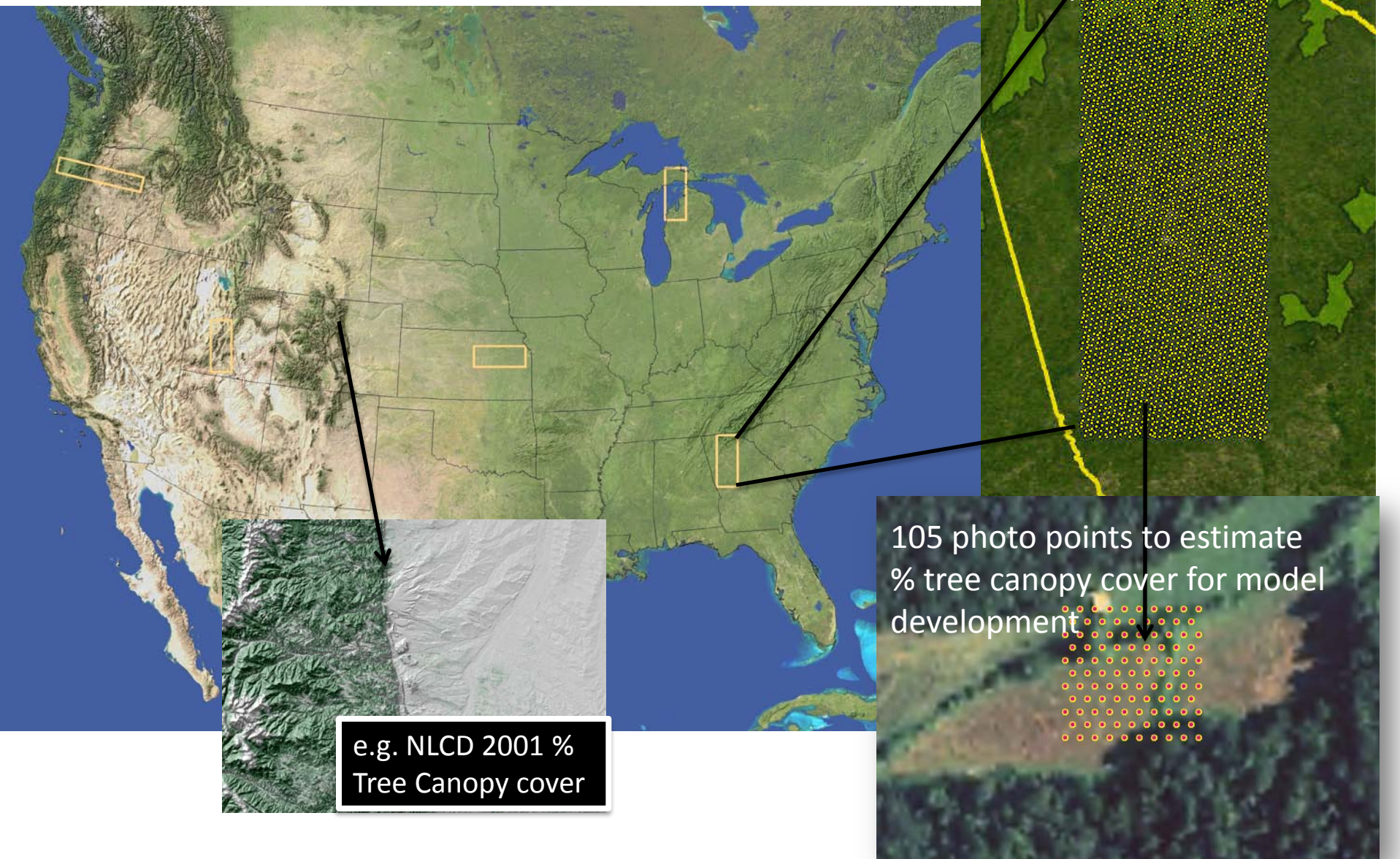
Powell et al.

FIA and Landsat

Percent Tree Canopy Cover

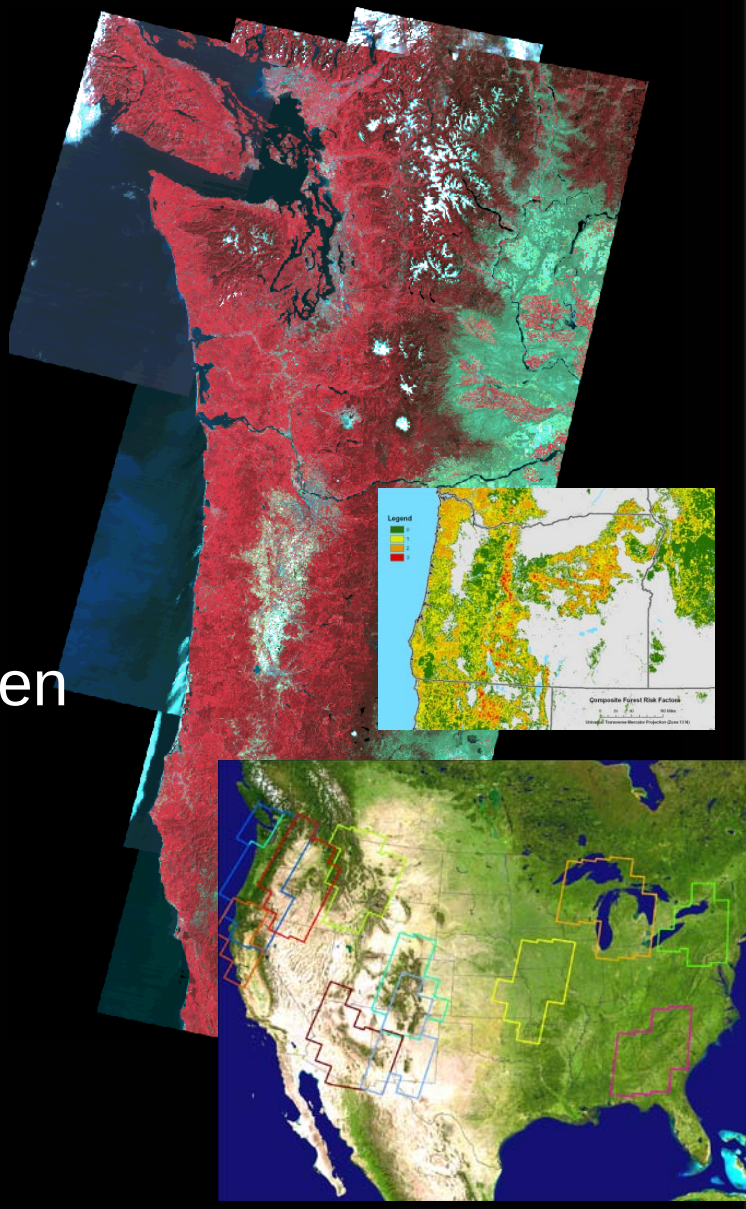
- The USGS lead the 2001 Landsat-based effort to map percent tree canopy cover for the United States at 30m resolution.
- Very popular product; plan for USFS to produce the 2011 version
- Proof of concept work funded
  - Photo interpretation 90% completed
  - Explanatory data stacks in place
  - Main research components to be completed FY10
- Internal Forest Service funding proposal to be submitted March 2010
- Prototyping work 2011 (dependent upon additional funding)
- Production work 2012-2013 (dependent upon additional funding)

