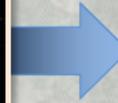
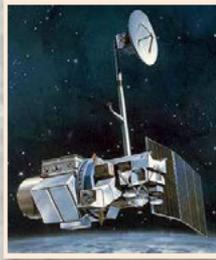




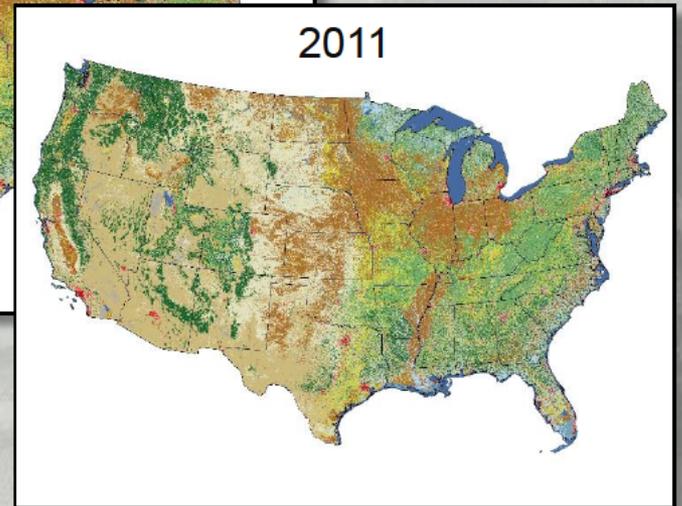
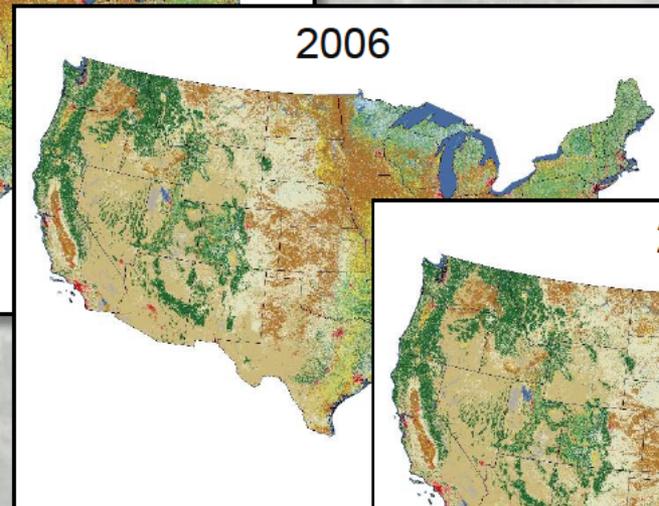
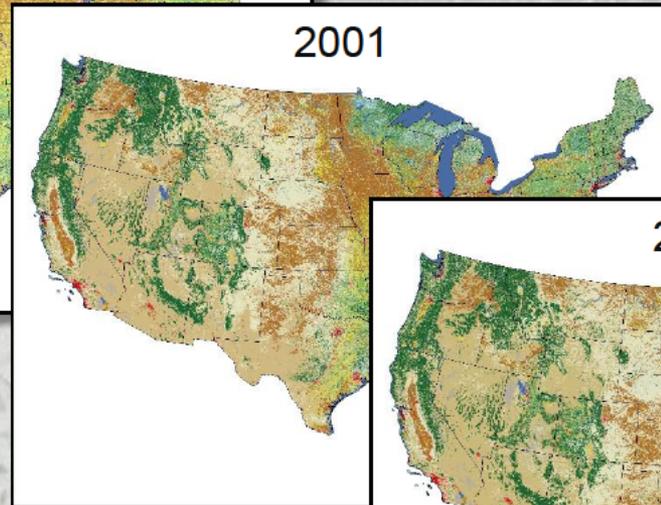
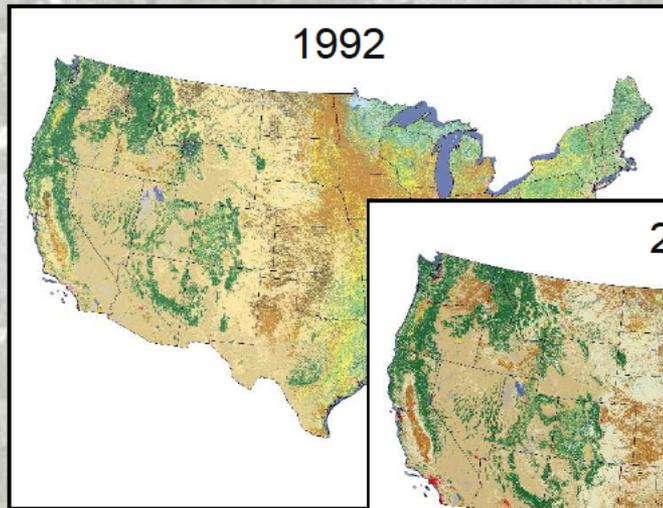
# EROS vision and way forward for Land Change Monitoring, Assessment, and Projection (LCMAP)

## 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 land-change events 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.

