Land Change Monitoring, Assessment, and Projection (LCMAP)

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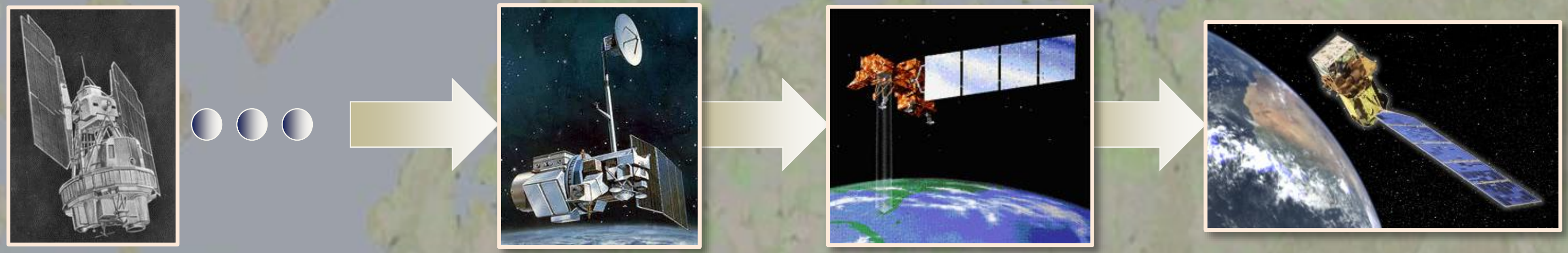
Objectives for LCMAP:

- Provide documentation and understanding of historical land change and contemporary land change as it occurs. Provision ongoing answers to questions on where, how, and why the landscape is changing.
- Explain how past, present, and future land change affects society, natural systems, and the functioning of the planet. What are the impacts of land change locally, regionally, and globally? Topical emphases include land-change impacts on weather and climate, the carbon cycle, water resources, and ecosystem functioning.
- Alert relevant stakeholders to important or emerging patterns of land change in their jurisdictions.
- Support others in the use of land-change data, information, and science results. This includes a state-of-the-art applications support capability, aggressive communications and outreach, and web-based capabilities for accessing all products. Provide “webinars” to explain and share land-change products and information.



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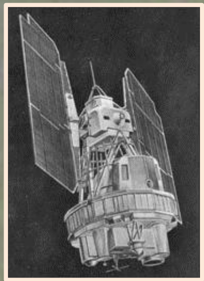
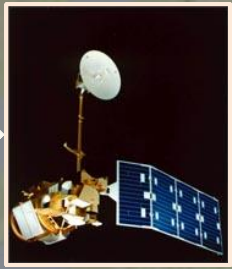
Landsat legacy


