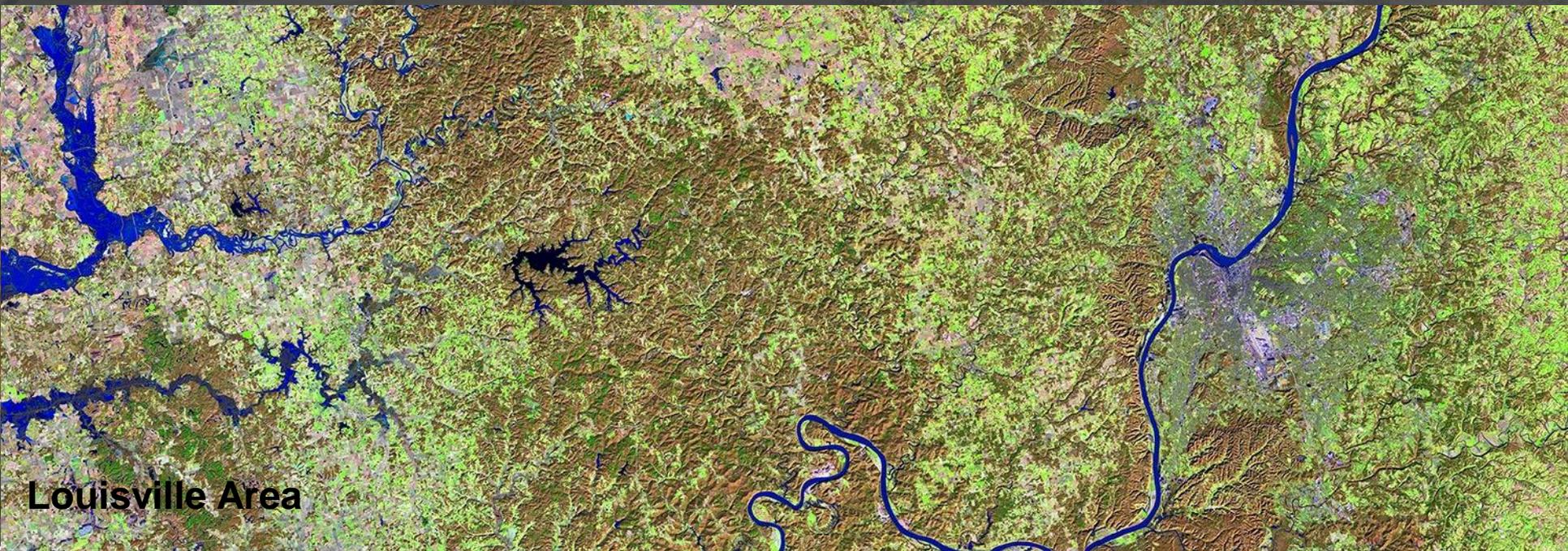


Landsat: *“What to do ... Now and into the Future?”*



Louisville Area

Bipartisan pride in Landsat 8

“Landsat is an American treasure... The data produced by Landsat plays a vital role in managing America’s natural resources and the industries and jobs that rely on those resources.”

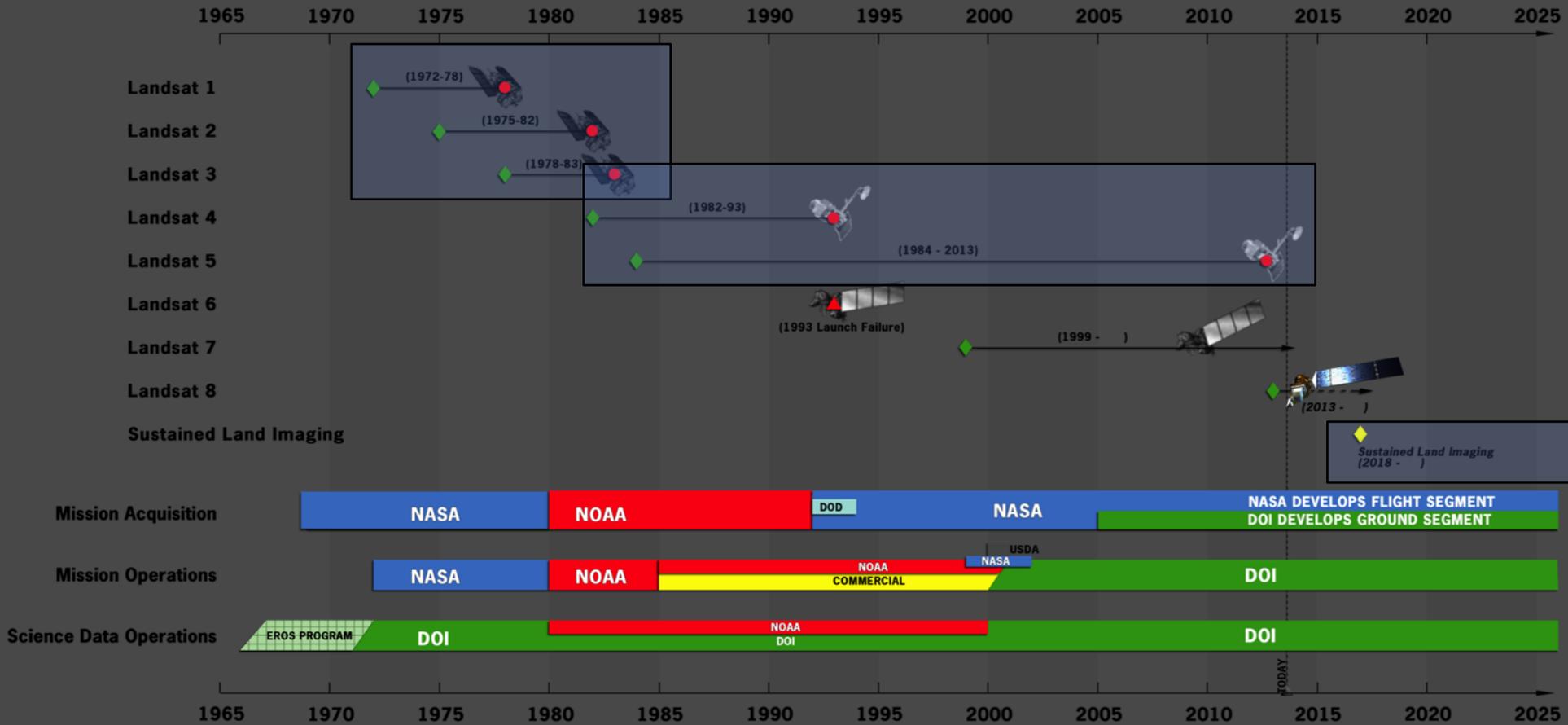
Senator Barbara Mikulski
Maryland

“For over forty years, the Landsat Program has provided a valuable stream of image data of the Earth’s landscape. The newly activated Landsat 8 satellite continues this mission, sending images to the USGS Earth Resources Observation and Science (EROS) Center near Sioux Falls, S.D.”

