Staying Alert: Spotting Deforestation with Landsat

Laura E.P. Rocchio

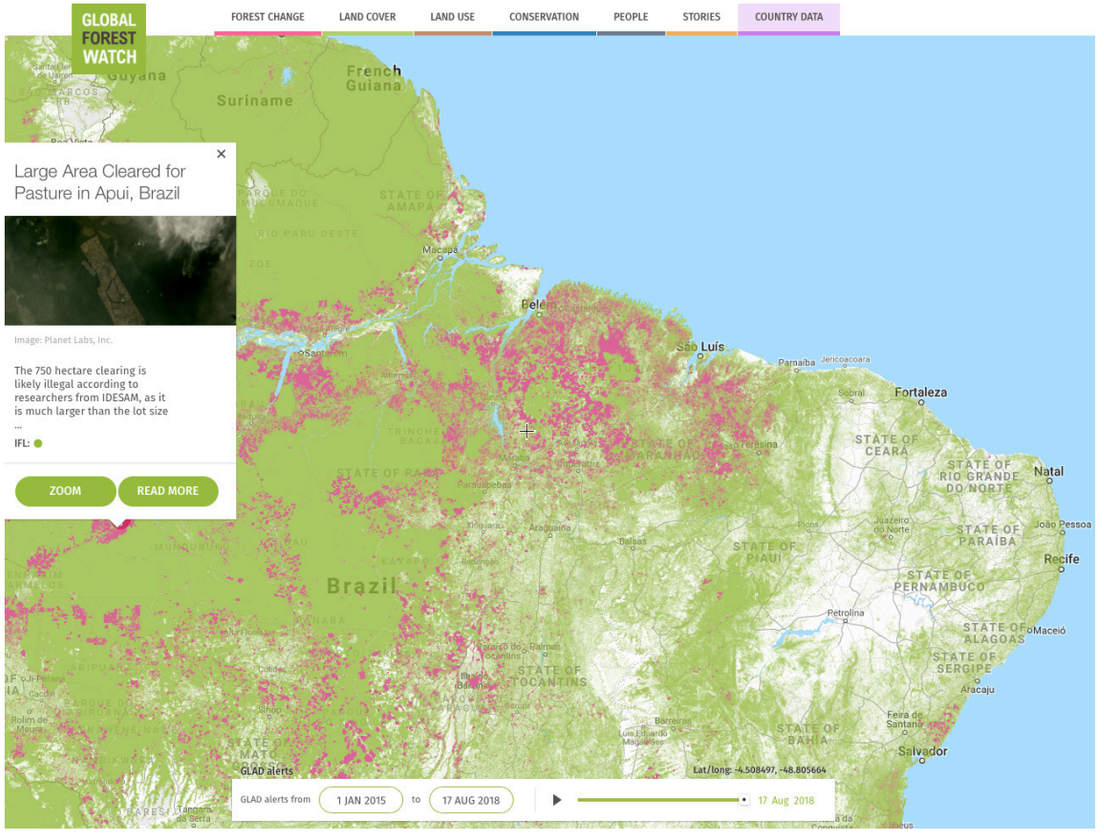
Forests are commodities. The biggest driver of deforestation worldwide is the economic value of trees and the land they stand on. With the high demand for agricultural land and wood products, deforestation has become an intractable problem.

To address this dilemma, the World Resources Institute, a not-for-profit, non-governmental research organization, released a Landsat-based alert system in 2016 as part of its Global Forest Watch (GFW) program. When a new road appears in the dense forests of Peru, or a baseball diamond-sized patch of forest is felled in the Republic of Congo or in Indonesia, anyone with an Internet connection can be alerted to the loss.

That's near-weekly alerts for changes smaller in size than a football field. That combined detail and pace makes this deforestation alert system revolutionary. Using Landsats 7 and 8 together, forests are potentially imaged every eight days. That revisit time, or data cadence, together with Landsat's 30-meter spatial resolution, allows land managers to know when small incursions into forests are being made—in time to respond before major damage has been done.

Caring about land stewardship goes beyond just forest managers. Frances Seymour, a senior fellow at the Center for Global Development, points out, "Government agencies, civil society watchdogs, and companies trying to get deforestation out of their commodity supply chains can all use these alerts to target their efforts and mobilize quick response."

