Remote Sensing for the Audit and Assurance of the Carbon Market

Keith W. Cunningham, PhD
University of Alaska Fairbanks
3352 College Road
Fairbanks, AK 99709
kwcunningham@alaska.edu

Marci N. Montgomery
Carbon Observatory
114 Sansome St, Suite 235
San Francisco, CA 94104
marci.montgomery@co-obs.com

***Abstract*—The United Nations REDD+ (Reducing Emissions from Deforestation and Forest Degradation) program has made forest preservation a priority, in part because forests sequester carbon and have made carbon value a new global currency. Large money transfers between nations for forest preservation are occurring, and credits for voluntary carbon standards (VCS) are already being traded. The 2011 market is US$30 billion and, by 2020, will include an estimated US$100 billion in UN-administered funding [1]. Driving this market will be the voluntary trading of carbon as a commodity.**

Several academic and non-governmental organizations (NGOs) are now monitoring deforestation and forest degradation using satellite remote sensing. Imagery archives in Europe and the United States are publicly available and in use. These archives have been used to establish baseline forest measurements necessary to quantify deforestation.

Quantifiable forest measurements allow experts to understand not only deforestation and forest degradation, but also the conservation performance of those Nations participating in the UN-administered REDD+ funding. This performance measurement is key to assuring the transparent function of the VCU market. Independent audits are standard accounting practice in the operation of global industries, and third-party assurance will be needed for the healthy functioning of global financial markets at the center of the REDD+ program. This paper will review the state of remote sensing for REDD+ and its role in the third-party audit and assurance processes used to validate the transparency of the VCS market.

Keywords-component; REDD+; audit; assurance; third-party verification; transparency; remote sensing; carbon bank

I. Forests as Capital Assets

Mankind has always seen forests as an asset. Traditional uses of forest assets include harvesting some portion of it for fuel, building materials, and food, often in a sustainable manner. But changes in the perception of forest value have led to unsustainable forest management and even illegal deforestation, with clear-cutting turning forests into pastures. Both sustainable and unsustainable practices reflect the perceived economic value of the forest; however the latter exemplify the typical approach to forest "development" around the world.

Forests also happen to be a foundation in the carbon cycle. The carbon sequestered as biomass in tree canopy, woody branches and tree trunks, as well as peat in the soil, plays a critical role in the planet's carbon cycle by holding carbon and keeping it from entering the atmosphere. When trees are cut, the leafy canopy and wood decompose. This is accelerated when felled trees are burned, which more rapidly releases carbon into the atmosphere as smoke. Soils where trees are removed begin to dry, and the organic matter, especially peat, begins to decompose, releasing even more carbon. Thus, a healthy forest ecosystem is the reservoir where nature "banks" its carbon, holding it from entering the atmosphere as a greenhouse gas.

Seeing the value of a forest as a carbon bank represents a shift in value perception. A forest may also be seen to have other values that occur only through preservation: tourism, habitat conservation, biodiversity, and the preservation of indigenous cultures. Treating forests as an asset for which value can be accurately and transparently calculated, and whose value can be widely bought and sold, creates a breathtaking new use for forests.

But how do you determine the value of a forest for the biomass it holds and the carbon being sequestered?

Under the auspices of the UN REDD+ program, the economic value of forests in carbon sequestration is beginning to be established. One way to view this value creation is that it employs free-market economic principles, i.e., the REDD+ program seeks to value forest conservation at a greater level than extraction. REDD+ calls for monetary value to be exchanged not for receipt of a product or service but for the act of withholding a product (in this case, forest lands) from other potential uses in the marketplace. The scope, magnitude, and value of the REDD+ program sets the stage for a new capital market based on the valuation and trading of sequestered carbon stocks in the form of forests.

This new market is already evolving, with nation-to-nation cash transfers underway or planned. Norway and Indonesia have concluded a deal valued at US$1 billion, in which Indonesia begins implementing a forest conservation effort based on the REDD+ program. The REDD+ cash transfers for 2011 are estimated to be US$30 billion, with anticipated cash transfers by 2020 of US$100 billion. These values will certainly grow as this market becomes more accepted and legitimized by government policies.

REDD+ is not the only program involving market principles. When cap-and-trade schemes are implemented, market investors will seek assurance that carbon values are accurately and transparently calculated. Investment based on trust requires that governments, property owners, and caretakers of sequestered carbon live up to their side of the bargain. This type of market involves assets that are difficult for investors to assess for themselves. We can't stroll by tropical rainforests in the same way we might jog through Central Park or hike in Yosemite to gain comfort that the value purchased remains intact. Nor can an outsider readily determine the level of emissions generated by participants in cap-and-trade.

Therefore, we can see that in order for a carbon-trading market to function, with the potential for wide investor participation, it will require an external means of assuring investors that stated values are verifiable—in other words, a means of audit. Just as other capital markets rely on the audit function to provide third-party attestation of management assertions, so will the REDD+ program, and ultimately the carbon trade, need a reliable form of auditing and assurance.

II. A Role for Remote Sensing

The best way to measure the amount of carbon sequestered in a forest is to do so with direct field measurements. On-the-ground inspections would utilize hand-held GPS measurements and geo-tagged photography. While field inspections may be the perfect solution, they are impractical for measuring and monitoring entire forests. The expense of conducting detailed ground surveys would be greater than the value achieved, and the talent may not be available even if it were affordable.