Senator John Thune
South Dakota



USGS/NASA Landsat Partnership Since 1966



USGS commitment

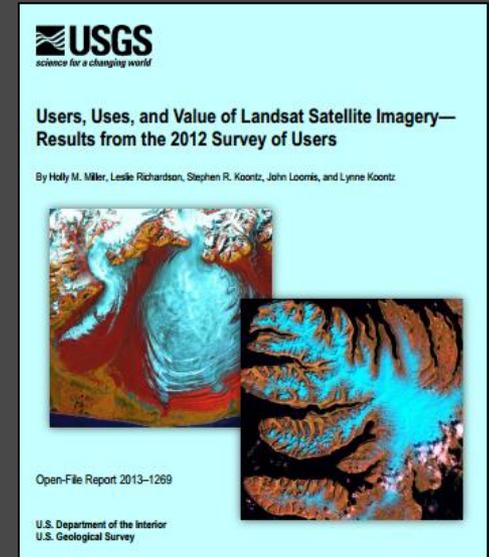
As the operational agency responsible for Landsat, the USGS is strongly committed to data continuity.

Tens of thousands of users rely on Landsat's capabilities.

Studying Land Imaging Users

Landsat User Survey (2013)

- Conservatively estimated Landsat's value to U.S. users at \$1.8B/year
- 1/3 of users classified themselves as “operational”.
- 1/4 of users relied completely on Landsat.
- 3/4 of users, Landsat was the major data source but they used a mix of satellite imagery.
- If Landsat imagery were no longer available, 62% would need to discontinue some of their work.



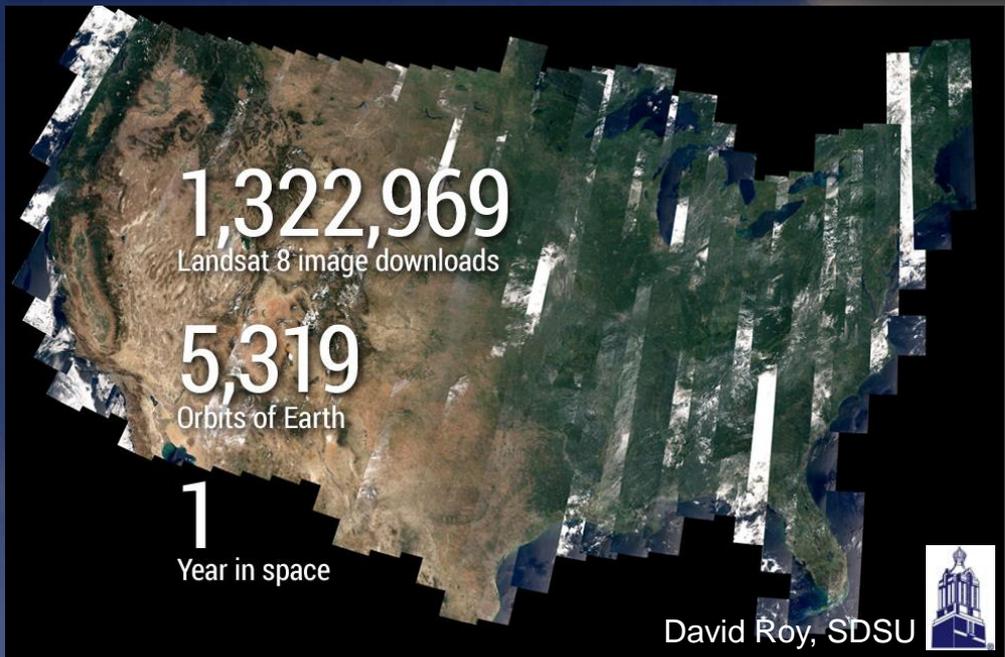
Requirements analysis (2012, 2013, ongoing)

- 2/3 of applications require 8-day repeat (crop productivity, fire assessment, flood monitoring, irrigation management, etc.)
- 1/3 of applications require thermal data

Landsat 8 Launched Feb. 11, 2013

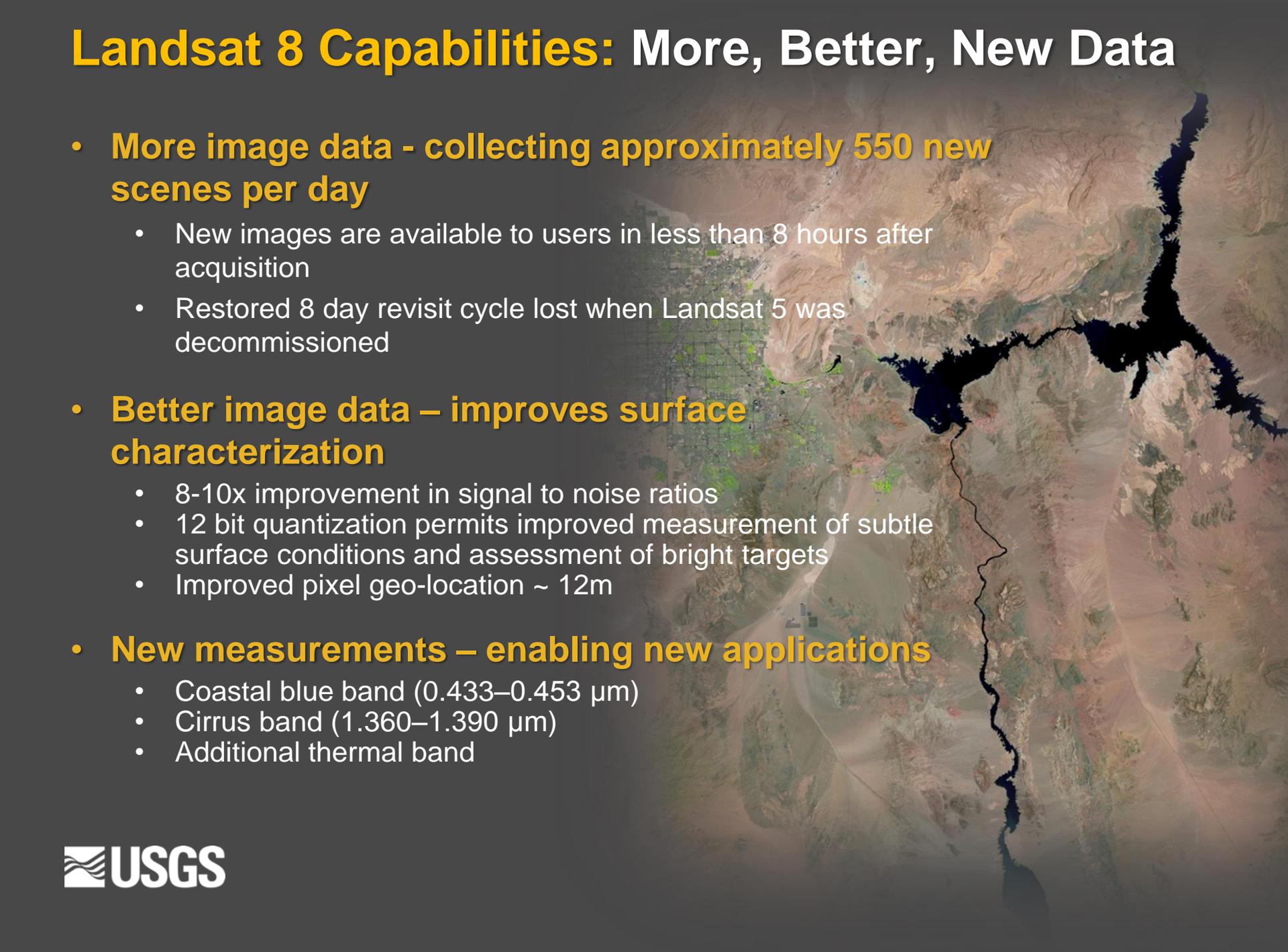


Landsat 8 Operational May 30, 2013



One of the first complete views of the United States from Landsat 8.