Global Forest Watch—whose goal is to provide decision makers with timely information about global forests—teamed up with the University of Maryland's Global Land Analysis and Discovery (GLAD) team and scientist Matt Hansen to make these near-weekly alerts happen. The three essential ingredients are freely-available Landsat data distributed by the United States Geographical Survey (USGS), the Hansen-GLAD tree cover loss algorithms, and big data computing power like that of Google's Earth Engine. All of this is wrapped up and distributed via GFW's user-friendly mapping interface. ▸



Above: The protected forests of Alto Mayo, Peru. Photo credit: Bruno Locatelli, Center for International Forestry Research (CIFOR)

In-page: Pink pixels in the GFW-GLAD alerts indicate a change in forest cover. GFW provides weekly alerts as well as detailed, comprehensive yearly deforestation measurements made using Landsat data. A comprehensive view of deforestation that occurred between January 1, 2015–August 17, 2018 is shown here.

Opposite: Transporting logs along a logging road in Gunung Lumut, East Kalimantan, Indonesia. The detection of new roads in tropical forests is important since they are often a harbinger of deforestation. Photo credit: Jan van der Ploeg, CIFOR

Above: A red earthen road through an oil palm plantation in Brazil. The palm plantation replaced the native forest. Photo credit: Miguel Pinheiro, CIFOR

As of summer 2018, the GLAD alerts were tracking forest changes in 22 countries in South America, Central Africa, and Southeast Asia as well as Russia's Far East boreal forests.

Use of the alert system by stakeholders is growing. In Uganda, for example, the Jane Goodall Institute has taught government rangers how to access the GLAD alerts so they can respond to illegal deforestation events. And, the World Resources Institute has created a GLAD-based "Places to Watch" identification tool that provides a monthly list of locations where new deforestation is most concerning—like in remote undisturbed forests and protected areas.

"When old growth forests are logged, what is the legal context?" asked Hansen, "If such activity occurs in a protected area, it is likely illegal. However, official forest land use plans are lacking or not openly shared in many countries."

That lack of transparency is a point of legitimate contention. The GLAD forest alert system increases transparency. It tracks forest exploitation, including the nascent stages—new access roads, selective tree removals—so all interested stakeholders in land use development and conservation can have the same set of facts.

"We hope the alerts stimulate improved, consensus-based planning on how remaining high-carbon-stock, high-biodiversity forests will be developed and protected," Hansen said.

As climate change threatens humanity with destructive storms, drought, and sea level rise, tangible forest commodities (food, fuel, paper, and timber) must be weighed against the more indirect ones (carbon sequestration, biodiversity, and clean water). If the alert system can stem the exploitation of tropical old growth forests, the so-called high-carbon-stock, high-biodiversity forests where 90 percent of tree cover loss takes place, it could play a key role in keeping these forests intact and limiting their carbon emissions.

Forests and Climate Change

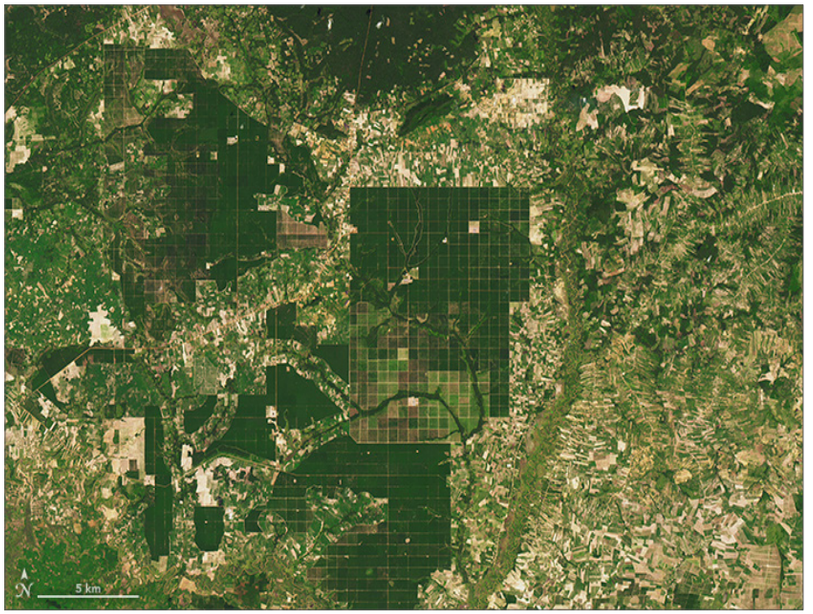
In December 2015, the Paris Agreement recognized the urgent need to respond to climate change and to attempt to keep global warming below 2 degrees Celsius. Drafters of the agreement specifically mentioned efforts to conserve and enhance forests for carbon mitigation.