Landsat 1


Landsat 2

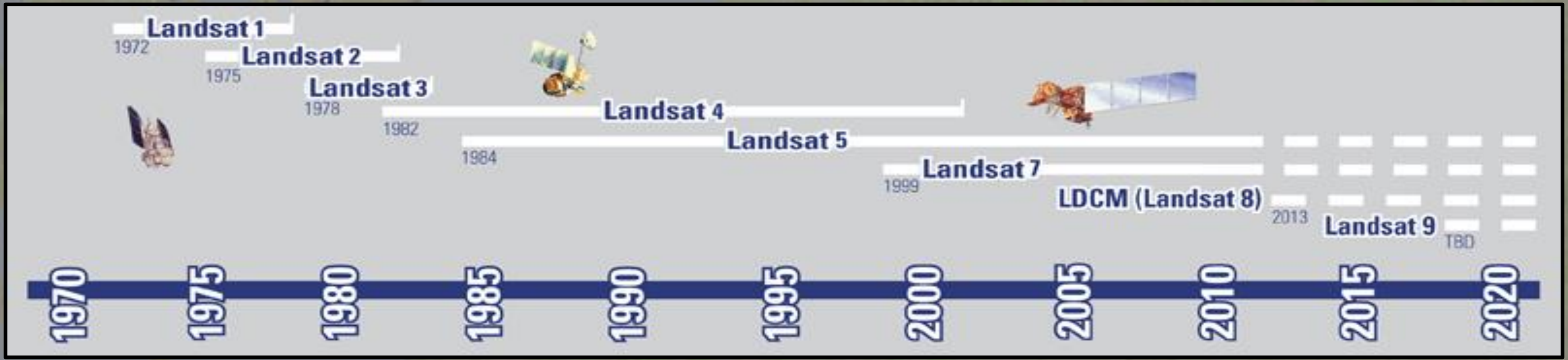

Landsat 3


Landsat 4

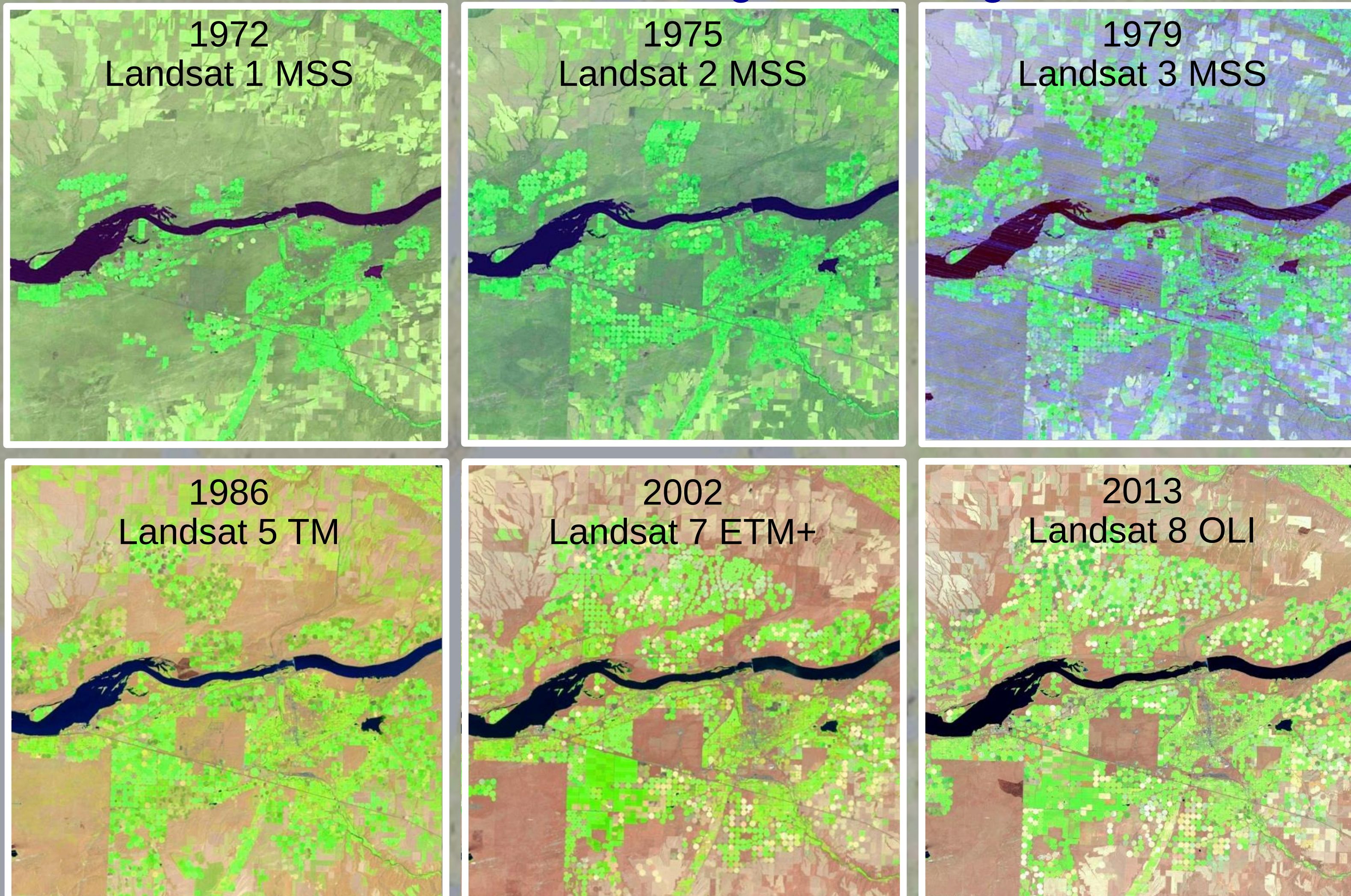

Landsat 6


Landsat 7


Landsat 8

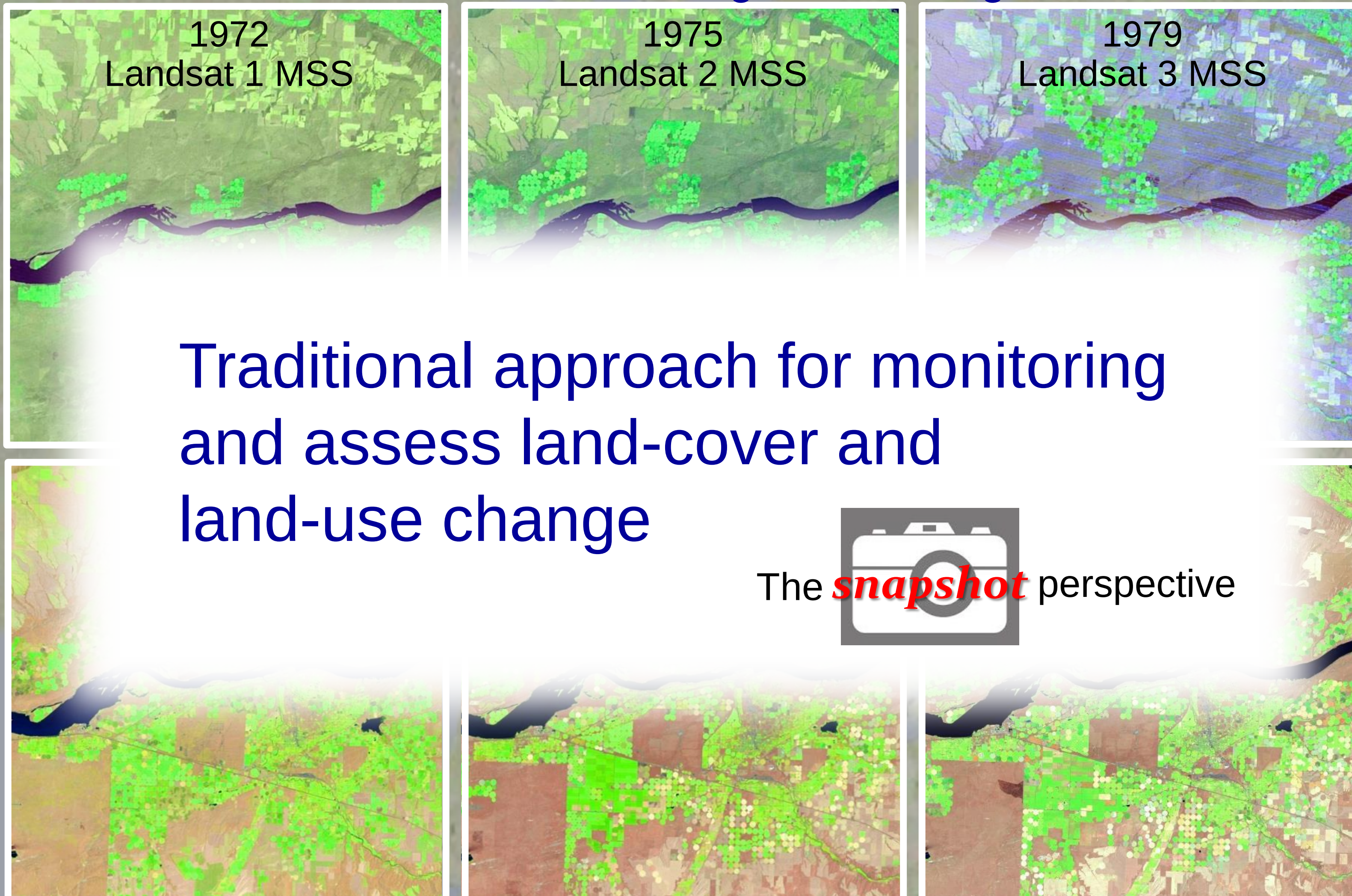


Columbia River – Oregon, Washington



MSS — Multispectral Scanner: 80m resolution, 4 spectral bands
TM — Thematic Mapper: 30m resolution, 7 spectral bands
ETM+ — Enhanced Thematic Mapper Plus, 30m resolution, 8 bands
OLI(&TIRS) — Operational Land Imager: 30 m resolution, 11 spectral bands

Columbia River – Oregon, Washington



Traditional approach for monitoring and assess land-cover and land-use change

The ***snapshot*** perspective

MSS — Multispectral Scanner: 80m resolution, 4 spectral bands
TM — Thematic Mapper: 30m resolution, 7 spectral bands
ETM+ — Enhanced Thematic Mapper Plus, 30m resolution, 8 bands
OLI(&TIRS) — Operational Land Imager: 30 m resolution, 11 spectral bands

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Limitations of snapshot approach for time-series analysis

Data preparation is considerable:

- Cloud-free imagery can be difficult to obtain over large areas for a desired time period.
- Data download one scene at a time from the EROS archive is inefficient.
- Pre-processing data (i.e., correcting to top-of-atmosphere or surface reflectance, screening for clouds/cloud shadows, re-projecting scenes to desired map space, aligning pixels through all the layers in the time series) is time consuming and can put a strain on compute resources.
- Compositing imagery to fill gaps created by clouds, shadows, missing data is time consuming and may take experimentation to achieve acceptable results.

Spectral response of land cover types is ambiguous:

- A given vegetation cover type can have vastly different spectral responses depending on recent weather conditions, phenological stage, reflectivity of background substrate or understory, sun angle, etc.
- Timing of data acquisition and environmental conditions therefore have heavy impact on how well we can detect land-cover change.

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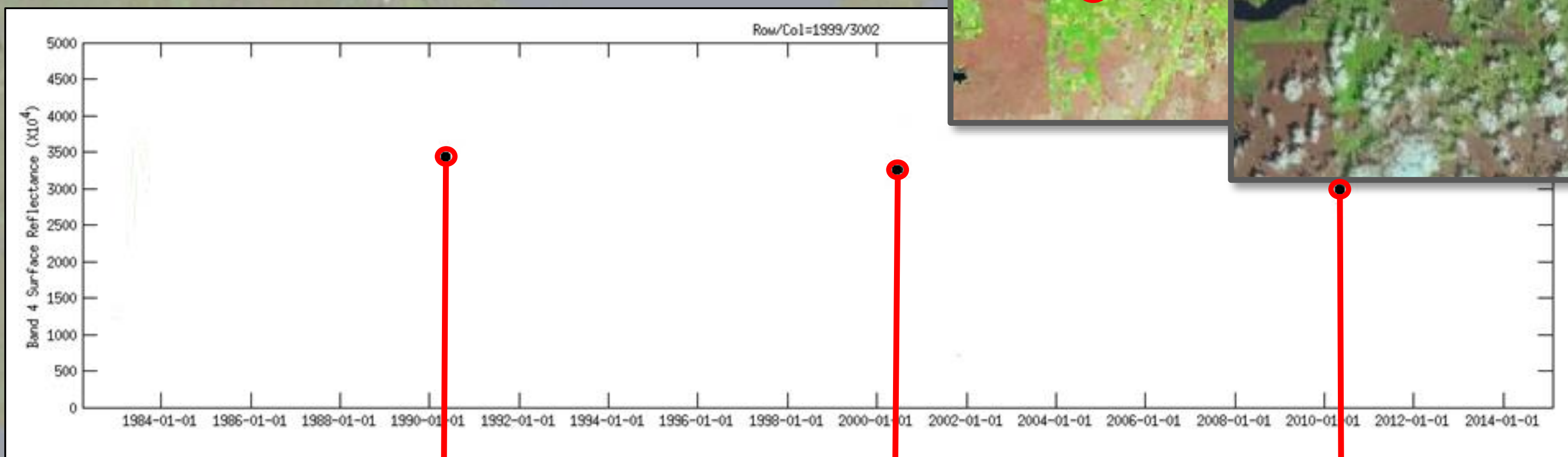
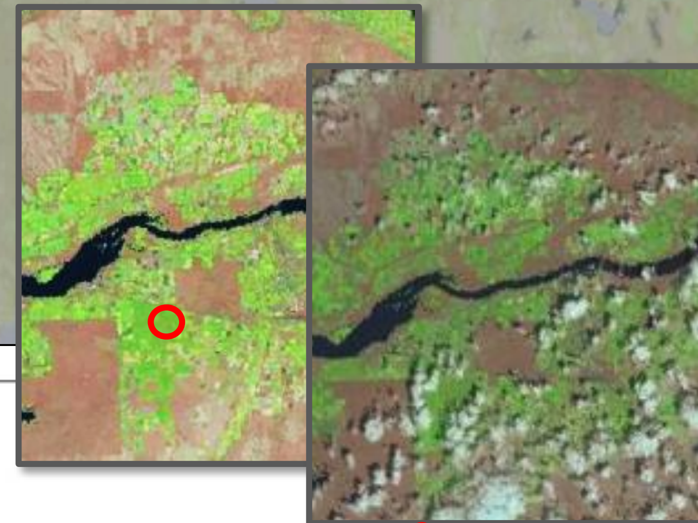
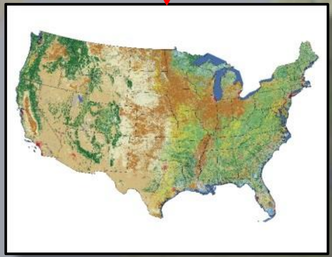
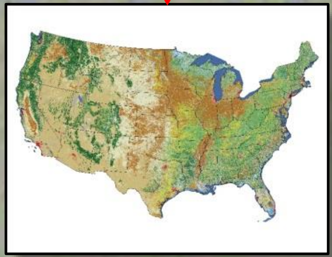
Three decadal observations:
growing seasons 1990, 2000, and 2010