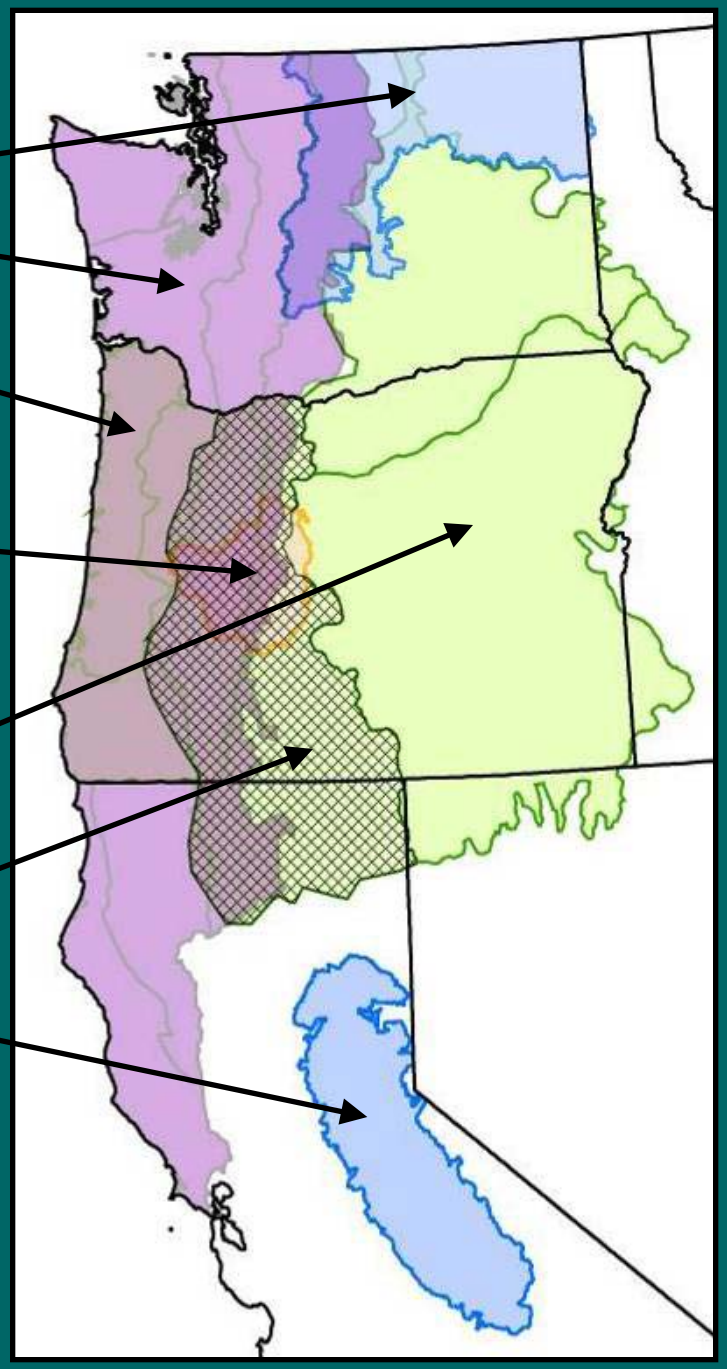
2011 NLCD Percent Canopy Cover Map



Regional Assessments

- Landsat is the baseline for regionwide assessments
  - Large area mosaics from Landsat are assembled
  - Gradient Nearest Neighbor (GNN) modeling done using FIA data
  - ~ 12 other mosaics have been created for other USFS projects
  - ~ 1 TB of data total