Forests can be a carbon sink or source. At their height, the daily CO_2 emissions from the 2015 Indonesian fires, which consumed tropical forests and carbon-rich peatlands, were on par with those from the daily economic activity of the entire U.S.

Policy programs like the United Nation's Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (known as REDD+) aim to reduce emissions from tropical forests by giving intact forests an economic value—tropical nations are paid to preserve their forests (on the basis of performance). The linchpin for this type of policy concept is an accurate baseline of forest cover and an unbiased mechanism for monitoring change.

The GLAD forest alert system gives timely forest cover information to any and all stakeholders so they can work together to use forests sustainably and plan for long-term conservation, balancing their need for increased tangible forest commodities with their commitments to emission reduction. It puts tools in the hands of all levels of government, private industry, and locals keen to prevent the irreversible loss and degradation of their forests.

"There's no question that the revolution in remote sensing technology in recent years has already had a dramatic impact on forest management throughout the tropics," said Seymour.



The Landsat 7 and 8 images shown here capture the immense loss of forest that took place in Cambodia between 2000 and 2015. Investment in rubber plantations has been a major economic driver behind Cambodia's rapid forest clearing. Image credit: NASA Earth Observatory

"These systems have changed the politics of forest management both within and between countries.They have empowered environmental activists and indigenous peoples to make visible what is really going on in the world's forests, and how it diverges from what is legal and sustainable."

Making GLAD Alerts Possible

The opening of the Landsat archive by the U.S. Geological Survey in 2008 was the spark that made massive operational systems like the GLAD alert system possible. In his 2016 Environmental Research Letters paper about the system, Hansen penned, "An alert system operating at the scale presented here depends on systematic global acquisitions, robust preprocessing, and free and accessible data. Only Landsat has these criteria at medium spatial resolutions, with Sentinel aspiring to emulate Landsat."

In the February 2016 issue of Nature Climate Change, a team of authors led by Johannes Reiche, from Wageningen University in the Netherlands, explained that the opening of the Landsat archive catalyzed important developments in forest monitoring, allowing the shift to global data time series analysis at a medium spatial resolution. Likewise, in the same publication, Douglas Morton, a research scientist at NASA Goddard, wrote: "Free and open access to the Landsat archive has already spurred scientific innovation and provided a foundation for REDD+ monitoring, reporting and verification."

Landsat imagery is used to inform forest change assessments by a majority of tropical countries. But there are some serious limitations—cloud cover chief among them. Clouds are a persistent feature of humid tropical forests, and many Landsat data collects are obscured by cloud cover.

To counter cloud limitations, researchers have called for acquiring data more often. Greater image cadence—a faster drumbeat of data—would help dodge clouds issues.

Above: A portion of the Congo River, northeast of Kinshasa. Forests provide many ecosystem services like keeping water clean. Photo credit: Ollivier Girard, CIFOR

"It's getting harder and harder for government officials and private companies to escape accountability for deforestation that happens on their watch."

—Frances Seymour, senior fellow at the Center for Global Development

A lumber truck near Ngon, a village in Cameroon. Photo credit: Olliver Girard, CIFOR

If the GLAD alerts incorporate data from the European Space Agency's Copernicus Sentinel-2 satellites together with both Landsats, the data cadence will reach a three-day repeat.

Another way to deal with persistent cloud cover is to look right through it. This is where radar could help. In their paper, Reiche and co-authors posit that an operational radar program following in the mold of Landsat is needed. Along those lines, the Brazilian Deforestation and Alert System added Sentinel-1 radar data to its workflow.