Landsat near-infrared, cloud-screened observations converted to surface reflectance using LEDAPS. Pixel row 1999, column 3002; WRS-2 path 12, row 31





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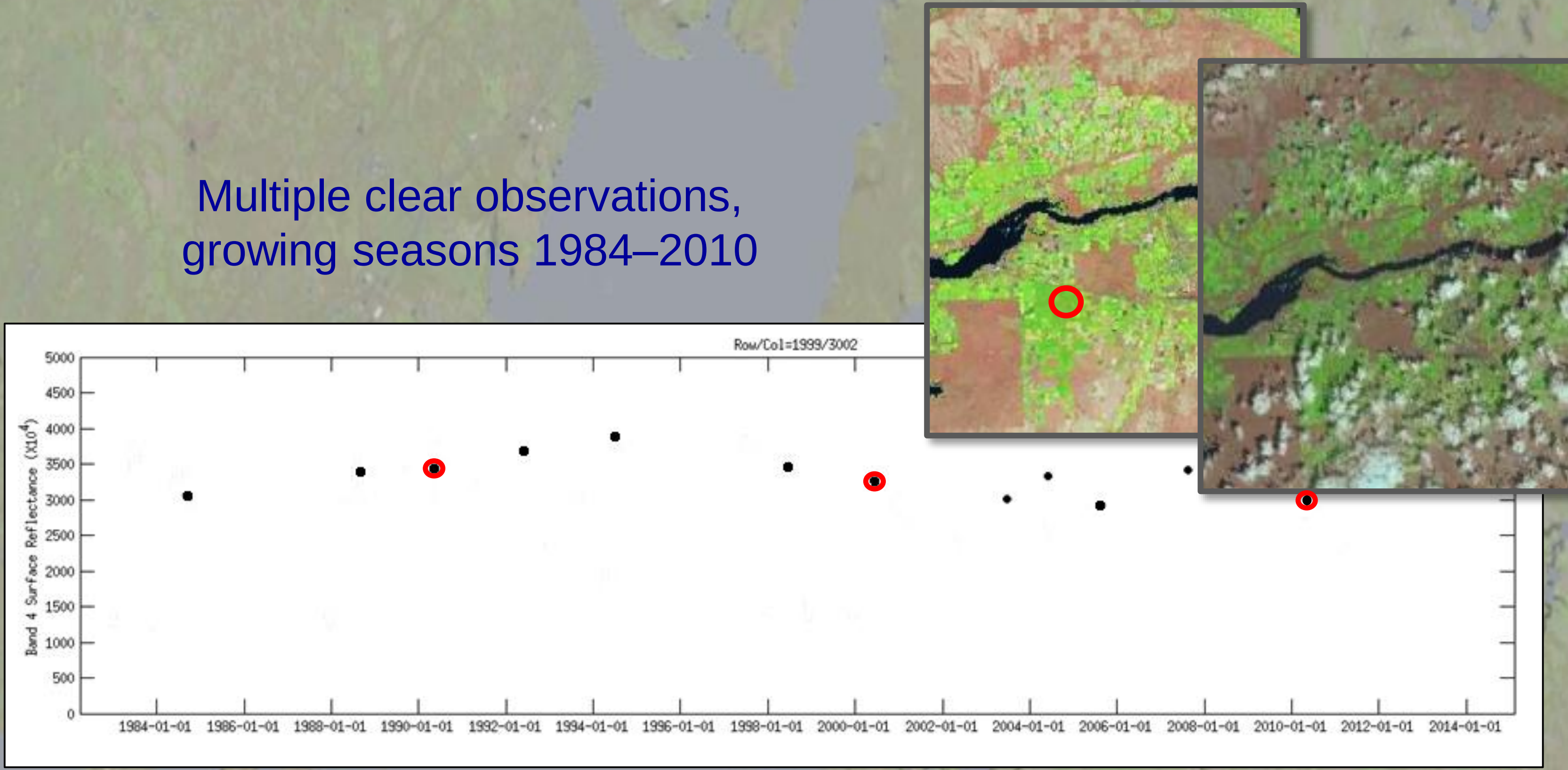
Multiple clear observations, growing seasons 1984–2010



Landsat near-infrared, cloud-screened observations converted to surface reflectance using LEDAPS. Pixel row 1999, column 3002; WRS-2 path 12, row 31

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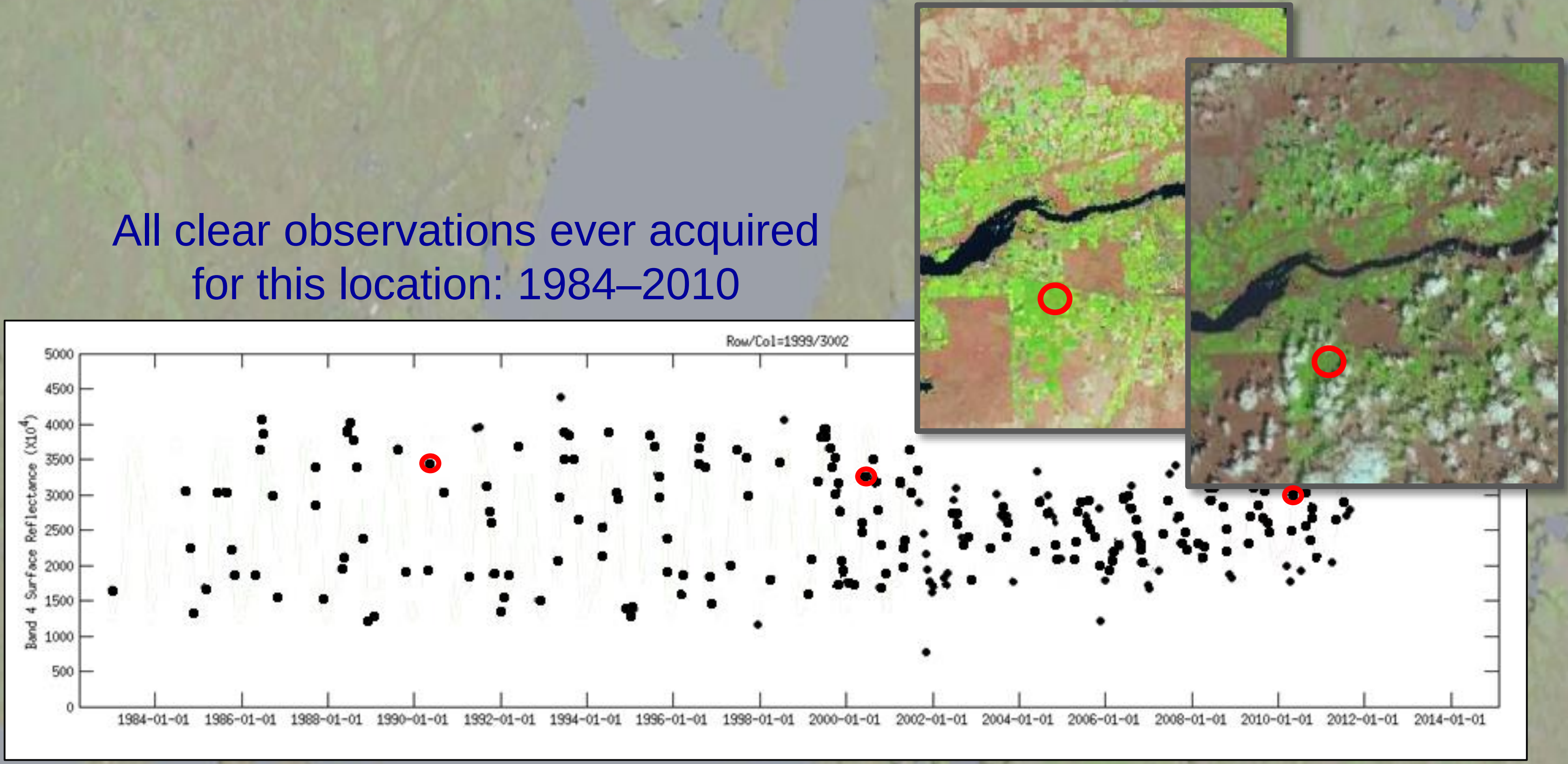
Graph adapted from C. Holden, Boston University

All clear observations ever acquired for this location: 1984–2010



Landsat near-infrared, cloud-screened observations converted to surface reflectance using LEDAPS. Pixel row 1999, column 3002; WRS-2 path 12, row 31