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



The *snapshot* perspective

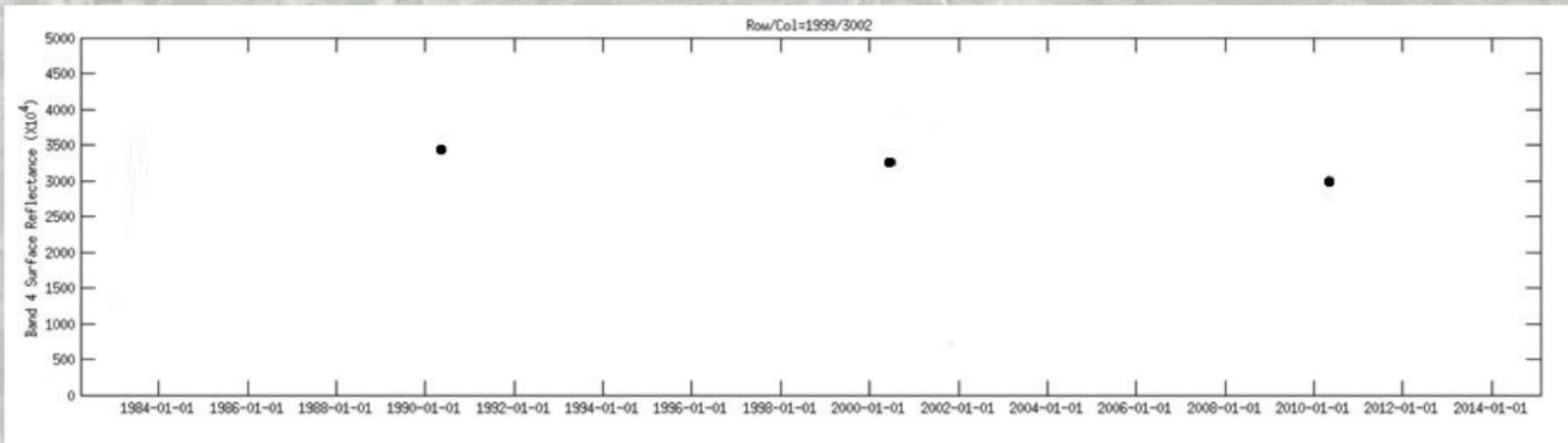
A stylized icon of a camera, representing the 'snapshot' perspective of the data.

Four vintages of the National Land Cover Database (NLCD)

## Limitations of this approach:

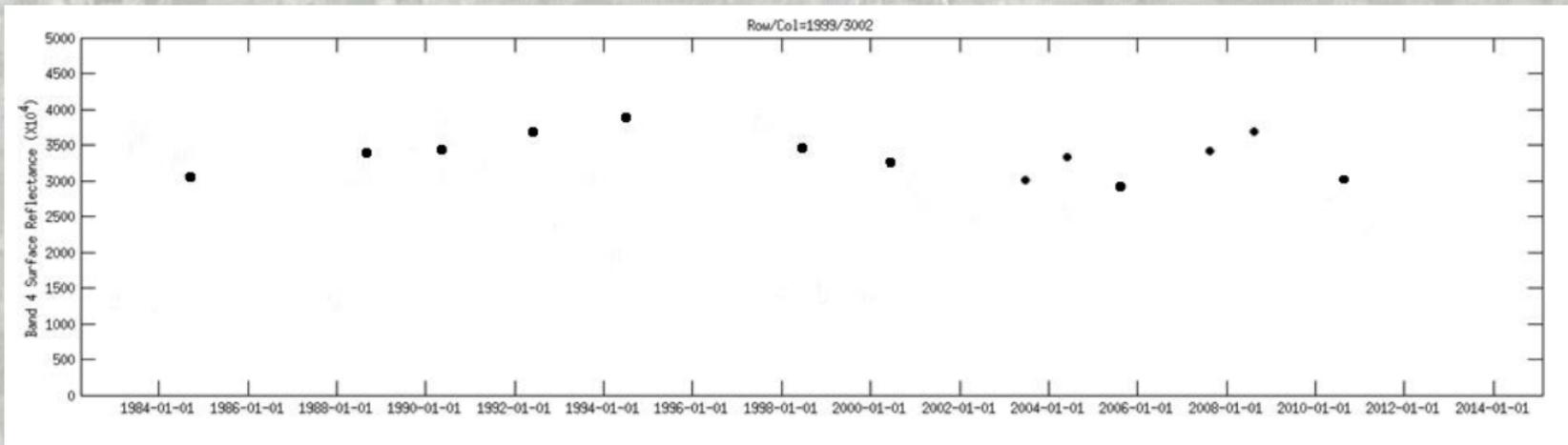
- (1) It takes a lot of time and resources to assemble clear scenes
- (2) There can be a lot of ambiguity in land-cover signatures, depending on atmospheric, phenological, land-management, and recent weather conditions at the time of the satellite overpass

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



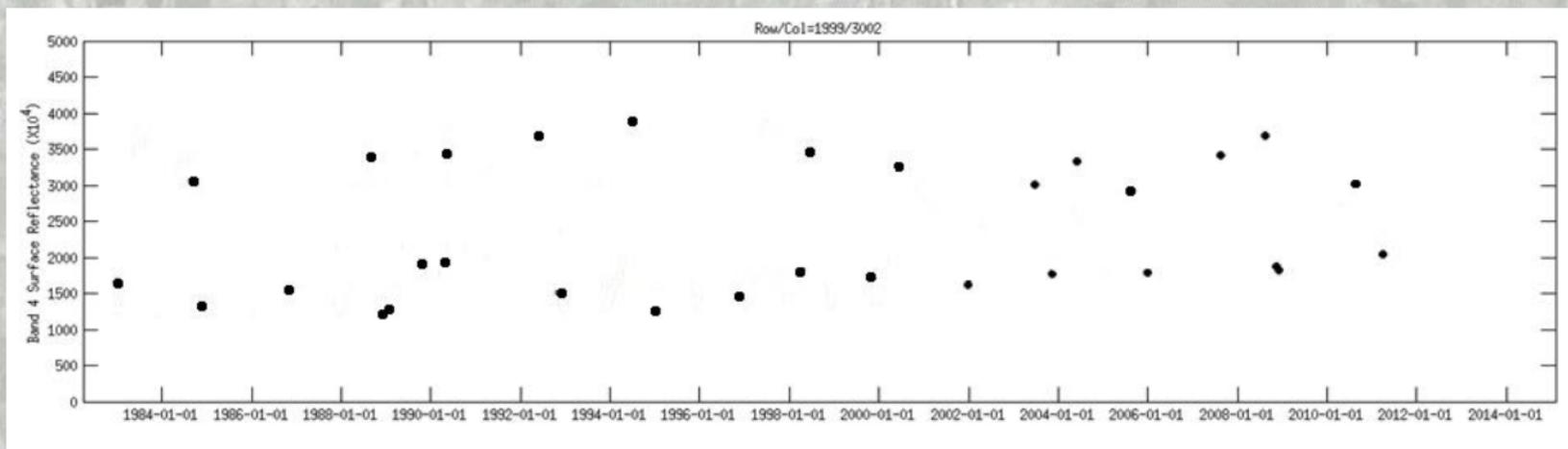
*Landsat NIR (band 4) cloud-screened observations converted to surface reflectance using LEDAPS. Pixel row 1999, column 3002; WRS-2 path 12, row 31*