Landsat 8 Capabilities: More, Better, New Data

A satellite image of a landscape, likely a desert region, showing a large reservoir on the right side and a city grid on the left. The terrain is a mix of brown and tan colors, with some green patches. The reservoir is dark blue/black. The city grid is visible as a pattern of light and dark squares.

- **More image data - collecting approximately 550 new scenes per day**
 - New images are available to users in less than 8 hours after acquisition
 - Restored 8 day revisit cycle lost when Landsat 5 was decommissioned
- **Better image data – improves surface characterization**
 - 8-10x improvement in signal to noise ratios
 - 12 bit quantization permits improved measurement of subtle surface conditions and assessment of bright targets
 - Improved pixel geo-location ~ 12m
- **New measurements – enabling new applications**
 - Coastal blue band (0.433–0.453 μm)
 - Cirrus band (1.360–1.390 μm)
 - Additional thermal band

More Data: Managing Landsat 7 and 8 as a Constellation

- Landsat 8 is being used to extend the capabilities-and lifespan-of the Landsat 7.
 - Landsat 7 recently went to a continental landmass acquisition strategy.
- Capturing images of islands has shifted to Landsat 8
 - The change helps to conserve the resources of Landsat 7
- **Result – more data being acquired by both satellites.**
 - Landsat 7's output has increased from 375 to 450 scenes per day while at the same time prolonging the life of the ETM+.
 - Landsat 8 is also collecting more than its anticipated 400 scenes per day – currently scheduling 550 images per day.

1000 scenes per day going to the Archive

Better Data: Landsat 8 Lunar Image

June 24, 2013

Landsat 8 calibration and instrument teams are scanning the moon, which is a very bright object with a very dark background, as a means to help further calibrate both TIRS and OLI.

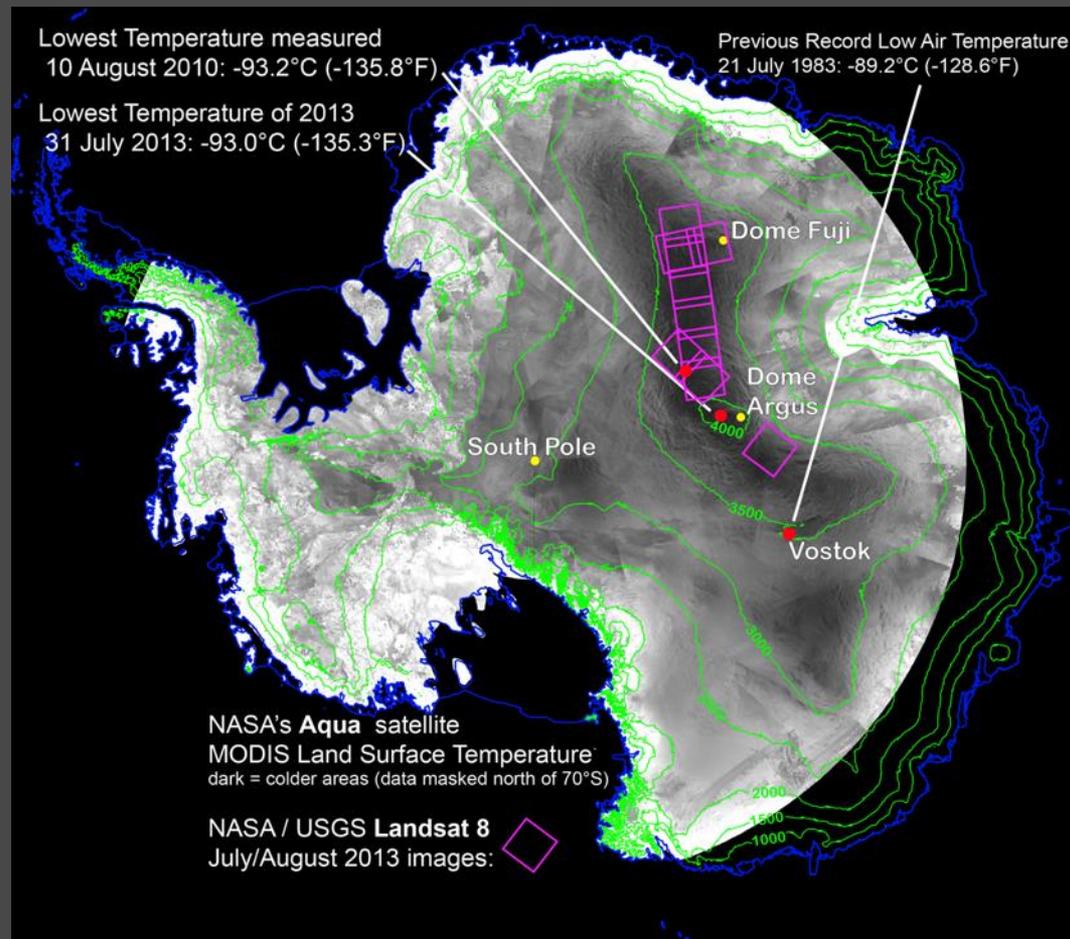


New Data: Landsat 8 measures the coldest place on Earth

Temperatures from -134 to -137 F in a 1,000-kilometer long swath on the highest section of the East Antarctic ice divide.