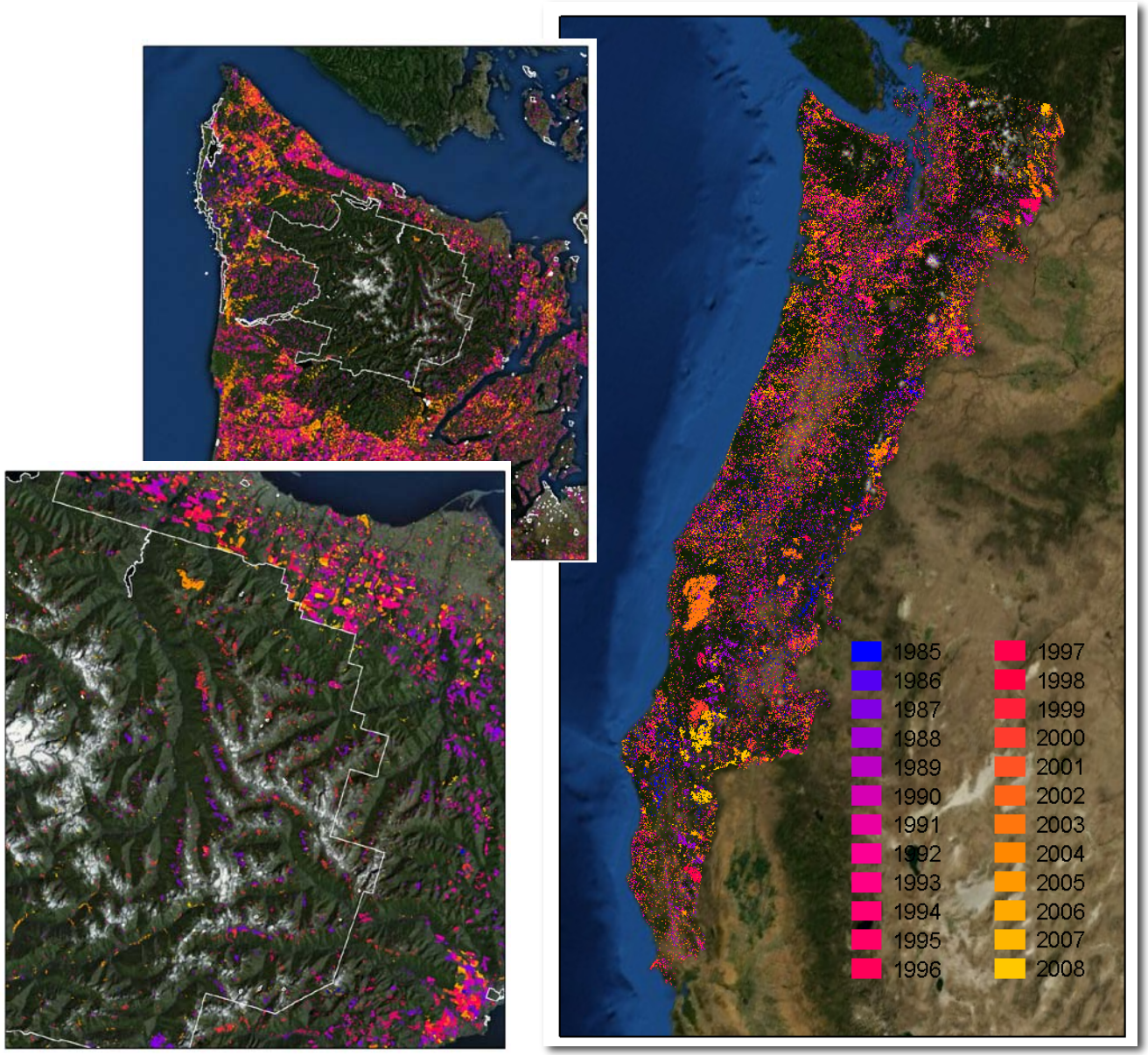




GNN mapping and applications in the western US

- Analysis of forest policy effects via landscape scenario analysis (CLAMS, COLA, IMAP)
- Regional risk assessments (WWETAC, RSAC 250-m study)
- Assessing fire hazard, planning fuel management, modeling fire behavior and effects (GNNFire)
- Land management planning (National Forest Plans, BLM Cumulative Effects Analysis)
- Biodiversity assessment and conservation planning (GAP)
- Regional and national inventory and monitoring (FIA, NWFP EM, NaFIS)
- *www.fsl.orst.edu/lemma*

Ohmann



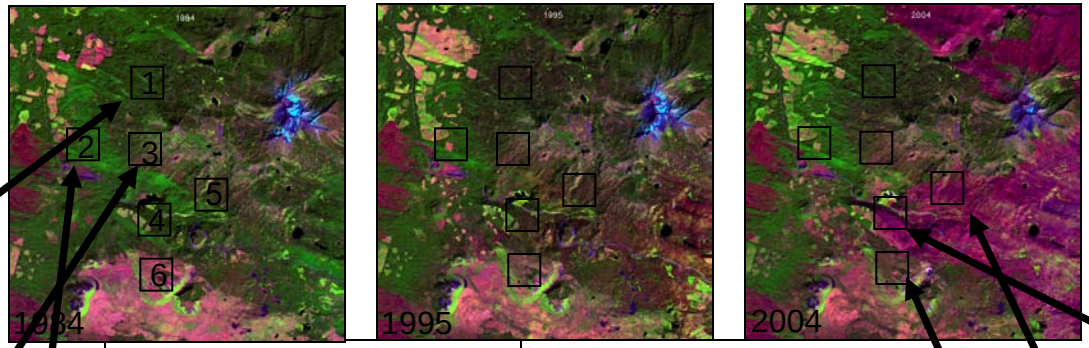
Project: Region 6 Effectiveness Monitoring Program for the Northwest Forest Plan (NWFP)

Data: > 500 individual Landsat images

LandTrendr – Kennedy et al.

Funding from USFS, NASA, NPS, DOE, and others

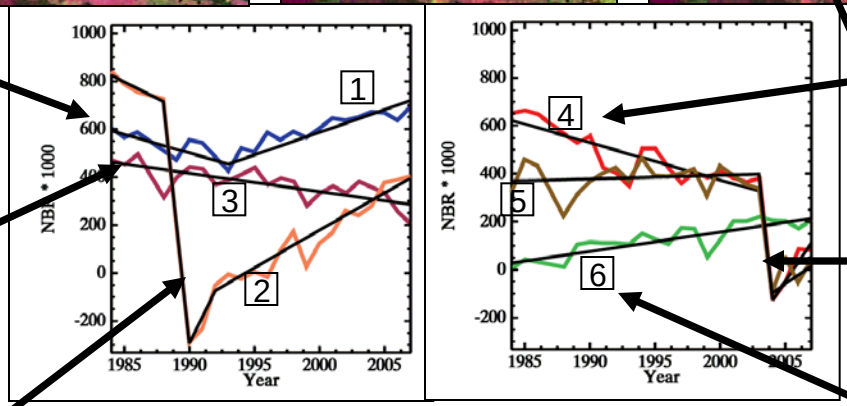
Disturbance year, magnitude, agent, regrowth rates