## Multiple observations: growing seasons 1984–2010



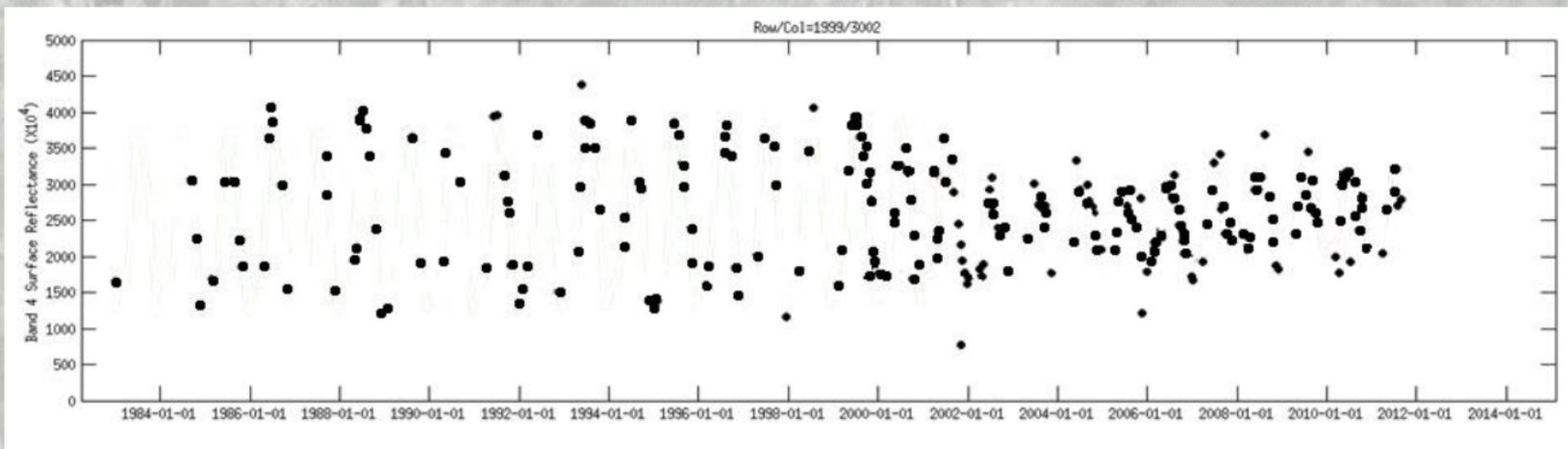
*Landsat NIR (band 4) cloud-screened observations converted to surface reflectance using LEDAPS. Pixel row 1999, column 3002; WRS-2 path 12, row 31*

## Multiple observations: growing and off-seasons 1984–2010



*Landsat NIR (band 4) cloud-screened observations converted to surface reflectance using LEDAPS. Pixel row 1999, column 3002; WRS-2 path 12, row 31*

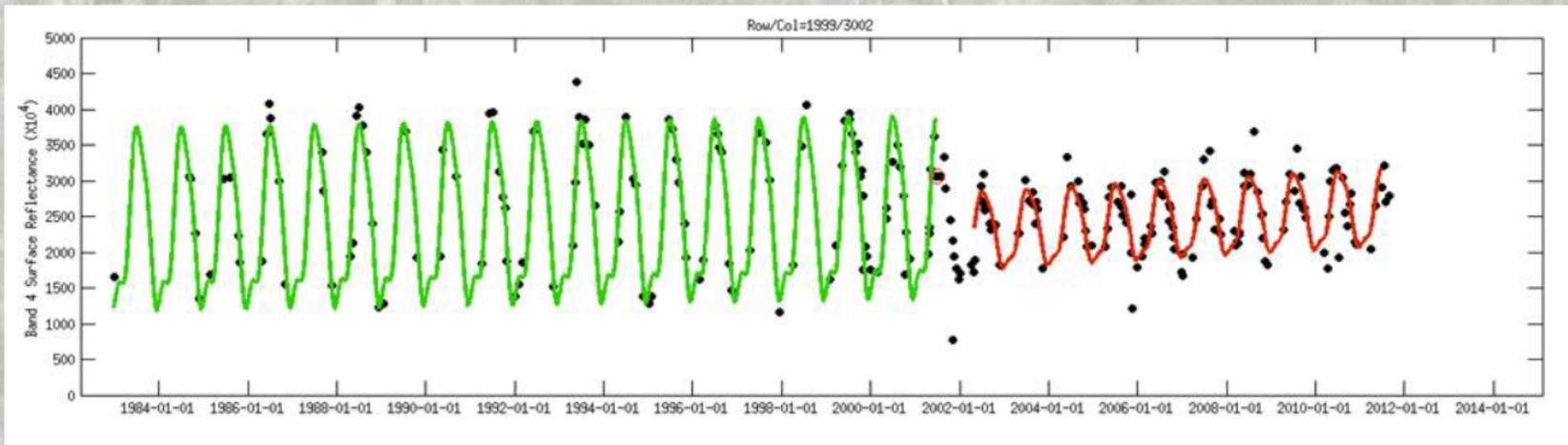
## All clear observations ever acquired for this pixel: 1984–2010



*Landsat NIR (band 4) cloud-screened observations converted to surface reflectance using LEDAPS. Pixel row 1999, column 3002; WRS-2 path 12, row 31*