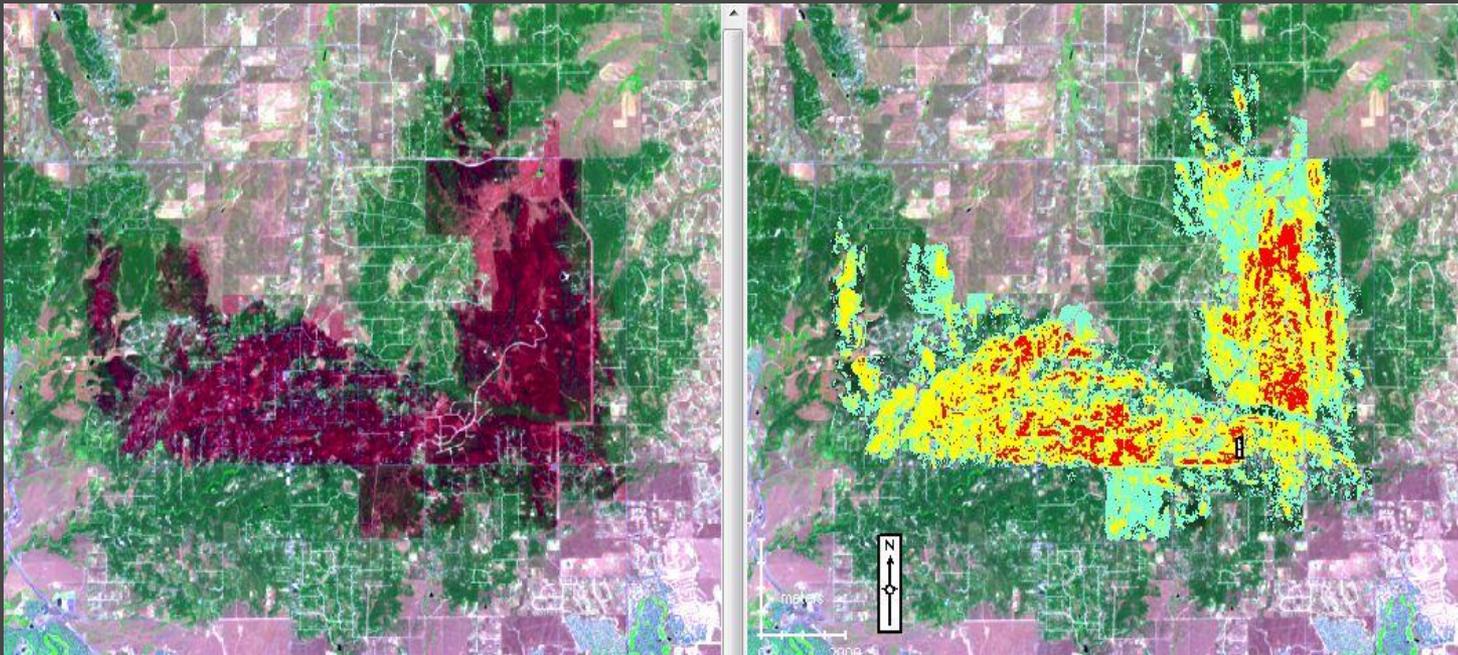
The measurements were made between 2003-2013 by MODIS and during the 2013 Southern Hemisphere winter by Landsat 8.

“Landsat 8 is still a new sensor, but preliminary work shows its ability to map the cold pockets in detail,” Scambos said. “It’s showing how even small hummocks stick up through the cold air.”



Science and applications using Landsat 8

- More than 5500 Landsat 8 scenes used for 2013 LandFire update
- Used in 2013 Monitoring Trends in Burn Severity project
- Providing NLCD with improved shrub land maps



Black Forest Fire, Colorado Springs

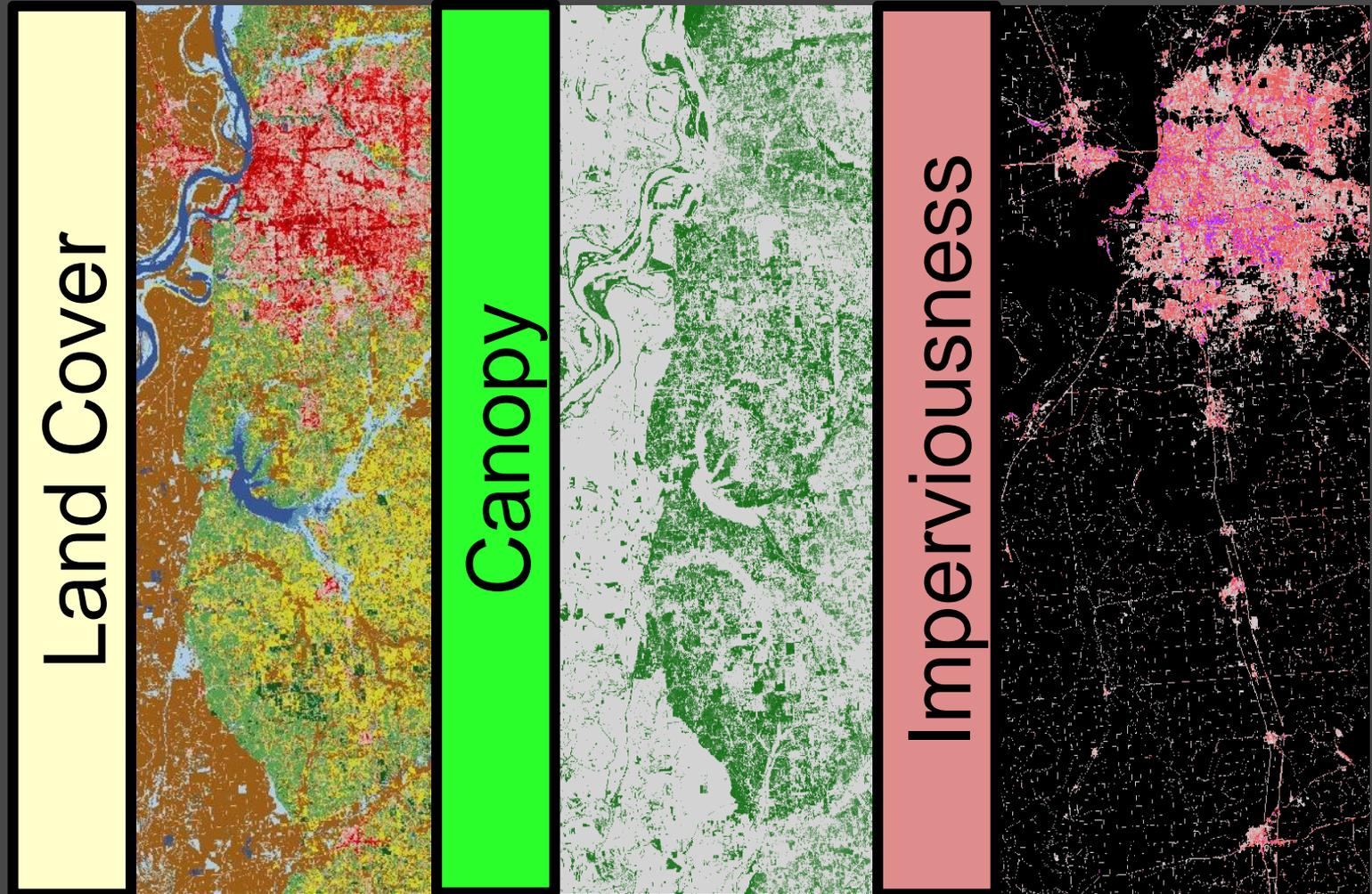
National Land Cover Database (NLCD)



NLCD 2011 is a Landsat derived 30m cell land cover change database covering the United States created by **10 Federal partners (MRLC)** using 2011 imagery