1: Insect, then regrowth

3: Insect-related mortality

2: Harvest, then regrowth



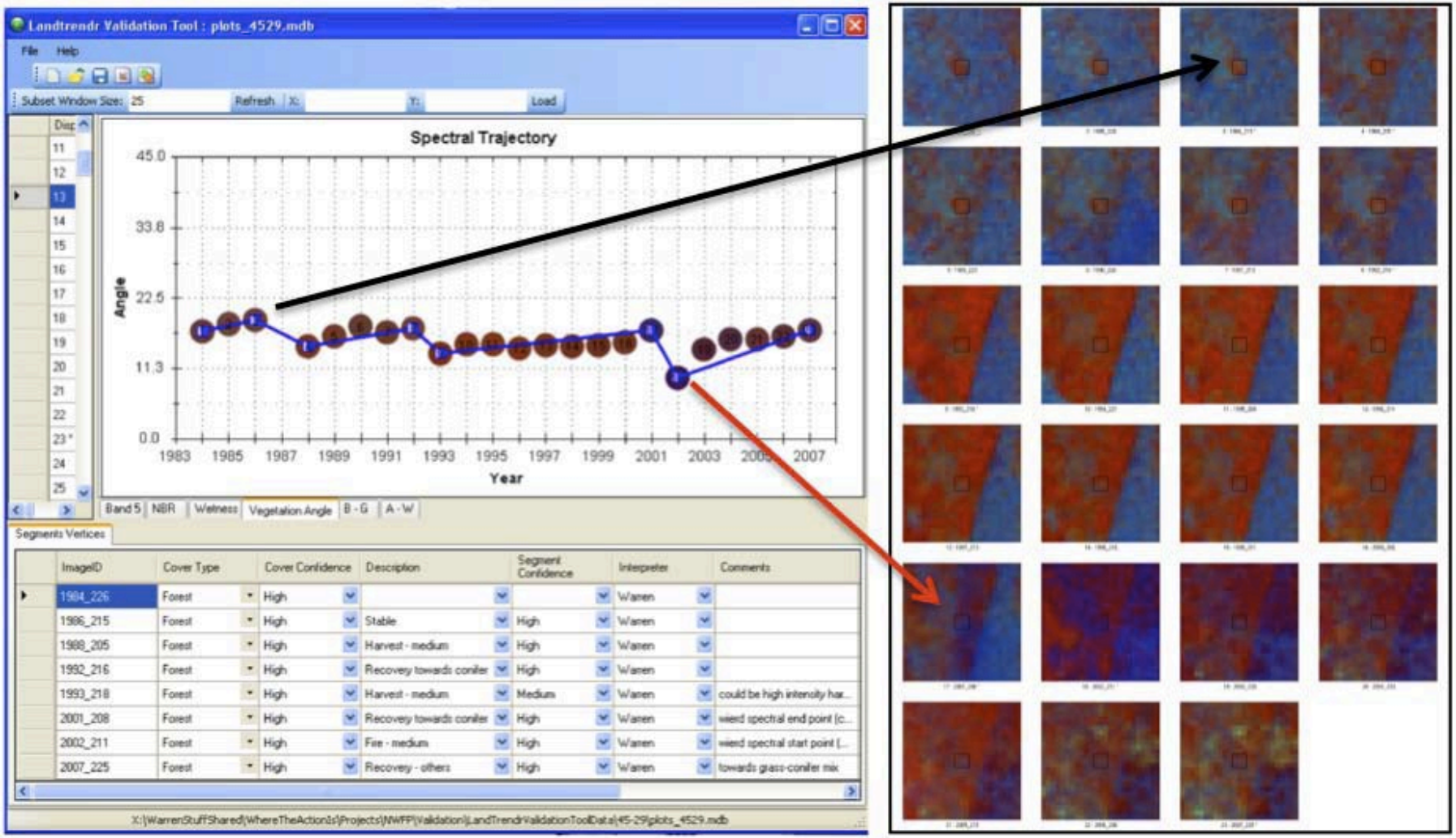
4: Insect, then fire

5: Growth, then fire

6: Growth

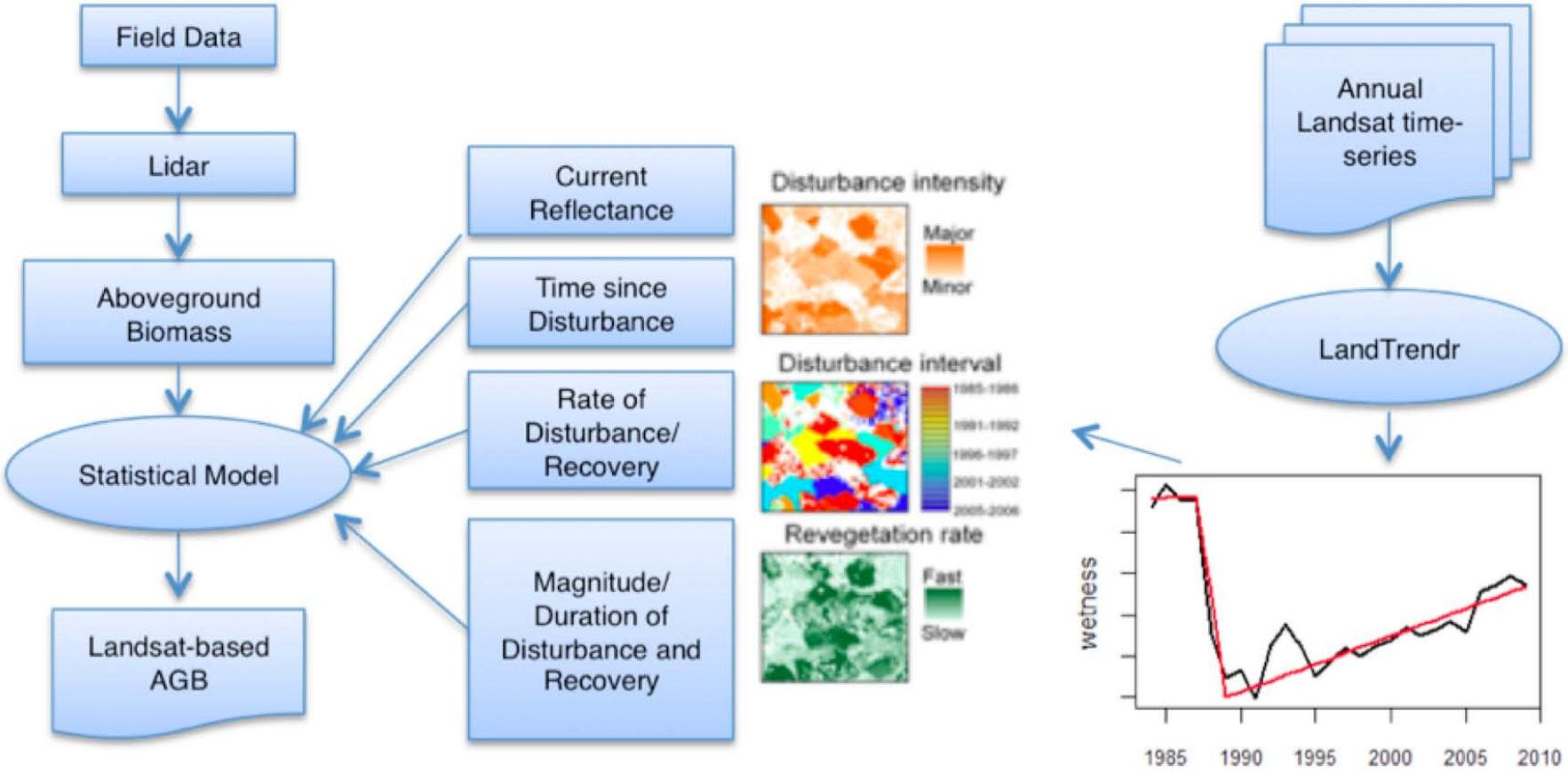
LandTrendr – Kennedy et al.