# A new paradigm for monitoring for change !

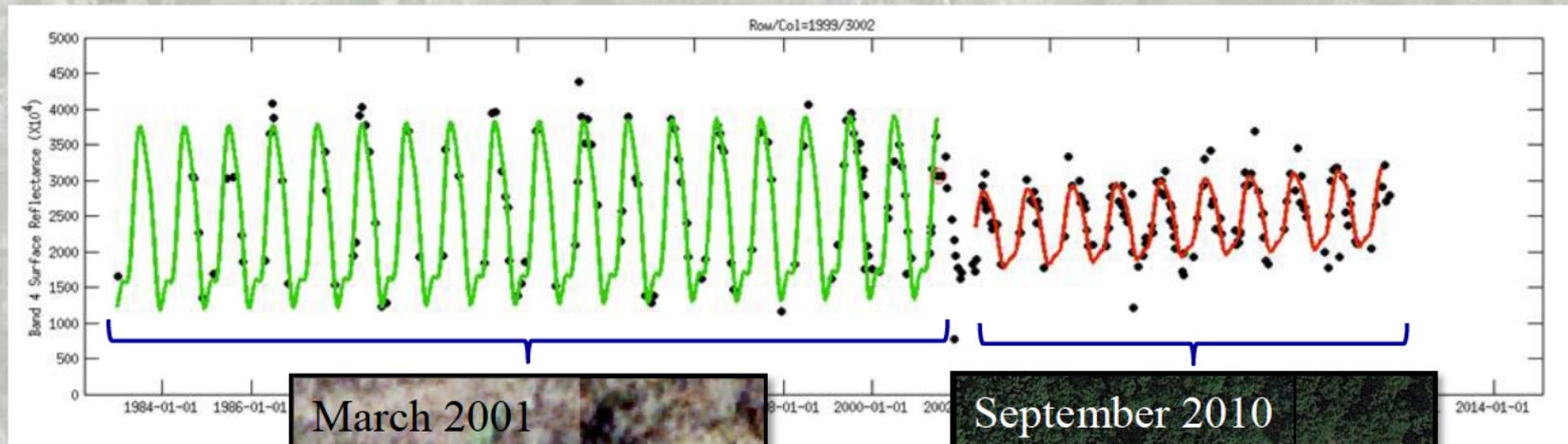
Mathematical prediction models fit to clear observations



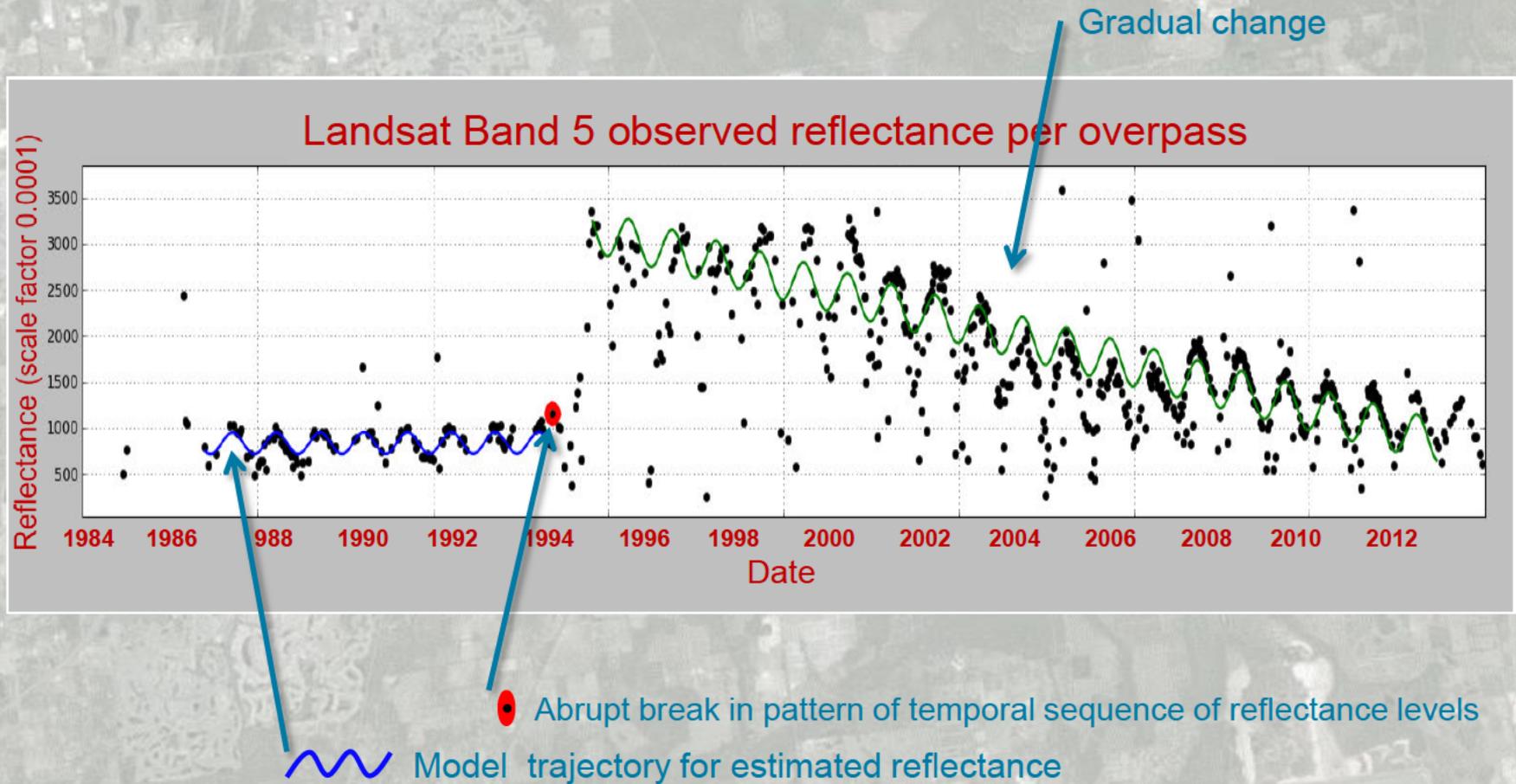
Reference: Zhu, Z. and C.E. Woodcock. 2014. Continuous change detection and classification of land cover using all available Landsat data. *Remote Sensing of Environment* 144:152–171.