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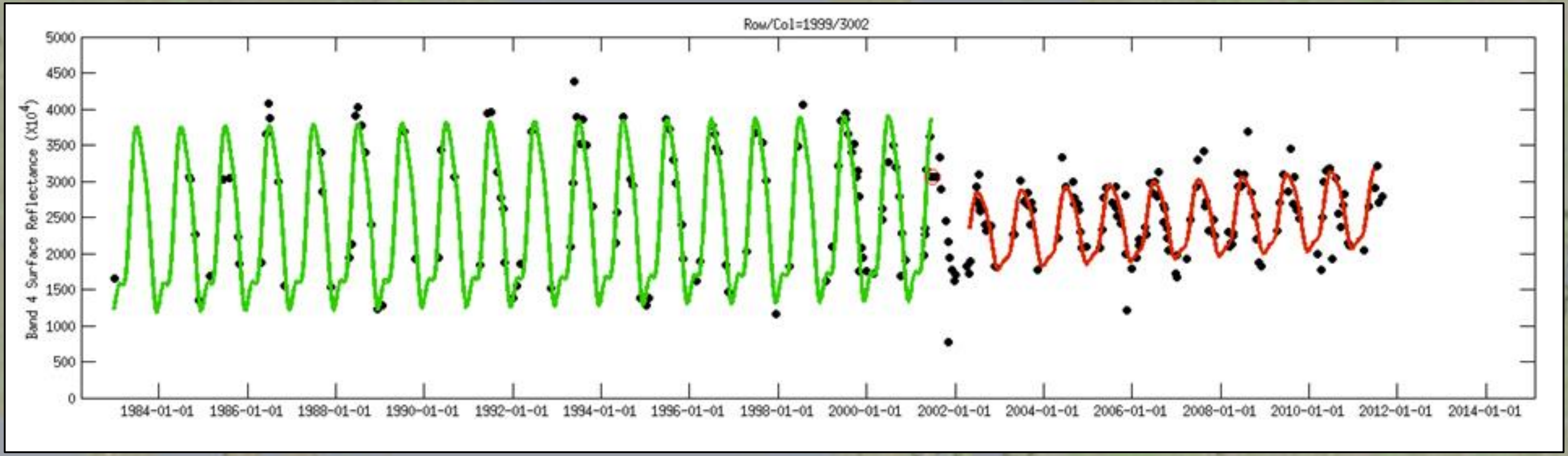
Graph adapted from C. Holden, Boston University

A new paradigm for monitoring for change !

Mathematical prediction models fit to clear observations



Reference: Zhu, Z. and C.E. Woodcock. 2014. Continuous change detection and classification of land cover using all available Landsat data. Remote Sensing of Environment 144:152–171.

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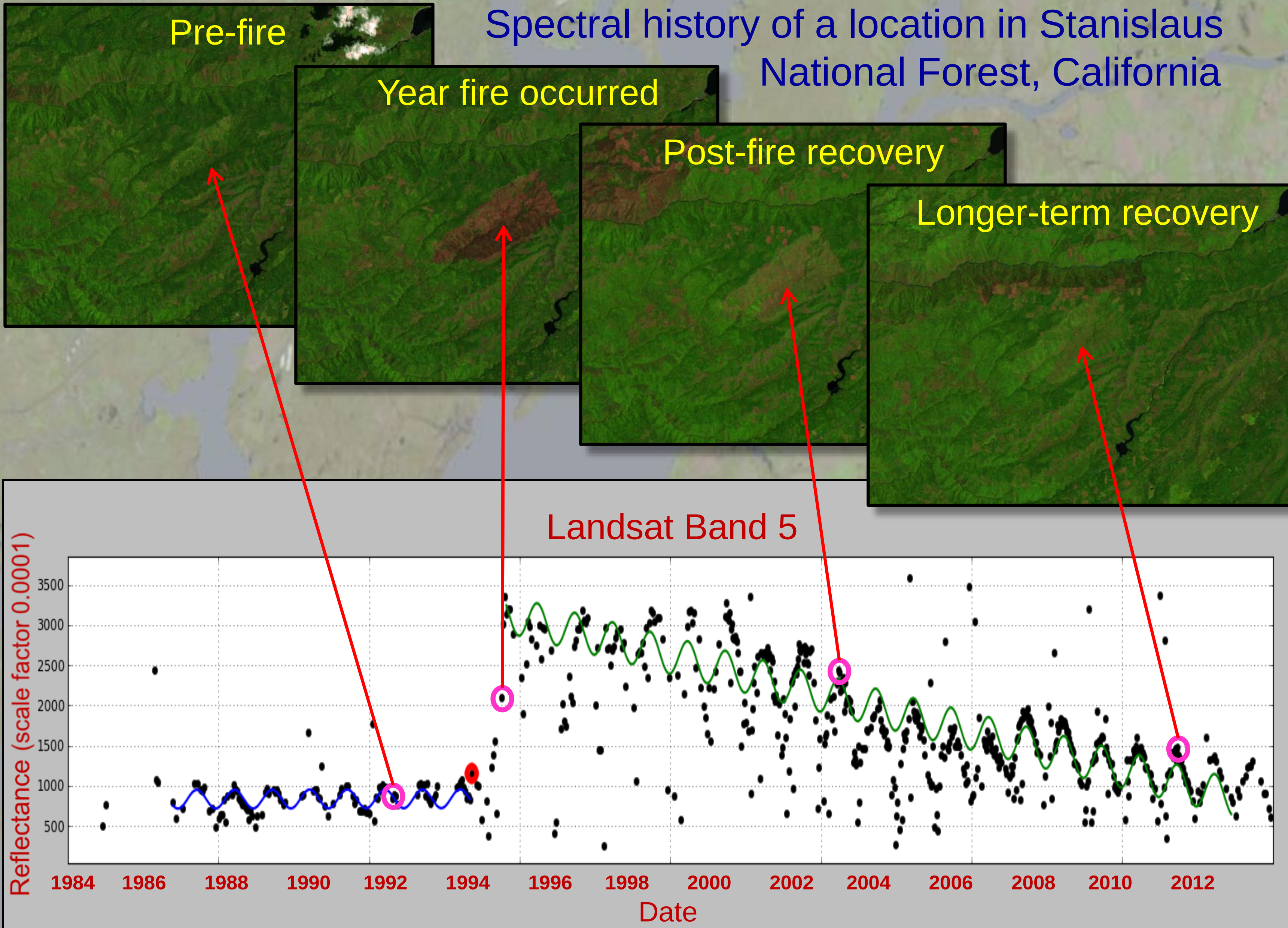
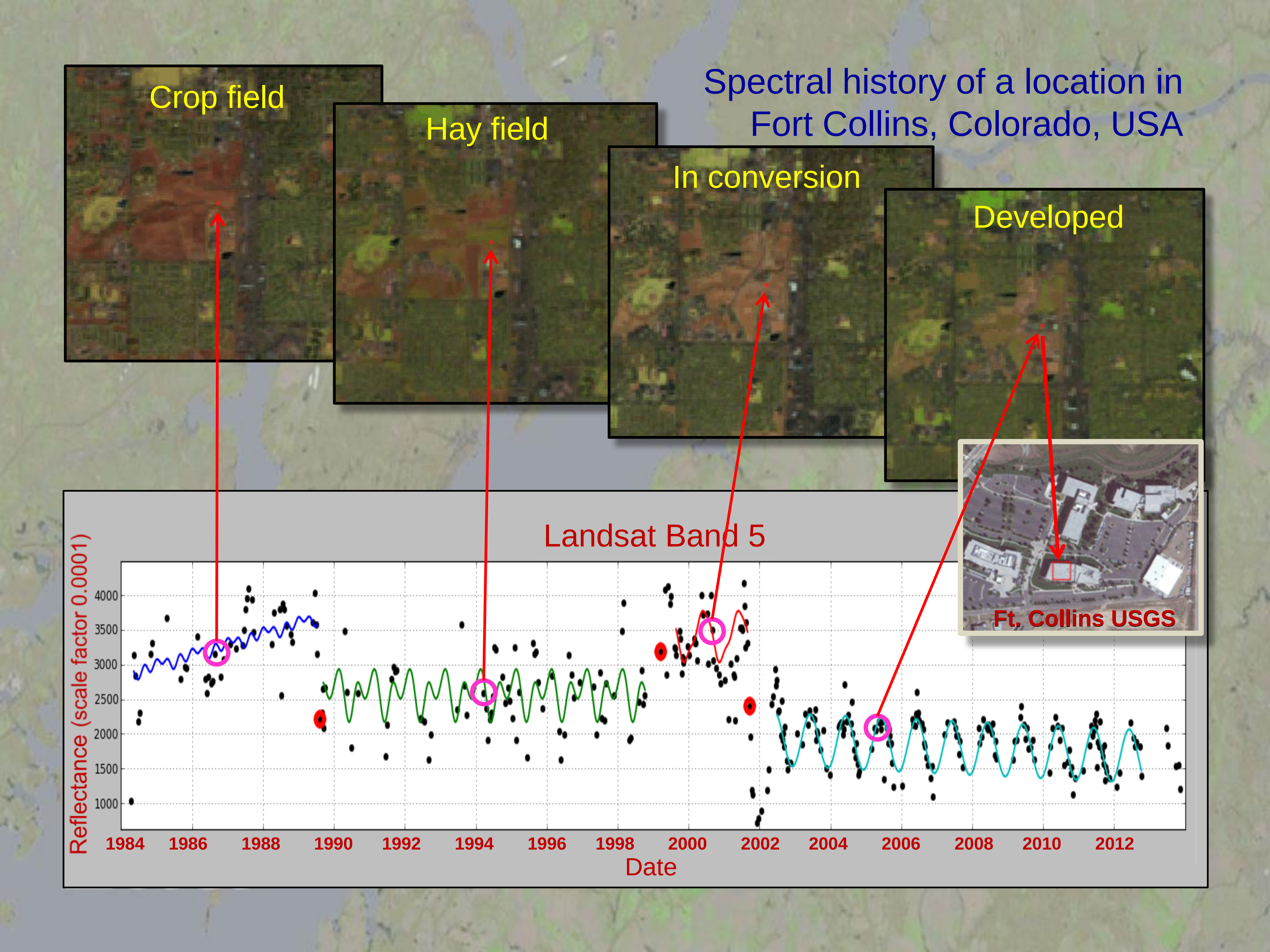
Graph adapted from C. Holden, Boston University