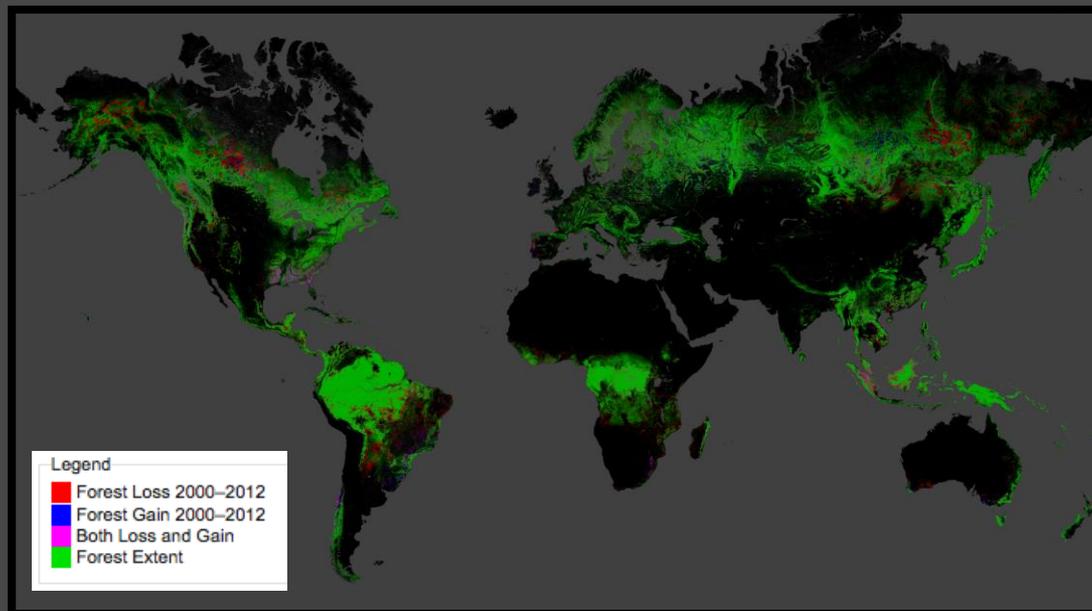


National Land Cover Database – 2011



NLCD 2011 contains 3 primary products – land cover, percent tree canopy and percent urban imperviousness, all shown here for the same geography over Memphis, TN

Global Forest Cover Gains and Losses - 2000 to 2012



What supports these studies?

Long-term continuity and Long Term Acquisition Plans

Free data policy

- Over 650,000 Landsat 7 scenes. Would have cost ~\$392M without the free data policy.