# A new paradigm for monitoring for change !

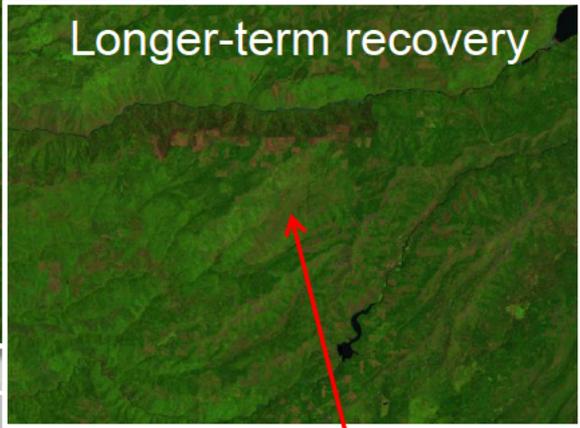
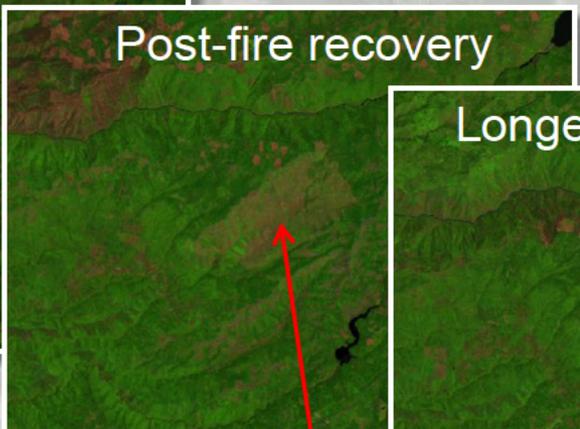
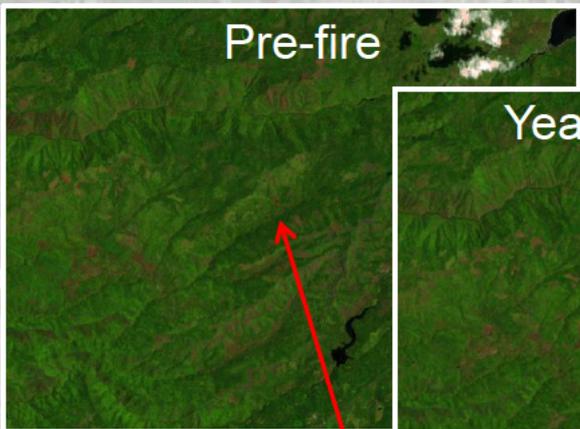
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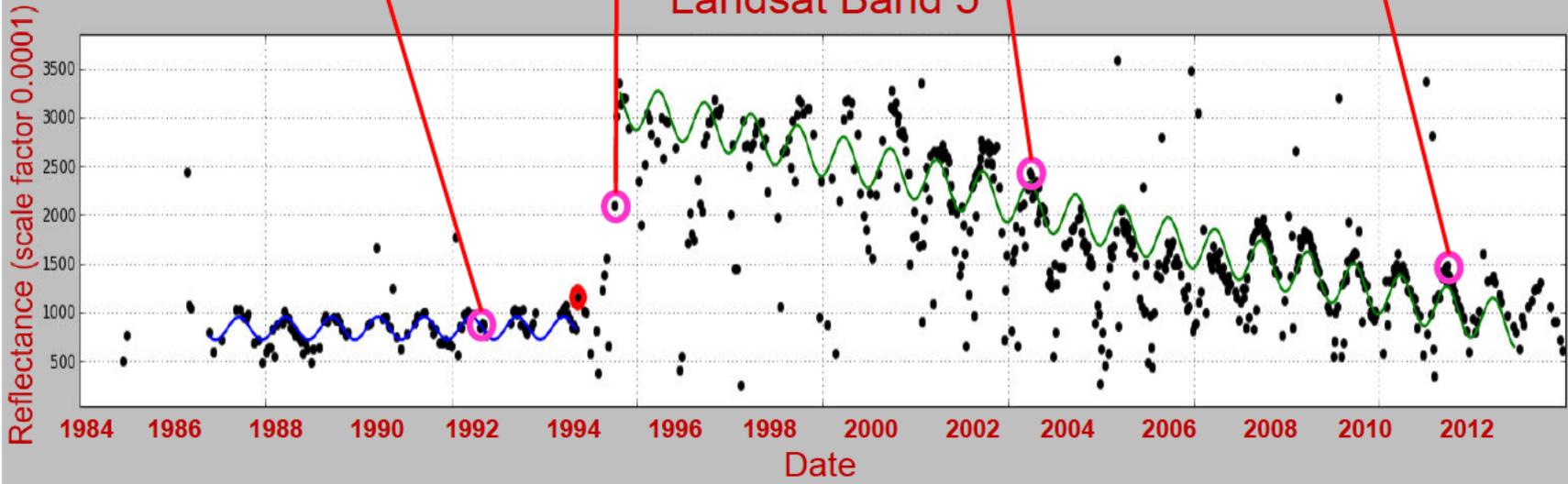
New approach for monitoring land-cover and land-use change:  
Use all available clear observations to track the spectral history of a pixel.