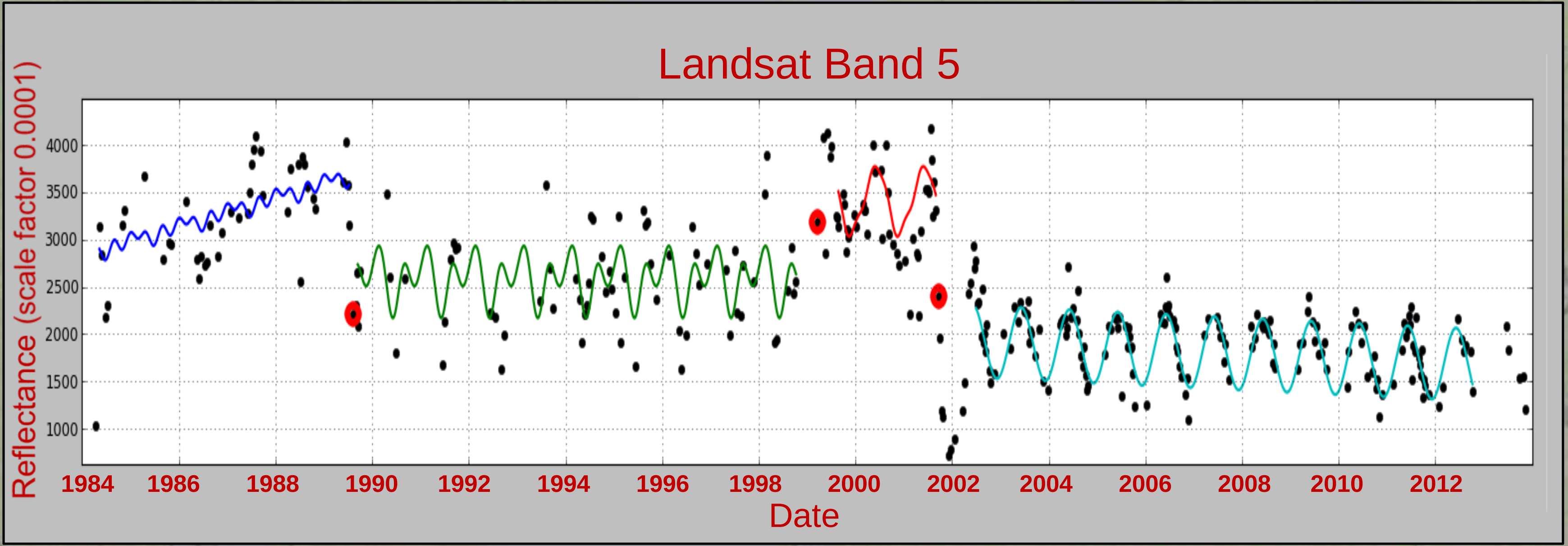
Spectral history of a location in Stanislaus National Forest, California





Spectral history of a location in Fort Collins, Colorado, USA
Crop field
Hay field
In conversion
Developed
Ft. Collins USGS
Landsat Band 5
Reflectance (scale factor 0.0001)
4000
3500
3000
2500
2000
1500
1000
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Date

This is happening in all bands simultaneously



- CCDC first works through the entire history of the pixel to define annual cyclical trajectories and flag changes.
- The coefficients that describe the mathematical trajectories in between change flags are fed to the Random Forest classifier to determine cover-class labels.

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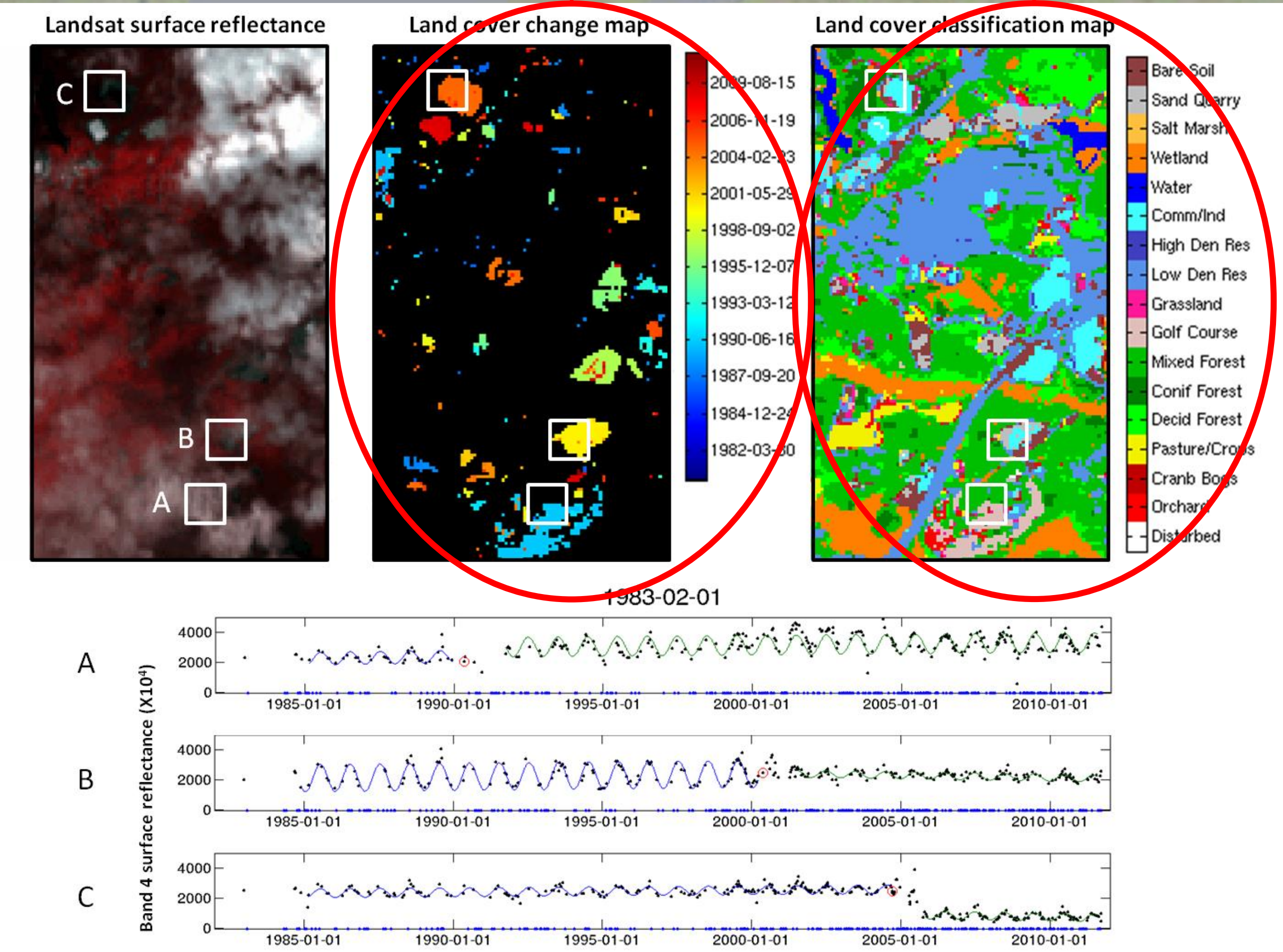
With this approach we can:

Map the timing of change

Stop the clock at any time to generate a land cover map

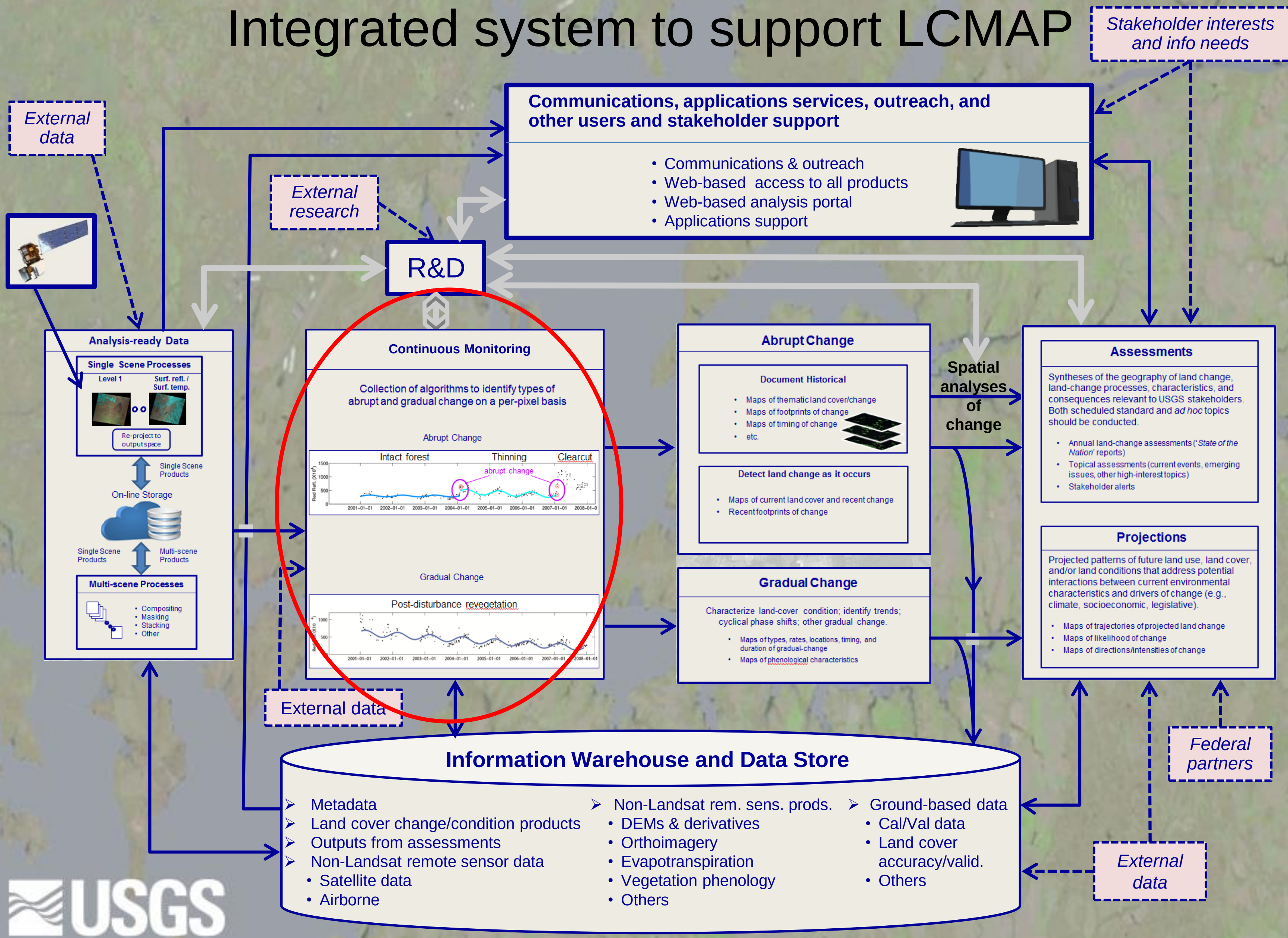


Material from C. Woodcock, Boston University

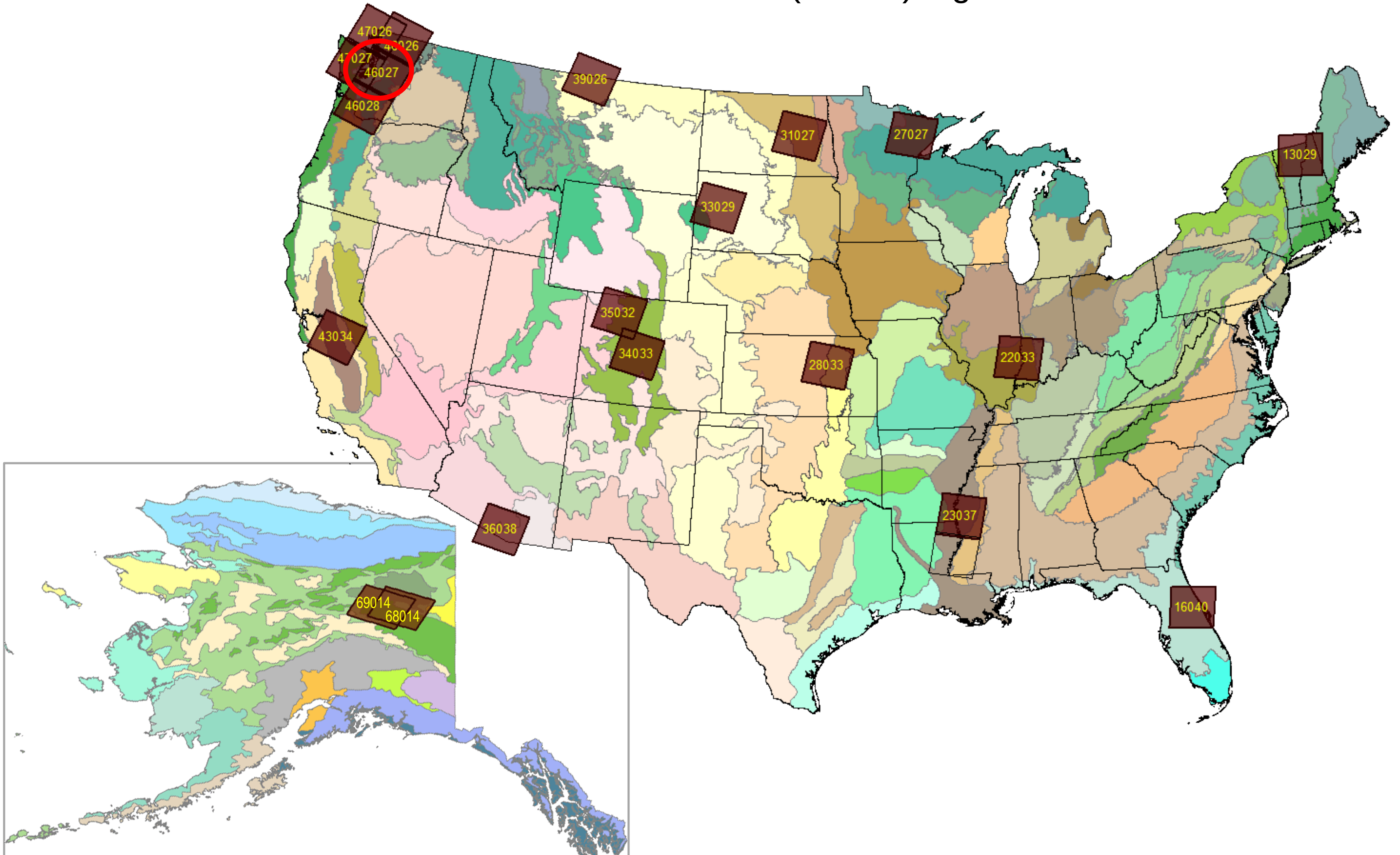
Key element of LCMAP

Refocus & integrate EROS capabilities to support continuous monitoring like this everywhere so USGS can provide timely data & information about land change.