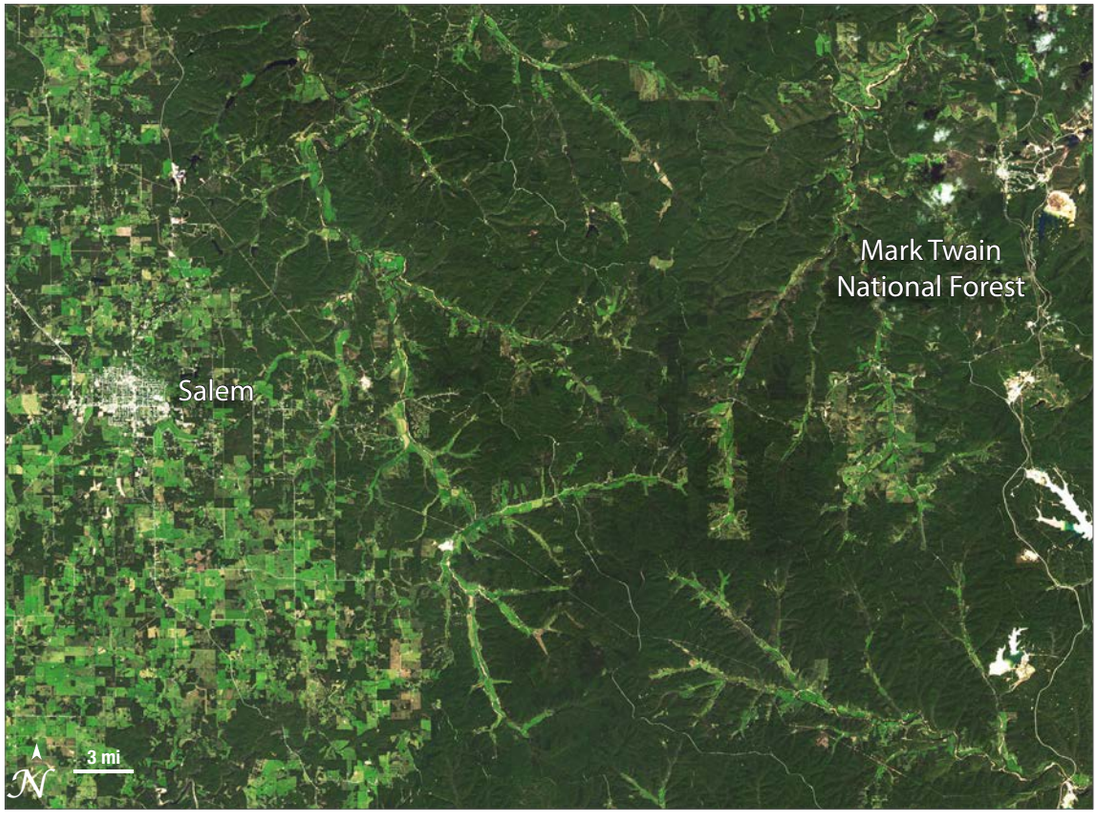
To help capture the three-dimensional structure of forests that is important for biomass measurements, upcoming lidar and radar missions such as NASA's Global Ecosystem Dynamics Investigation lidar (GEDI), NASA-ISRO Synthetic Aperture Radar mission (NISAR) and ESA's Biomass mission are currently in progress.

And lastly, being able to access fine-resolution data from commercial satellites and microsat constellations when areas of potential deforestation are found can give land managers a virtual magnifying glass for identifying hard-to-spot forest degradation.

As climate change raises the stakes, affecting the planet's health as well as ours, such an ensemble of data will give our remaining tropical forests a fighting chance.

As Seymour explained, "It's getting harder and harder for government officials and private companies to escape accountability for deforestation that happens on their watch." ■

This article was originally published on April 27, 2016 on the NASA Landsat Science website. Updates for this publication were made in August 2018.



Where the farmland southeast of Salem, Missouri meets the Mark Twain National Forest. Satellites weren't watching as American settlers made their march westward denuding the virgin forest that blanketed the United States from the east coast to the Mississippi. No aerial archive shows the mighty oaks, beech trees, and hemlocks that once stood there being cleared for farmland, logged for lumber, and burned for fuel. The use and commodification of forests is an old, old story—but modern technology and climate change have greatly modified the script. Image credit: Mike Taylor

Satellite Data Requirements:

- 8-day revisit (w/ L7)
- ≤ 30 m resolution
- Vis, NIR, SWIR, TIR
- Continuous spatial coverage
- Archive continuity & consistency
- Rapid delivery of free, unrestricted data
- Geolocation ≤ 0.5 pix
- ≤ 5% radiance calibration
- 8-bit data digitization