Error Assessment via TimeSync



Cohen et al.

Using disturbance history to improve lidar-based models for forest structure

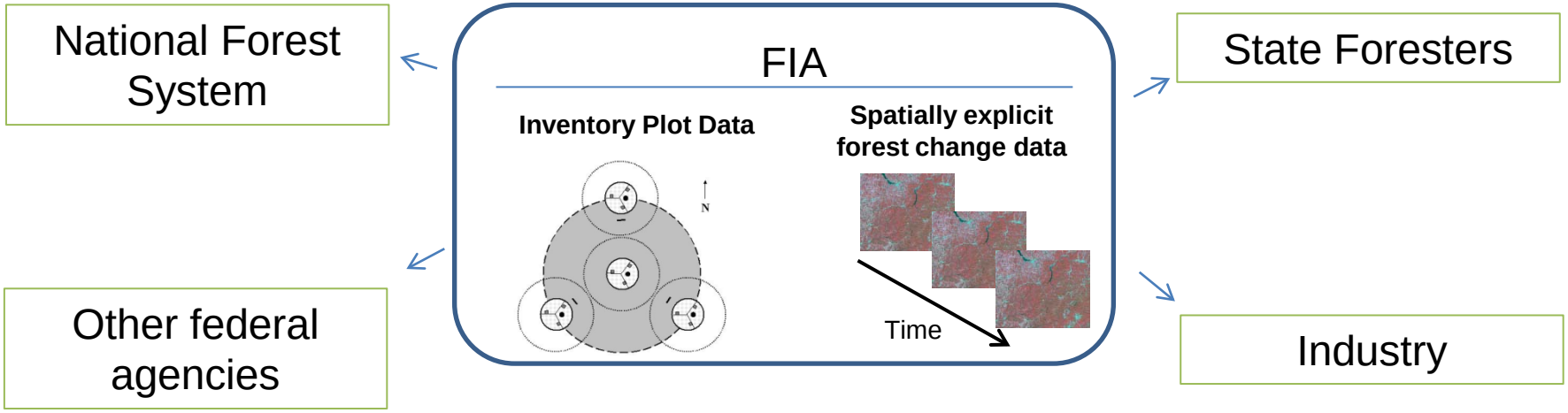


Pflugmacher, Cohen, Kennedy

NASA funded

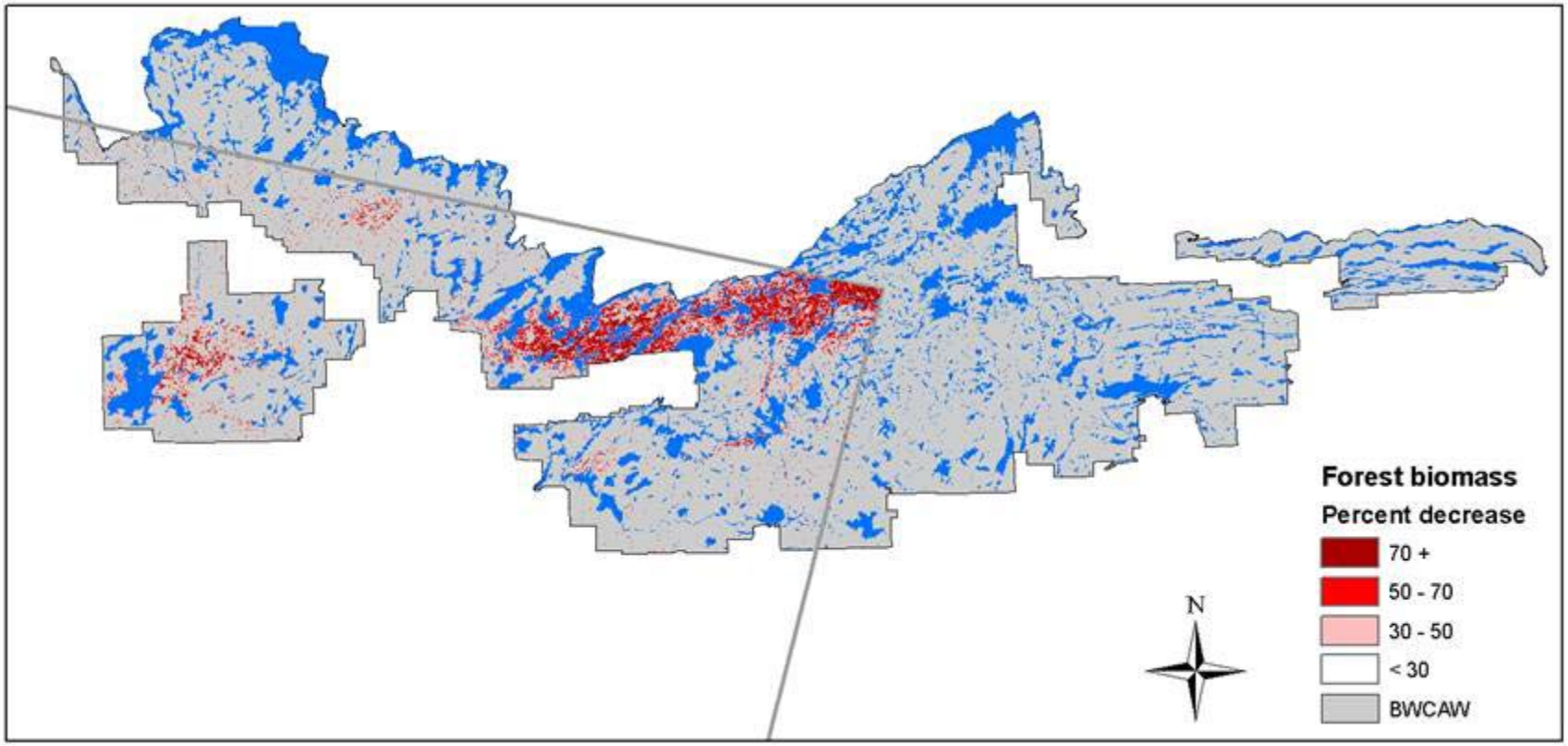
Partnership with NASA Applied Sciences Program (since 2005)