Integrated system to support LCMAP



Currently: Testing and refining the Continuous Change Detection and Classification (CCDC) algorithm



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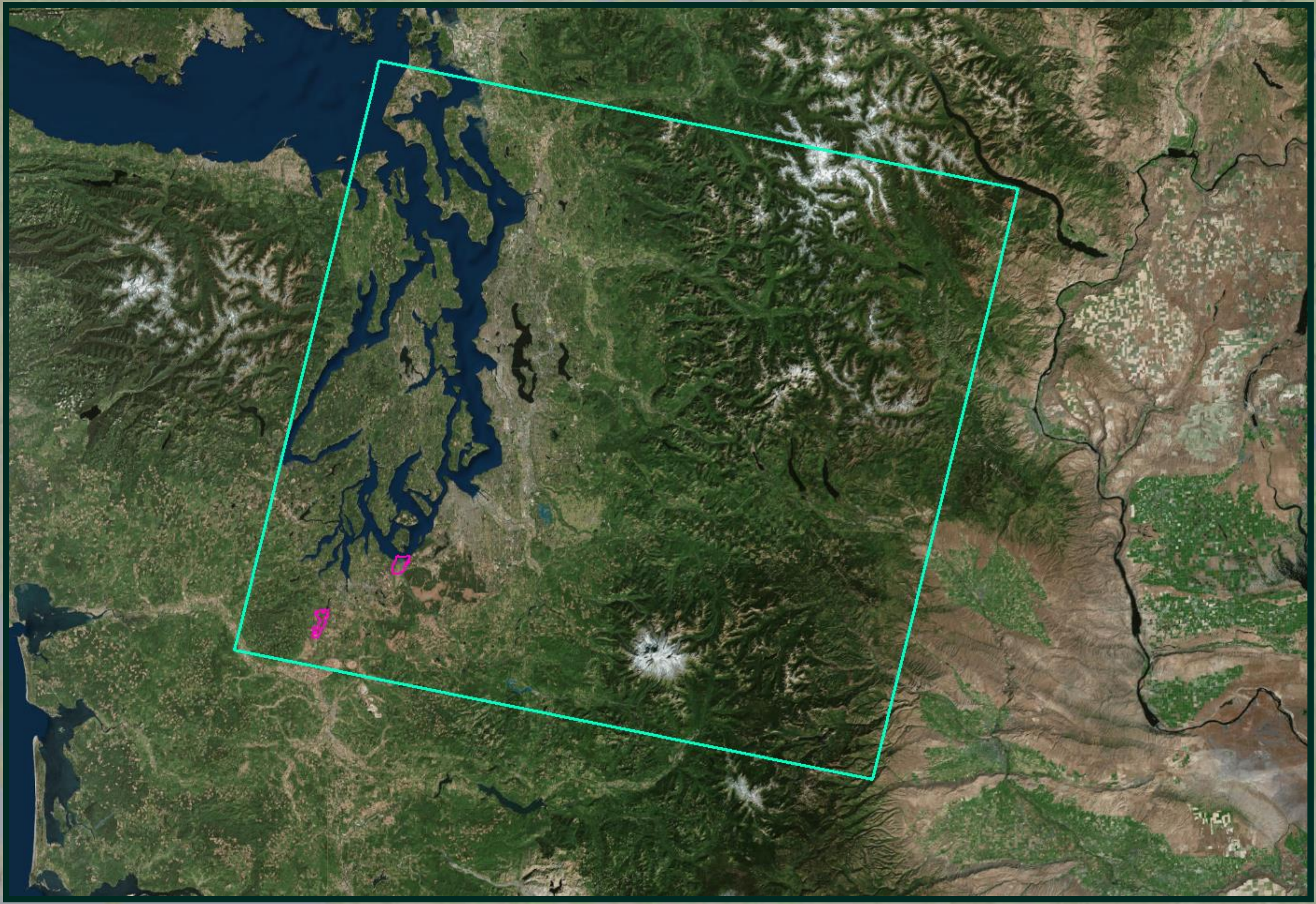

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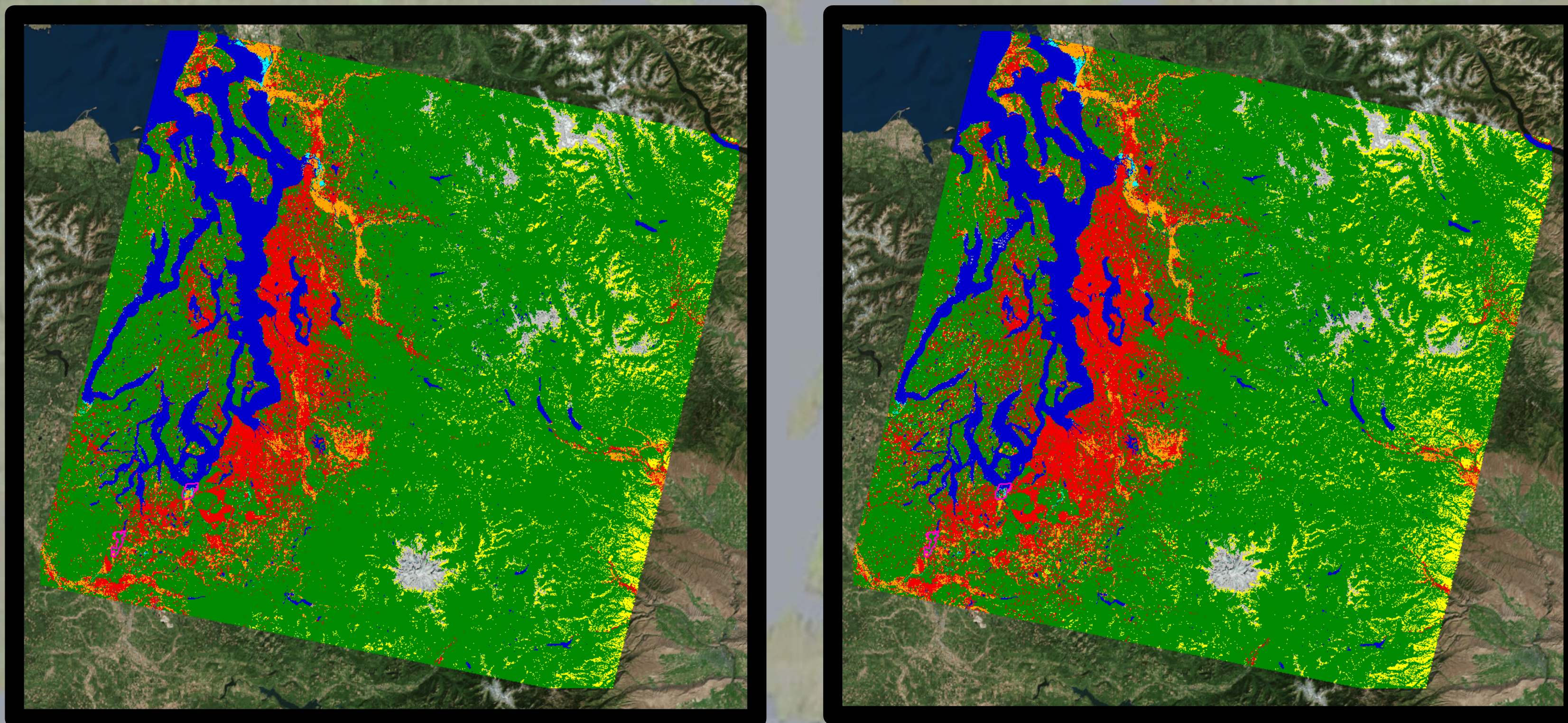
1985

2014



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Timing of change

Year of Most Recent Change

1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
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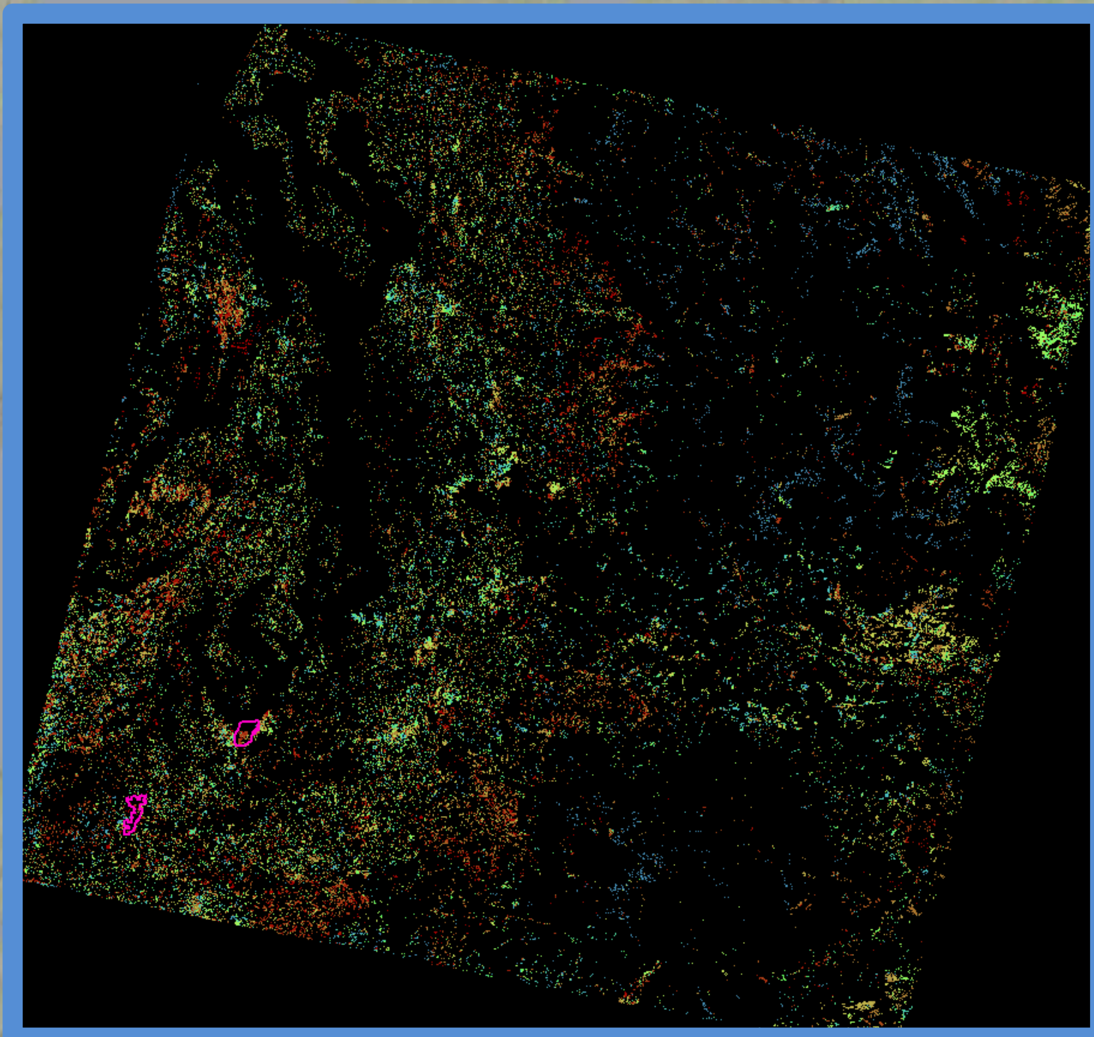
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