All Landsat data orthorectified and calibrated to a common radiometric standard

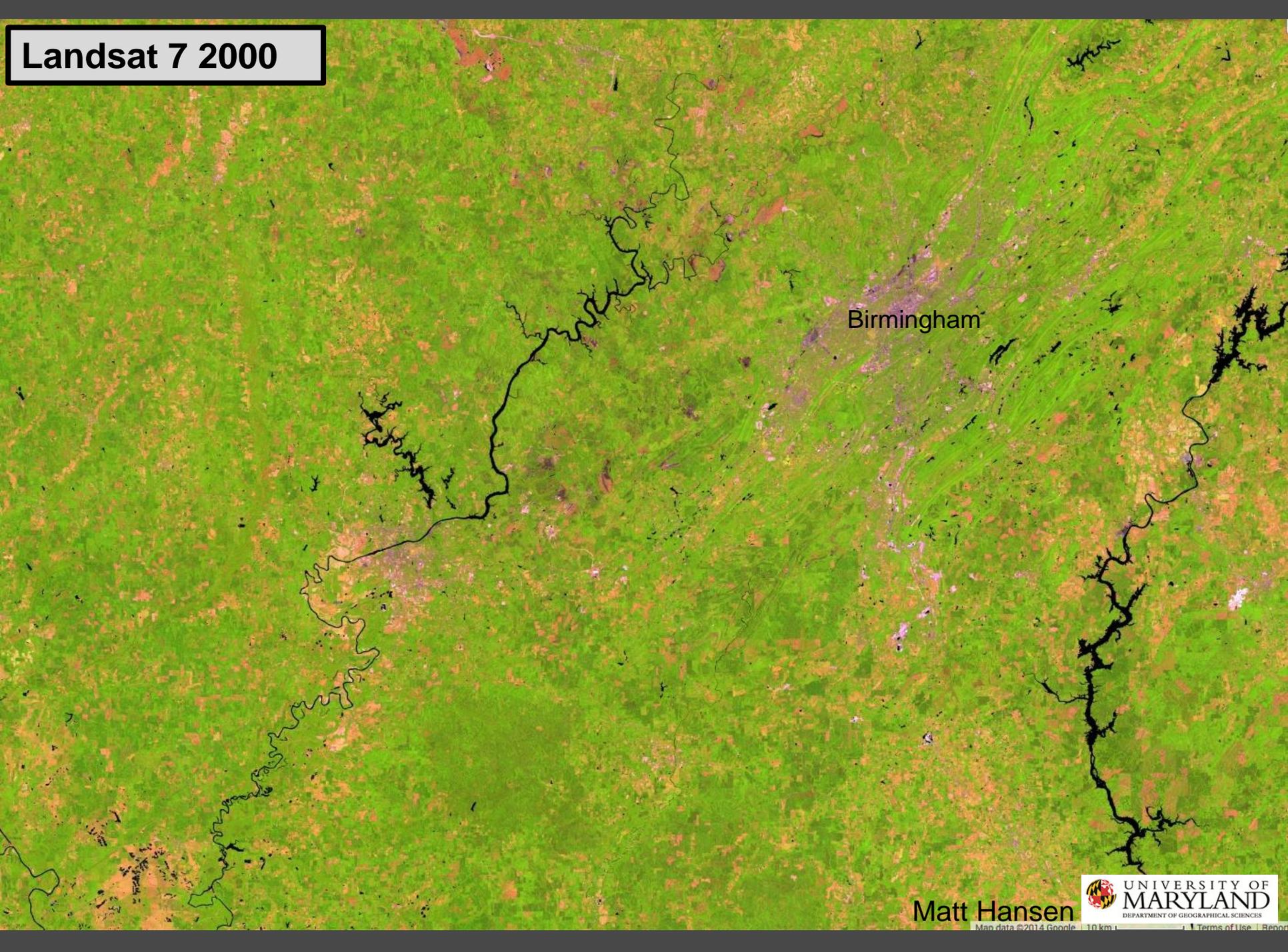


<http://earthenginepartners.appspot.com/science-2013-global-forest>

Matt Hansen



Landsat 7 2000



Birmingham

Matt Hansen



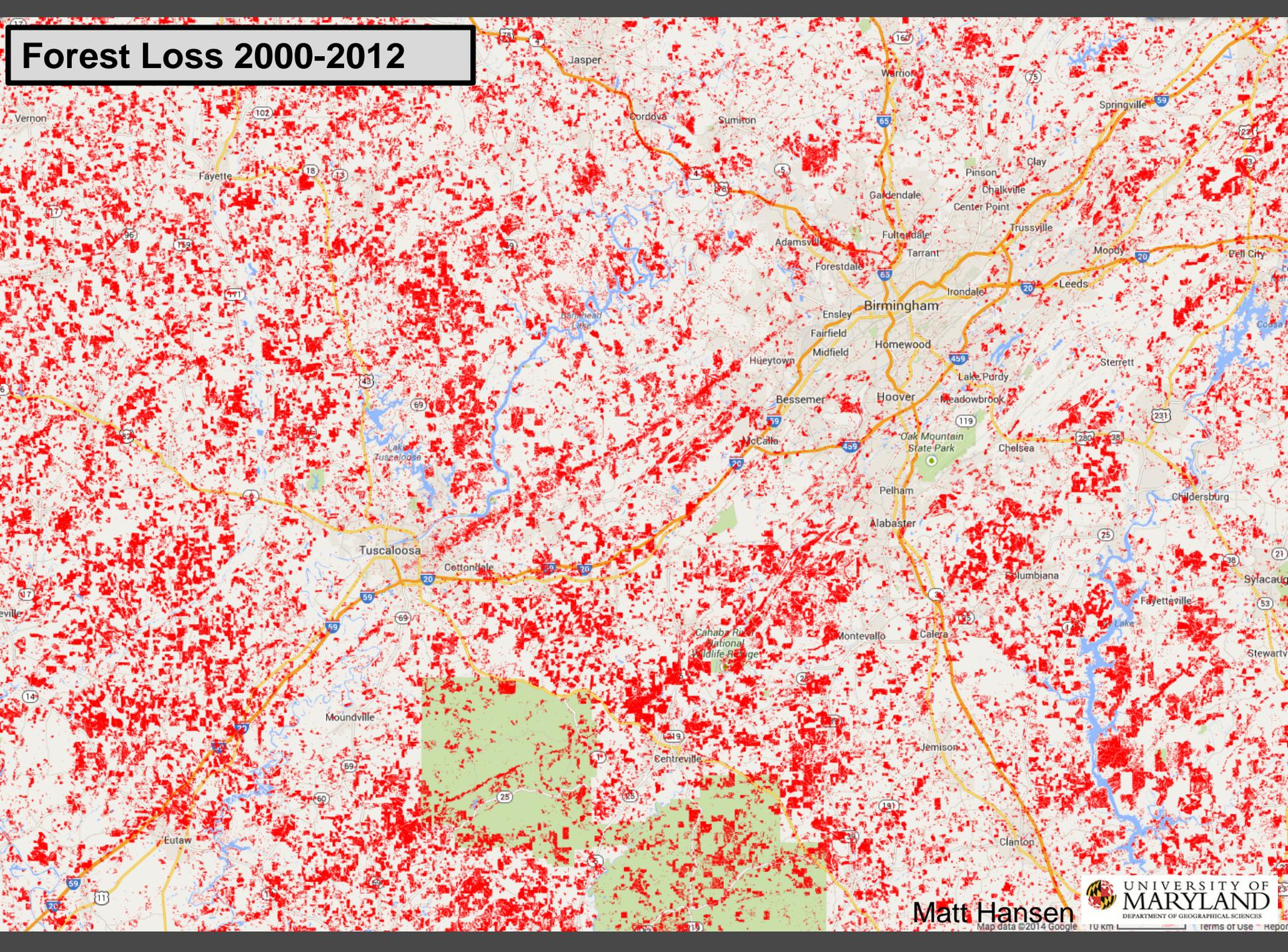
Landsat 7 2012

Birmingham

Matt Hansen



Forest Loss 2000-2012

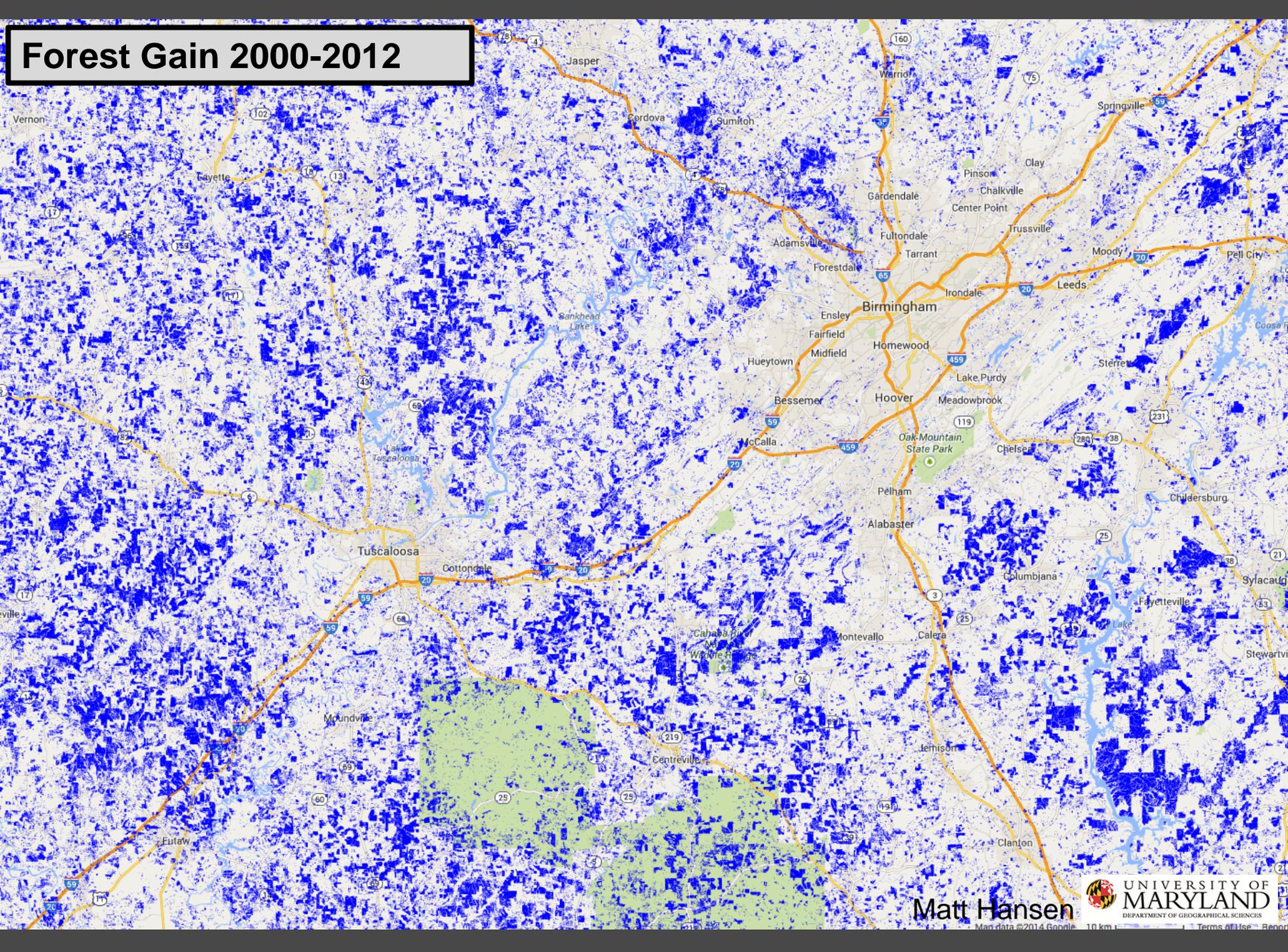


Matt Hansen

UNIVERSITY OF MARYLAND
DEPARTMENT OF GEOGRAPHICAL SCIENCES

Map data ©2014 Google 10 km Terms of Use Report

Forest Gain 2000-2012



Matt Hansen



Legend

- Forest Loss 2000–2012
- Forest Gain 2000–2012
- Both Loss and Gain
- Forest Extent