Goal: Support a range of Forest Service decisions by partnering with its Inventory and Analysis unit (FIA) to amplify impact and create a systematic home for techniques derived from the North American Forest Dynamics (NAFD) project



Obstacles addressed: 1.FIA lacked experience with mapped data, and, 2) Despite clear need, little work had been done to develop FIA-relevant applications of satellite change products

Early example: Combining Landsat satellite imagery with FIA data to assess damage severity following the 1999 BWCAW blowdown, northern Minnesota, USA

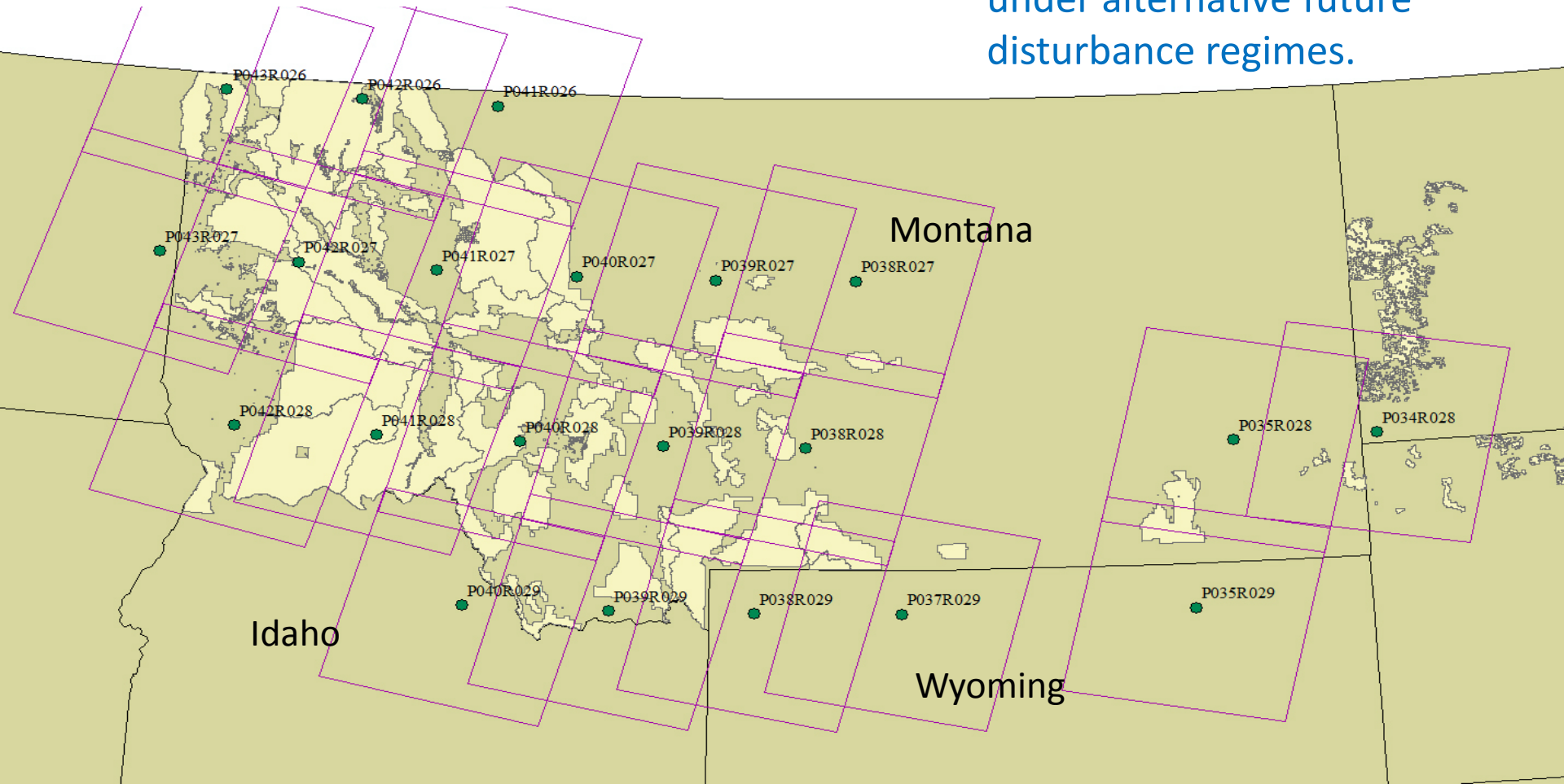


(Nelson et al. 2009.)

Region 1 of the National Forest System is implementing a carbon tracking and management system that integrates Landsat imagery with other monitoring data and a widely accepted forest growth simulator.