1985 - 2014



Timing of change

Year of Most
Recent Change

1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
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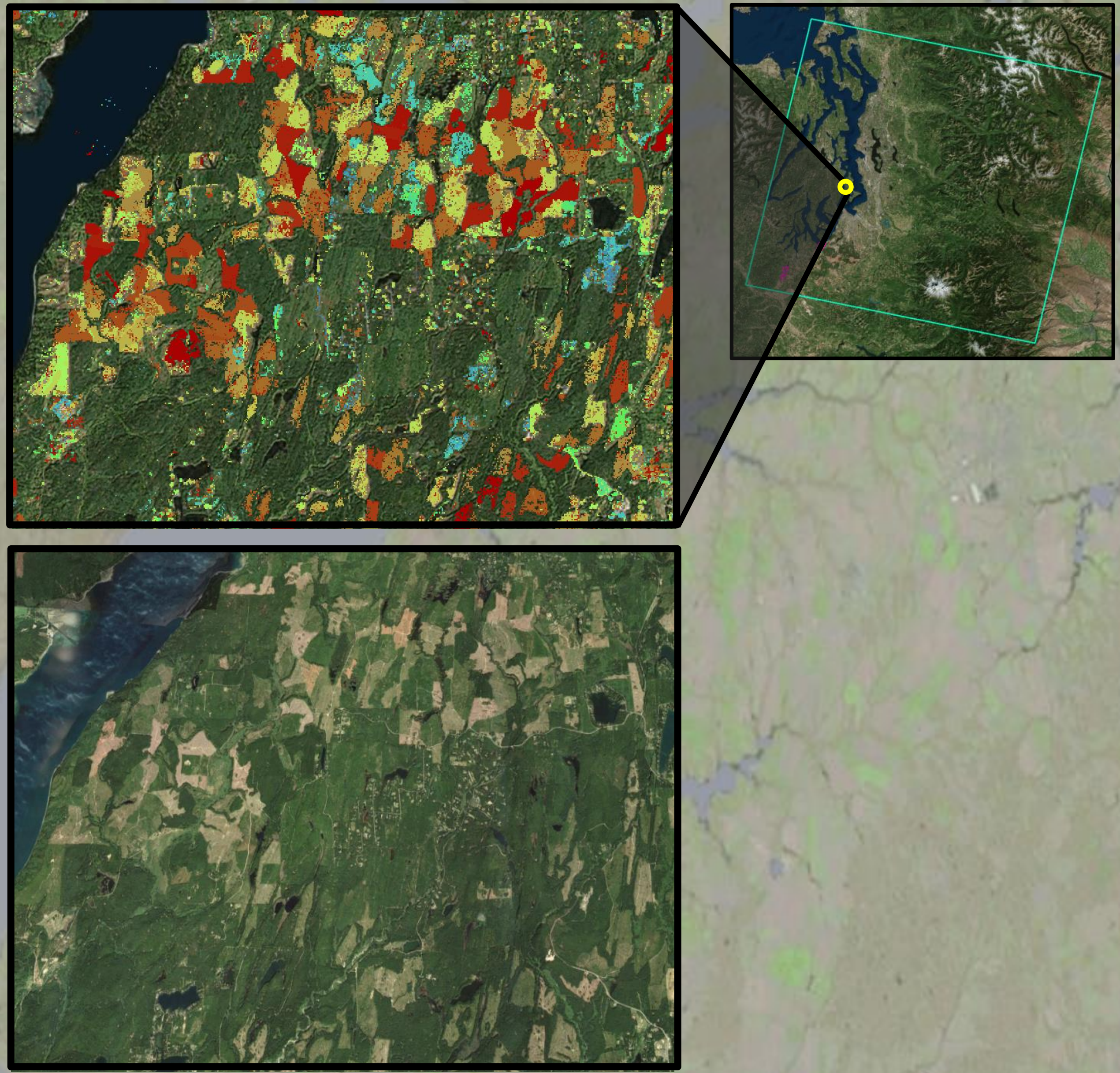
2013
2014



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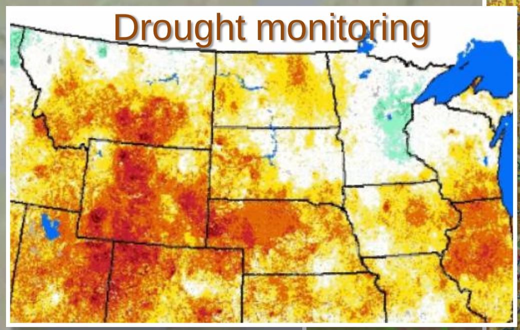
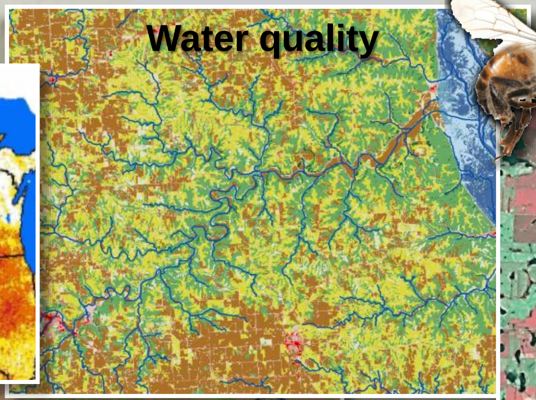
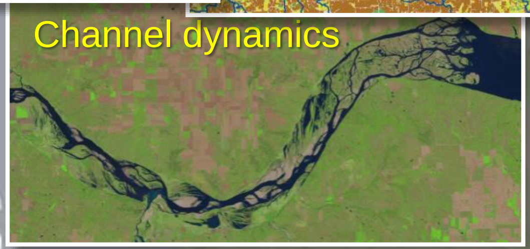
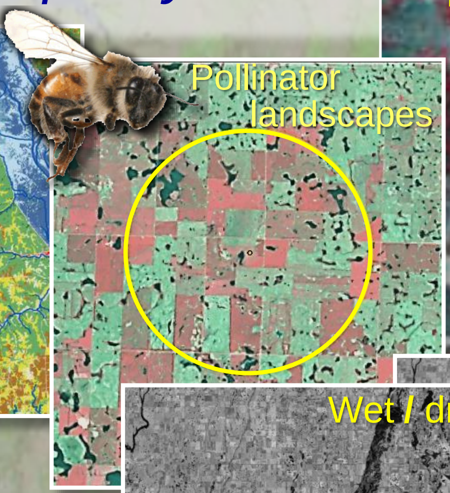
Land Change Monitoring, Assessment, and Projection

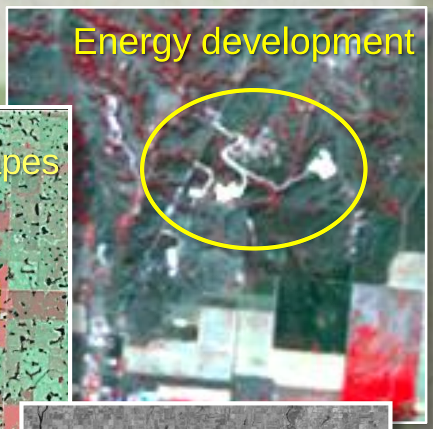
LCMAP ultimately is a capability to continuously track and characterize changes in land cover, use, and condition and translate such information into assessments of current and historical processes of change as a science foundation to support evaluations and decisions relevant to environmental management and policy.











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Questions ?
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