OPINION

Satellites and psychology for improved forest monitoring

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Forests are changing faster today than at any time since the Ice Age. The human enterprise has driven vast forest losses and a mounting wake of forest regrowth that defies historical biogeography. As the pace of change accelerates, so does the demand to monitor forests for conservation and resource policy.

When I was a graduate student in the 1990s, mapping Amazon deforestation was science at the bleeding edge. New reports of rainforest losses were trickling in, creating shock waves around the world. Although the problem of deforestation was known at the time, new satellite-based maps provided a strong propellant for rainforest action. The satellite of choice for deforestation monitoring was the National Aeronautics and Space Administration's Landsat, and images sold for more than $2,000. I vividly remember that breathtaking moment when my professor purchased three images for my thesis project. However, at least 250 cloud-free Landsat images are required to make one decent map of the Amazon each year. Back then only a few elite groups could afford such a trove of satellite data, and there were even fewer experts with their secret methods to convert impenetrable Landsat pixels into user-friendly maps.

Today the forest monitoring world has dramatically changed, but the difference hardly rests in the source of raw data: Landsat still stands as the most widely used and technologically appropriate satellite for monitoring the world's forests. With its 30-m by 30-m pixels, Landsat can accurately detect deforestation events down to about one-quarter acre, and it can even be used to monitor subtle forest disturbances, such as clandestine logging and gold mining. Understandably the Brazilian government makes Landsat its top choice for mapping its turf. However, two truly giant leaps occurred rather recently, each of which has helped to transform global forest-cover monitoring into a far more tractable enterprise.

In 2008, both the Brazilian and United States governments made their Landsat archives—all past and future data—completely free to the world. This groundbreaking development meant that anyone could download images using the Internet. In 2013, the National Aeronautics and Space Administration launched Landsat 8, a more advanced system that will support the global forest-monitoring community for many years to come.

The other advance took hold in 2005 in response to a deafening call by the climate policy community for improved forest monitoring. Tropical deforestation accounts for about 10% of global carbon dioxide emissions, and it is a continuing calamity for biodiversity. The call was heard around the world, in forums like the United Nations Framework Convention on Climate Change, and by academic, government, and nongovernment organizations alike. Even Google and Microsoft made big contributions to the effort (1). So far the fruits of this multisectorial revolution range from expanded computational access to new "big data" deforestation maps.

What has not yet accompanied this sea change in satellite science is an empowerment of the conservation and resource policy communities to perform their own forest monitoring. These are the folks on the front line of forest management and protection. A plethora of technology efforts are underway to make forest maps more accessible, but the effort continues forward mostly based on a model of centralized data production. Indeed there is a tendency for organizations to build their own expert forest-monitoring systems so that, perhaps, nonexperts can access the output without getting to the core technology. I see the value of this model: Experts control the algorithms to ensure that the product is of the highest quality.

The problem with the centralized model is that it does not foster widespread, unfettered learning, so it does not build lasting scientific capacity among fellow citizens. I have often witnessed would-be users of forest information walk away from conferences with more questions than answers. I have also seen recipients of deforestation data dispute results with the data creators over issues of accuracy and transparency. True capacity building relies on diligent teaching and learning across sectors, and that's where forest monitoring has been less successful, despite the recent leaps made within the expert community.

To provision nonexperts with forest monitoring know-how, we created CLASlite (2) [Carnegie Landsat Analysis System (lite)]. CLASlite was born in 2007 out of CLAS, a method originally designed to map subtle forest disturbances caused by selective logging (3). Following a study of potential user needs, we launched CLASlite v1.0 in 2008. To our dismay, despite the fact that our software worked fine for us (experts), we promptly received widespread negative user feedback. We had not explained the method and underlying concepts well enough; the software was clunky; the method produced crumby results at times. Longer and longer the list grew, so we built CLASlite v2.0.

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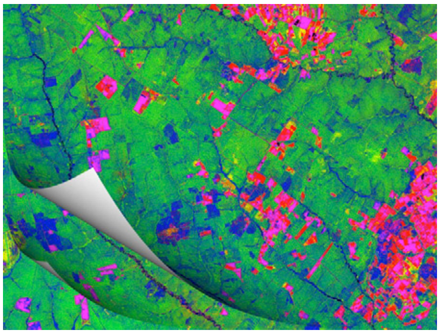
With enough entrained users, we eventually crossed a mutual psychological hump between producer and user that had previously hindered our progress. Our closest partner—Peru's Ministry of Environment—became our best source of feedback as they incorporated CLASlite into their national monitoring and training programs. All along, we followed in close scientific pursuit to support a CLASlite user community that has reached about 300 organizations in Latin America and beyond. Earlier in 2013, we launched a new and improved CLASlite v3, based on further input from a community ranging now from novice to expert. Today CLASlite supports forest monitoring with nine satellites, including the amazingly free Landsat series.

Throughout this process dating back to 2007, we learned how to teach the science and art of forest monitoring to nonexperts. Today CLASlite is as much about learning as it is about software, and that is what sets it apart from the centralized model. The psychology of empowered forest monitoring truly underpins any act of improved forest stewardship. Teaching people to monitor their forests is like that old metaphor of teaching a man to fish. The freedom and responsibility it imbues extends beyond a single meal; it allows him to fend for himself far into the future. Clicking Web buttons to access forest maps from Central Command has just become a reality (1), but learning the science and art of monitoring also really matters. Forests are too important to skip the deeply human step of learning how to take care of them. After all, we are talking about forests, not pixels, and forests are of incalculable natural and climate-stabilization value to us all.



The CLASlite system automatically converts freely available satellite images to maps of forest cover (green) and forest change (blues to reds). Image courtesy of Gregory P. Asner.

CLASlite Classroom, our new free Web-based Carnegie Institution course hosted by Stanford University, includes video-based lessons, guided exercises, a forum, and a final examination. Successful trainees are issued the latest version of CLASlite—for free—to monitor forests of their choosing using their own computer. My team and I believe in this capacity-building approach, putting learning first so that forest monitoring will be undertaken with independence and transparency. I hope the volume of empowered users will soar in the years ahead. Our forests depend on it, because forest stewardship begins with forest monitoring.

1 Hansen MC, et al. (2013) High-resolution global maps of 21st-century forest cover change. *Science* 342(6160):850–853.

2 Asner GP, Knapp DE, Balaji A, Paez-Acosta G (2009) Automated mapping of tropical deforestation and forest degradation: CLASlite. *J Appl Remote Sens* 3(1):033543.

3 Asner GP, et al. (2005) Selective logging in the Brazilian Amazon. *Science* 310(5747):480–482.