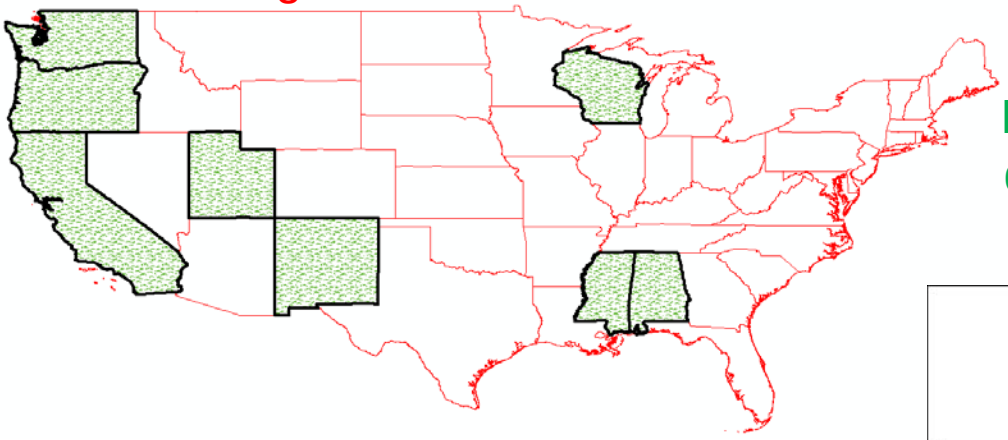
Enables estimation of:

1) carbon stocks and fluxes in the Landsat era,
2) the effects of mapped harvests and fires on forest carbon, and
3) landscape carbon stocks under alternative future disturbance regimes.



NAFD Disturbance Maps are being Completed Across the Country to Support a Range of Analyses and Applications

Forest Service-funded state and regional assessments



EPA-funded FIA analysis of effects of disturbance on water quality in Great Lakes Region (41 scenes)

Special issue pilots

- Effects of management and fire on landscape carbon storage
- Rapid assessment of catastrophic storm damage
- Effects of disturbance on habitat
- Relationship between time since disturbance and biodiversity

Accomplishments

An institutional shift has occurred: Because of NASA-funded science and applications FIA is now willing and able to complement traditional plot-based data with critical and consistent satellite-derived forest disturbance information.

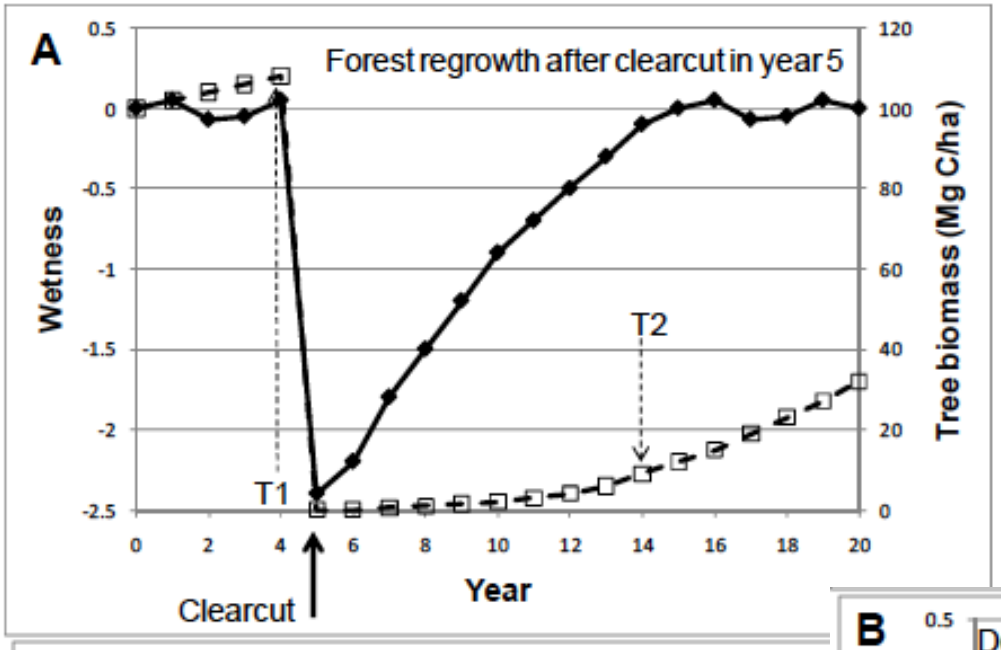
Evidence

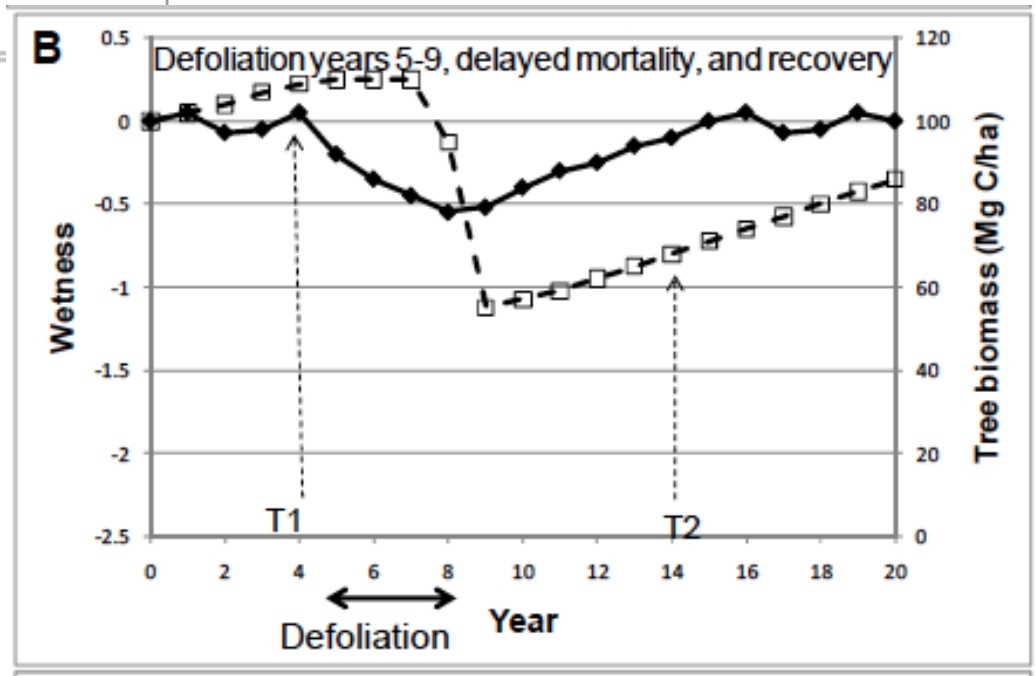
1. FIA's strong support of the inter-agency Monitoring Trends in Land Change (MTLC) project, which aims to expand Landsat-based change detection over the entire country
2. Long list of NAFD assessments funded by the Forest Service
3. A post-doc (Healey) from this project hired by FIA as a permanent scientist for the purpose of furthering Landsat applications