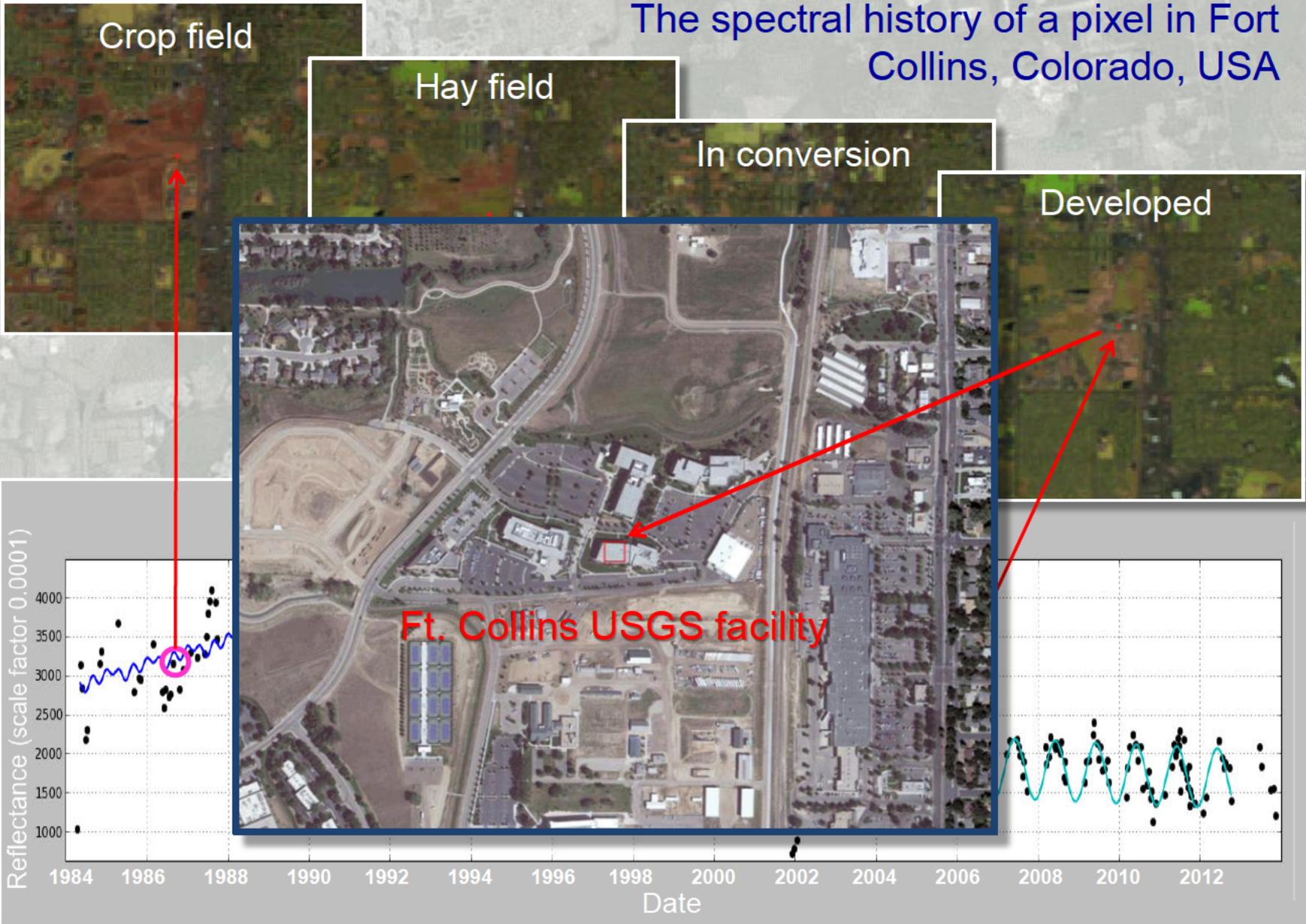
# The spectral history of a pixel in Stanislaus National Forest, California



Landsat Band 5



# The spectral history of a pixel in Fort Collins, Colorado, USA

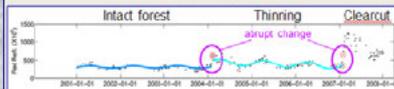


What would it take to support the capability to monitor continuously like this everywhere ?

### Continuous Monitoring

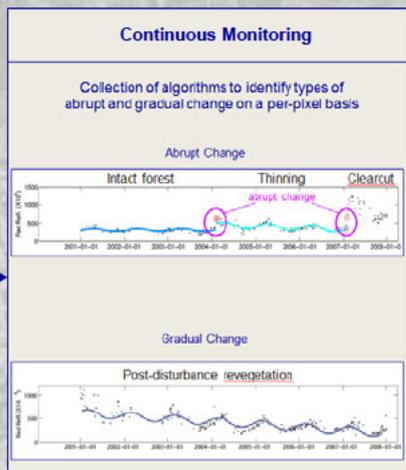
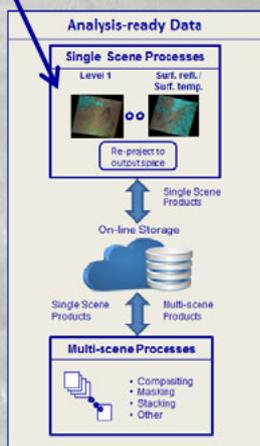
Collection of algorithms to identify types of abrupt and gradual change on a per-pixel basis

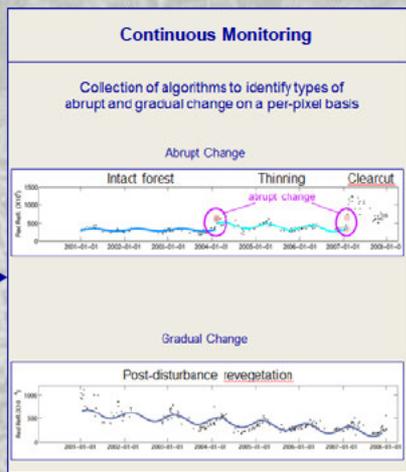
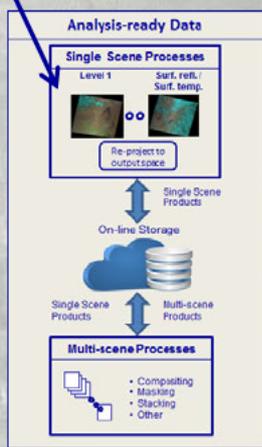
#### Abrupt Change