Birmingham

Matt Hansen



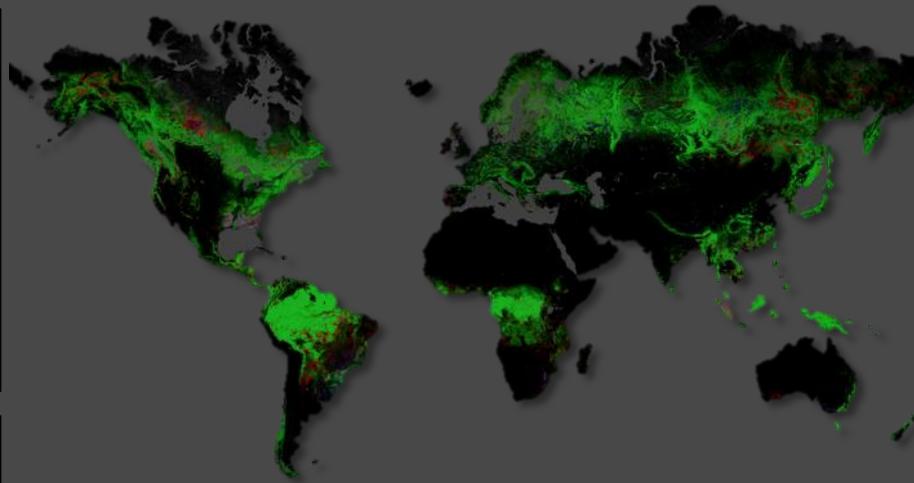
Land Change Science

Monitoring, Assessment, and Prediction

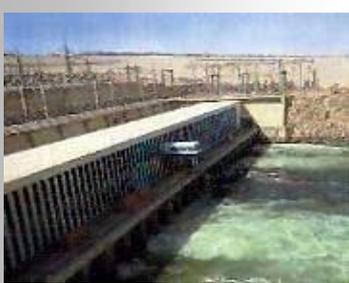
Understanding patterns, processes, and consequences of land change, as it occurs, using a framework that is globally consistent and locally relevant – and that meets the needs of decision makers.



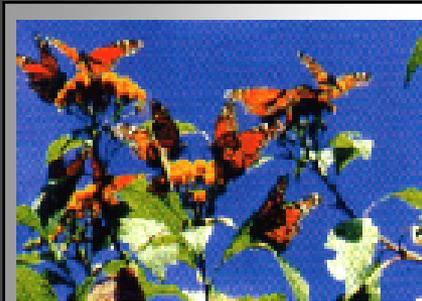
**POPULATION /
LANDCOVER**



HUMAN HEALTH



**WATER
RESOURCES**



BIODIVERSITY

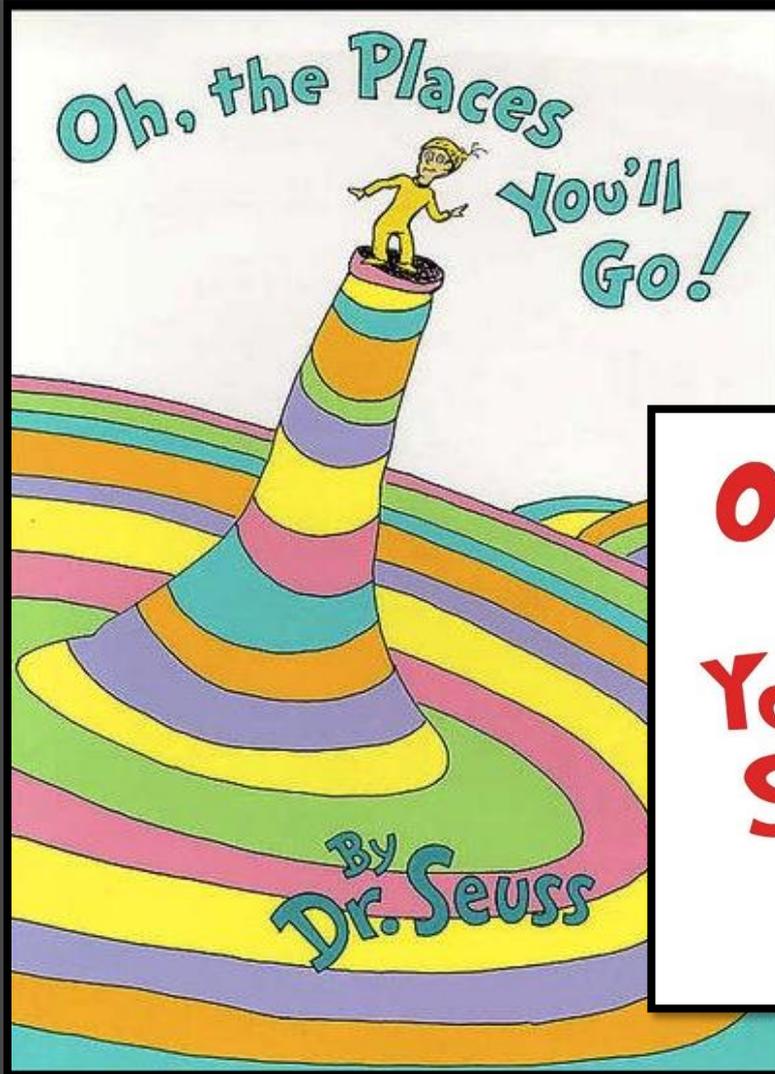


AGRICULTURAL / FOREST



**NATURAL DISASTER
MANAGEMENT**

Oh, the places Landsat will go.....



Oh the places you'll go,
Today is your day!
Your MOUNTAIN is waiting,
So ...get ON your way!

--Dr. Seuss

Existing situation

- Although Landsat 8 is operational, **Landsat 7 is well past its design life** and will run out of fuel in the next 3-4 years.
- Landsat 8 has ten years of fuel, while the instruments have a **three-year (TIRS)** and **5-year (OLI) design life**.
- That means **in about three years there's a significant threat** to both spectral (thermal) and temporal (8-day revisit) continuity.



Solving a 40-year problem

- We are **on the verge** of solving a decades-old budget problem.
- The Landsat satellites provide extraordinary value to the Nation's Earth science, natural resource management, and economy, **but have never had solid budgetary footing**. As each satellite ages, its successor is funded on a one-time emergency basis.
- There is currently support from the Administration and bipartisan support within the Congress for making the program “operational”, with the successful NASA/USGS partnership **for a sustainable land imaging architecture**. **The 2014 direction to develop a long-term plan is an excellent step forward**.
- The next Landsat space segment will be funded out of the Sustainable Land Imaging budget line under the NASA Earth Science Division. **USGS and DOI are working with NASA to meet near and long term needs**.