Potential Future Directions for US Forest Service Uses of Landsat

- Wall-to-wall mapping of disturbance and recovery using VCT (Goward, Masek, Moisen, Huang, Cohen et al.)
- Integration of Landsat trajectories and FIA plot data
- Trade-space studies
- Monitoring Trends in Landcover Change (MTLC)

Annual biomass trajectories from FIA data and Landsat Time Series





Gray, Cohen, Monleon, Kennedy

Trade-space: products, carbon, biodiversity

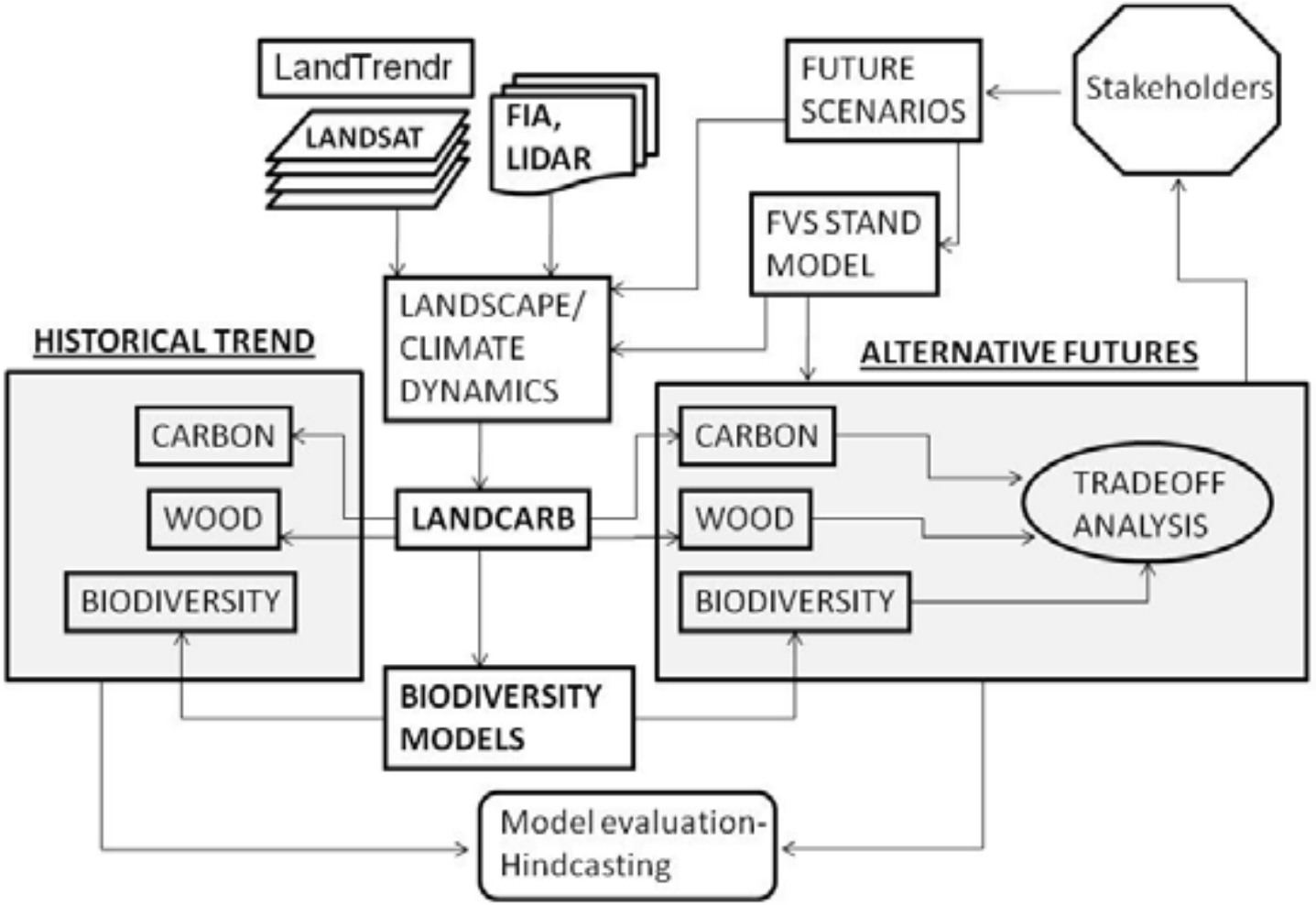


Figure 3. General structure and flow of the project

Spies, Harmon, Cohen, Kennedy et al.

Monitoring Trends in Landcover Change (MTLC)

Goal: Promote interagency coordination in monitoring landcover change (leader: Brewer) – tie together multiple existing efforts

First step: develop foundation for a Landsat-based analytical engine as key component of a larger framework designed to meet U.S. Forest Service and partner needs for monitoring carbon and other resource dynamics

Objectives:

1) Information needs assessment involving key agency representatives from managerial and science entities (Schwind –RSAC)

2) Integrate current landcover change algorithms (VCT and LandTrendr) to provide more broad change detection options for use in characterizing carbon flux and other resource dynamics (Cohen, Huang, Kennedy)

3) Develop flexible statistical estimation processes to address diverse user needs (Moisen)

4) Transfer technology to, and share data with, a large client base (Healey)

USFS and Landsat

A long and productive relationship – Long Live Landsat!