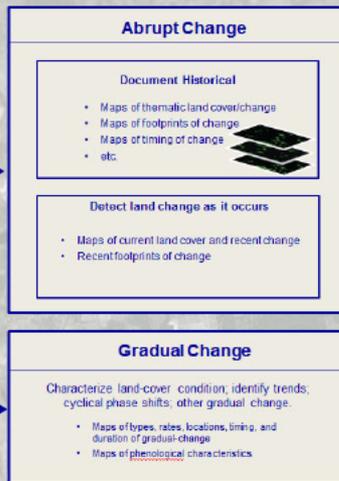
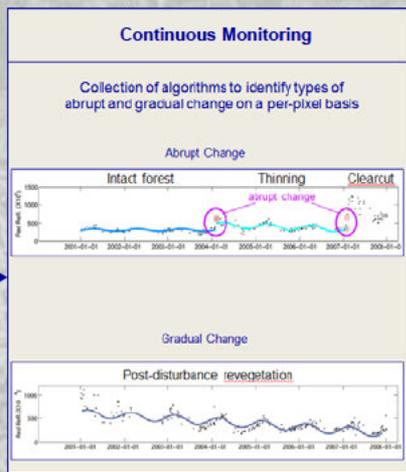
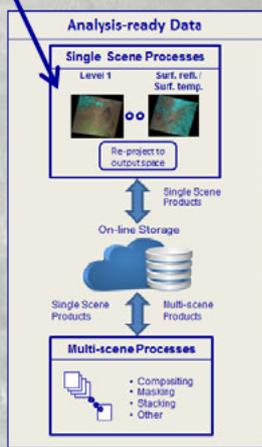


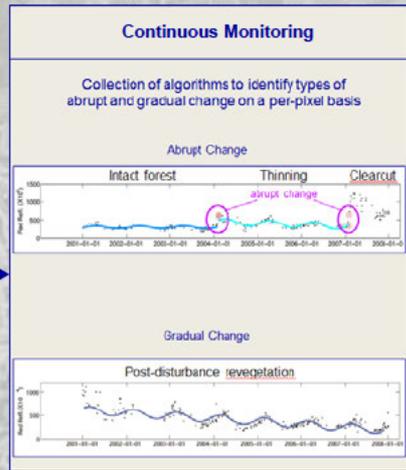
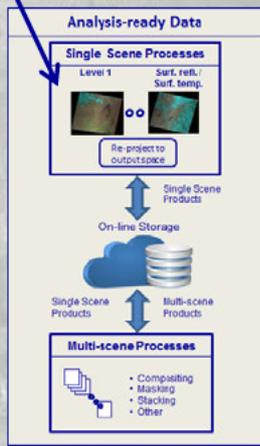
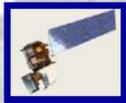
#### Gradual Change



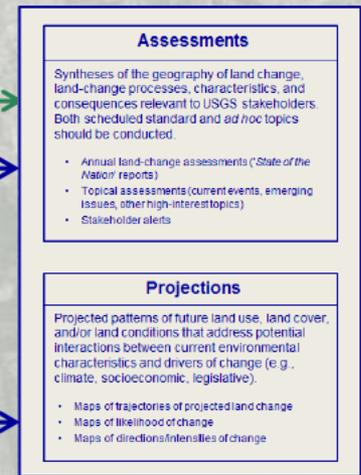








Spatial analyses of change



**Communications, applications services, outreach, and other users and stakeholder support**

- Communications & outreach
- Web-based access to all products
- Web-based analysis portal
- Applications support



**Analysis-ready Data**

**Single Scene Processes**

Level 1  
 Surf. refl. / Surf. Temp.  
 Re-project to output space

Single Scene Products

On-line Storage

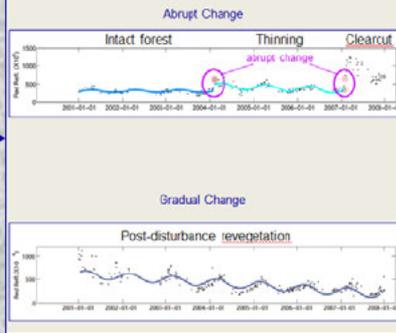
Single Scene Products ↔ Multi-scene Products

**Multi-scene Processes**

- Compositing
- Masking
- Stacking
- Other

**Continuous Monitoring**

Collection of algorithms to identify types of abrupt and gradual change on a per-pixel basis



**Abrupt Change**

**Document Historical**

- Maps of thematic land cover/change
- Maps of footprints of change
- Maps of timing of change
- etc.

**Detect land change as it occurs**

- Maps of current land cover and recent change
- Recent footprints of change

**Gradual Change**

Characterize land-cover condition, identify trends, cyclical phase shifts, other gradual change.

- Maps of types, rates, locations, timing, and duration of gradual change
- Maps of phenological characteristics

Spatial analyses of change

**Assessments**

Syntheses of the geography of land change, land-change processes, characteristics, and consequences relevant to USGS stakeholders. Both scheduled standard and *ad hoc* topics should be conducted.

- Annual land-change assessments ("State of the Nation" reports)
- Topical assessments (current events, emerging issues, other high-interest topics)
- Stakeholder alerts

**Projections**

Projected patterns of future land use, land cover, and/or land conditions that address potential interactions between current environmental characteristics and drivers of change (e.g., climate, socioeconomic, legislative).