Existing direction

- The Administration has directed **NASA** to study options for a future sustained land imaging system, in collaboration with **USGS**, and report results by August.
- The study is to define **a system for sustained global land imaging** multispectral and thermal infrared information for an approximately 20-year period starting in 2018.
- This is **an outstanding opportunity** to place Landsat into the category of a **sustained, operational program**, on the same level as GPS and the weather satellite programs.



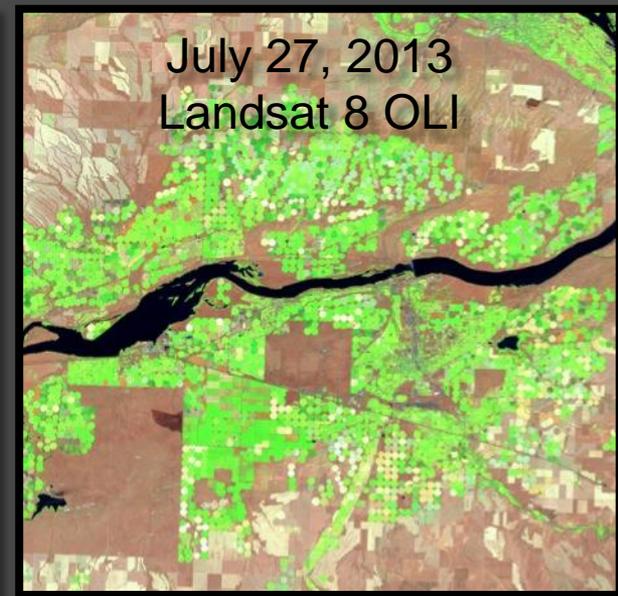
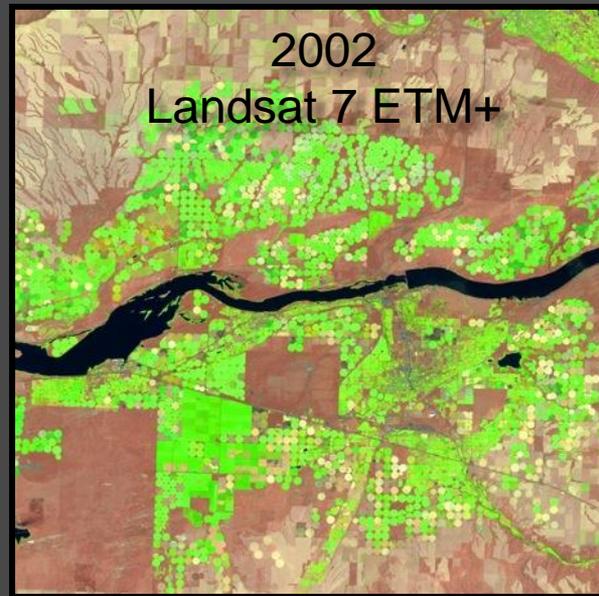
What to do

- The USGS is participating in the study representing user requirements.
- Ongoing work has focused on possible solutions—full spectrum capabilities, hyperspectral, international collaboration.
- The timeline calls for delivery of the report in the next several months. And as we all know, it takes 4-6 years to develop and build a new system.
- Our near-term problem remains.



Stepping forward with care

- The **Senate understands** the need for a near-term solution.
- Commerce Science and Justice, FY14...**"Committee is highly skeptical of either a hosted payload or international partner concept for Landsat 9"** and "discourages NASA from spending an inordinate amount of time or funds" on some alternate approaches, which already have been considered on multiple occasions over the past four decades and have only distracted and delayed **the inherently governmental role in preserving the continuity of Landsat data."**



NASA/USGS Landsat Roles

NASA:

- Develops sensors, satellites, and launches land imaging space systems
- Co-chairs USGS-funded Landsat Science Team
- Performs Earth-system measurements and research using land-image data

USGS:

- Documents user land imaging requirements
- Develops ground systems for land imaging space systems
- Operates land imaging satellites
- Collects, processes, archives and disseminates land-image data
 - Establishes global land-coverage acquisition strategy
 - Coordinates International Partner ground receiving station network
 - Distributes data and information products at no charge
 - Develops new data products and applications

Steering a direction....

- We must reduce mission costs. One feasible way is to reuse flight and ground system hardware and software wherever possible.
- Buying systems on-orbit--allowing space system builders to provide launch services--is another possible way to reduce costs
- Taking a 'block buy' approach - as in earlier Landsat missions
- In short, a reduction in mission costs is possible, but will require a change in current program acquisition practices.
- Taken together, these approaches could conceivably reduce costs down to the level specified by the Senate language - \$650M

USGS is studying Landsat's user needs...

Cannot afford to lose....	Can afford to consider options..	Would like to have....
8-day revisit – Two satellites on-orbit	>185 km swath width	More frequent observations – reduced revisit times
30m-resolution	International Cooperator network	60m-resolution thermal observations
12 bit quantization	WRS-2 orbit	Expanded daily acquisitions (continuous mode)
Multispectral bands	Panchromatic band	15m- resolution red and NIR bands
On-board calibration	Off-nadir viewing capabilities	
10am Equatorial crossing		

What are we waiting for....

- As we all know, Washington loves to do studies.
- USGS is eager to participate, and is working hard with NASA.
- Recent studies have demonstrated **Landsat is an essential tool for:**

- | | | |
|-----------------------------------|-------------------------------|---|
| • Agricultural | • Deforestation | • Land Use/Land Cover Classification |
| • Mapping | • Global Change | • Water Resources Management |
| • Fire/Disaster Management | • Flood management | • Glacier Monitoring |
| • Carbon Inventory/Credits | • National Security | • Insurance Risk Management |
| • Land Use Planning | • Ecosystem Management | • International Treaty Management |

- Landsat is clearly in the **top-most tier of the Nation's earth observation missions**, alongside other critical space infrastructure like GPS and the weather satellite programs.

Today is our day...let's get on our way

USGS sees two connected challenges:

- **Near-term** need for observational continuity given:
 - Landsat 7 reaching end of fuel in the next 3-4 years
 - Landsat 8 Thermal Infrared Sensor design life of 3 years (Class C instrument)
- **Long-term** need to ensure continuation and continual improvement of satellite-based land imaging

Both challenges need to consider:

- Observational requirements necessary to **preserve continuity** with the 42-year archive
- **Risk tolerances** of this operational program
- Goal of **lowering the overall costs** associated with:
 - Building, launching and operating future space segments
 - Ground systems and data and information archival processing systems

“We do not inherit the Earth from our ancestors, we borrow it from our children”

Ralph Waldo Emerson

1972

**3.9 Billion people
9.4 acres
per person**

1999

**6.0 billion
6.2 acres
per person**

2014

**7.0 billion
5.2 acres
per person**

2054

**9.0 billion people
4.0 acres
per person**