- Maps of trajectories of projected land change
- Maps of likelihood of change
- Maps of directions/intensities of change

**Information Warehouse and Data Store**

- Metadata
- Land cover change/condition products
- Outputs from assessments
- Non-Landsat remote sensor data
  - Satellite data
  - Airborne
- Non-Landsat rem. sens. prods.
  - DEMs & derivatives
  - Orthoimagery
  - Evapotranspiration
  - Vegetation phenology
  - Others
- Ground-based data
  - Cal/Val data
  - Land cover accuracy/valid.
  - Others



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**R&D**



**Analysis-ready Data**

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Single Scene Products

Multi-scene Products

**Multi-scene Processes**

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- Other

**Continuous Monitoring**

Collection of algorithms to identify types of abrupt and gradual change on a per-pixel basis

**Abrupt Change**

Intact forest Thinning Clearcut

**Gradual Change**

Post-disturbance revegetation

**Abrupt Change**

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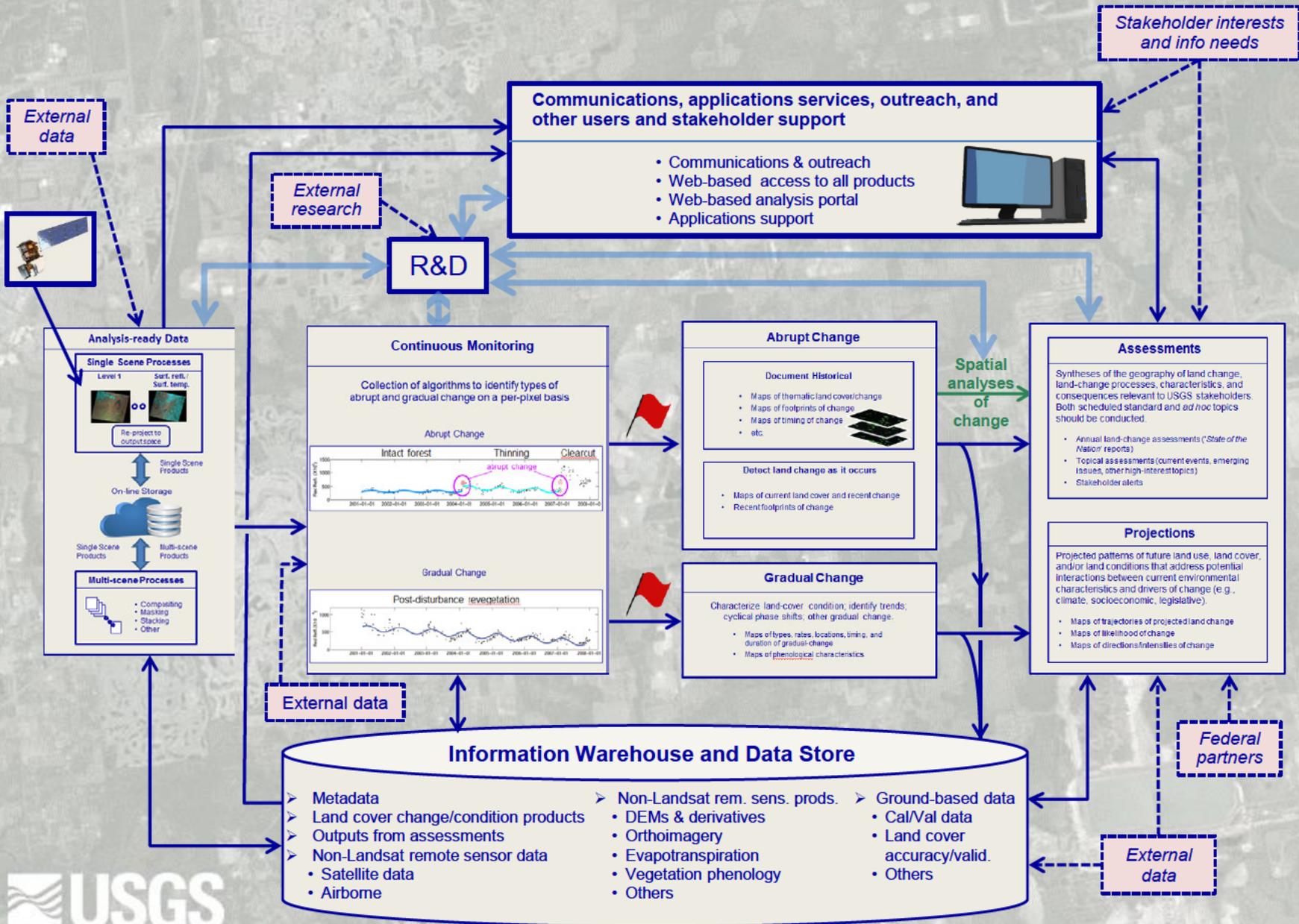
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Stakeholder interests and info needs

External data

External research

R&D

Communications, applications services, outreach, and other users and stakeholder support

- Communications & outreach
- Web-based access to all products
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- Applications support



Analysis-ready Data

Single Scene Processes

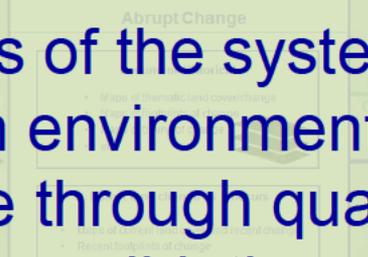
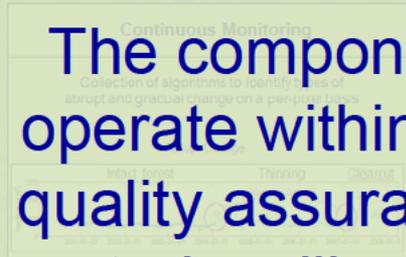


On-line Storage



Multi-scene Processes

- Compositing
- Masking
- Draping
- Other



External data



Federal partners

External data

The components of the system operate within an environment of quality assurance through quality control, calibration, validation, and accuracy assessment.



# LCMAP highlights: What's new?

Perform corrections, projections, masking, tiling, time-series stacking, compositing **for** users.

Get **answers** without moving data.

Implement a collection of automated **continuous-monitoring algorithms**.

Use **every** (pixel-based) **clear observation**.

Detect both abrupt and **gradual** forms of change. Detect change **as it is occurring**.

Produce cyclical and special-topic assessments of land change. Initiate **annual State of the Nation reports** on land change and institute **targeted stakeholder alerts**.

# **Land Change Monitoring, Assessment, and Projection**

*LCMAP ultimately is a capability to continuously track and characterize changes in land cover, use, and condition and parlay 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.*