Fortunately, technology exists to confidently measure the carbon sequestered in forests around the world. Baseline measurements are performed today using remote sensing technology. Remote sensing is a general term describing the technology and application for observing the earth. Glamorous technologies include satellite imaging, but remote sensing also includes traditional aerial photography. Remote sensing technology is not only used to make accurate maps and measurements of forests, but more sophisticated sensors utilizing LiDAR (Light Detection and Ranging) and SAR (Synthetic Aperture Radar) can be used to quantify the biomass content of a forest.

The American Landsat and the French SPOT satellites have been in operation for several decades. In the case of Landsat, the archive of its satellite imagery dating to the 1970's is publicly available. Both satellite imagery archives are being actively used to create baseline measurements [2]. Users of Landsat and SPOT include universities, national governments, and NGOs.

Landsat, SPOT, and private commercial imaging satellites are primarily digital cameras snapping photographs from space. Cameras on these satellites can capture infrared information which is particularly useful because infrared can easily distinguish vegetation from other types of terrain as well as measure the health of a forest. The interpretation and measurement of forests using infrared imagery is simple to perform and easily taught, so this form of imaging is a preferred choice when budgets are small and staff is not highly trained.

Optical sensors do have drawbacks. Images from space and aircraft are limited to when the earth is well illuminated by the sun. Thus optical satellite sensors may not be the best tool for mapping forests during high-latitude winters in the arctic. Optical sensors also cannot see through clouds. In places with persistent cloud cover, like the tropics, clouds occlude viewing the ground and forests. So a significant drawback with optical technology is having to wait, often weeks, before a suitable, cloud free image can be collected of the area of interest. Optical remote sensing may not be the best tool for mapping tropical forests, but it is relatively inexpensive and easy to use.

Still evolving are radar sensors used to image the earth, specifically synthetic aperture radar (SAR). SAR not only creates photo-like images, but also the manner by which the microwave energy bounces and scatters allows the classification of features. Certain frequencies and polarization of SAR microwaves interact with vegetation, creating specific patterns of signal scatter. This allows SAR to be used to classify forests based on species and to estimate the volume of biomass found in a forest.

SAR, unlike optical sensors, is also immune to problems associated with poor solar illumination and cloud cover. This is because the microwave energy emitted from the SAR antenna illuminates the surface of the earth being imaged, so imaging can be conducted in darkness. SAR microwaves also easily penetrate fog, clouds, and smoke allowing imaging in atmospheric conditions adverse for optical sensors.

SAR has been used successfully to make the first maps of the tropical and boreal forests. The Japanese Aerospace Exploration Agency (JAXA) has a strong history of SAR satellites developed for this very purpose. In fact, the JERS-1 was used in the 1990s to create the first SAR forest baselines. Its follow-on ALOS mission acquired significant amounts of radar data to perform the Pan-Tropical Forest Inventory led by the Woods Hole Research Center [3]. The Pan-Tropical Forest Inventory contributed greatly to the science used to set the policy of the REDD+ program.

Unfortunately, SAR data processing is still largely in the realm of technical researchers. SAR is not commonly used for terrestrial ecology and forestry applications. Though this is changing, working with SAR data can be complicated, and accurate biomass estimates are not derived from standardized processes.

Another very interesting remote sensing technology that is quickly maturing is LiDAR. Evolving from simple laser range finders, the technology is now mature for detailed elevation modeling of the ground surface. Features above the ground, such as vegetation, are finding LiDAR applications evolving so that detailed forest profiles can be collected and estimates of biomass determined. LiDAR data can be collected from satellites and aircraft. Early satellite systems included IceSat and future missions may include DESDynI. IceSat was designed to measure glacier heights, but the LiDAR data has also been used to refine forest biomass calculations. DESDynI's LiDAR was expressly designed to work in concert with its SAR sensor, teaming the two remote sensing technologies to better map forest biomass.

No single remote sensing technology is a perfect solution for measuring and monitoring changes in the world's forests. SAR may be the preferred tool for inventorying tropical and boreal forests. But SAR may only be useful in the hands of experts. Optical platforms such as Landsat are inexpensive and easily interpreted, but persistent cloud cover in certain regions of the globe diminishes its utility. Very detailed biomass measurements are evolving with LiDAR sensors on aircraft, but data collection is expensive, and software has not yet evolved to manage the massive LiDAR datasets being collected. Ultimately, multiple remote sensing technologies will need to be fused and even incorporated with ground observations to calibrate and validate the remote sensing measurements.

Another important aspect of remote sensing applicability is that the world's forests will need some form of systematic strategy for their monitoring. This means REDD+ policy should be a factor in a long-term observation strategy. Central to continuous monitoring will be follow-on remote sensing missions to ensure there is data continuity across collection times, places, sensors, and even among countries supporting these missions and policy [4].

As a final point, all remote sensing methods still require people to field-check remotely sensed data [5]. This process, known as "ground truthing," is used to calibrate and validate the data collected from space and aircraft platforms. The UN REDD+ program has established procedures called MRV (Measurement, Recording & Verification), intended to supplement and validate that the measurements from remote sensing are accurate and complete.

III. AUDIT AND ASSURANCE FOR MARKET TRANSPARENCY

Key to the transparency and confidence of a biomass and forest-carbon sequestration market is trust created through verification. This trust will be drawn from clear and uniform definitions, requirements, rules, and reporting. Remote sensing will be the primary tool for conducting this verification. However, comprehensive verification solutions will utilize the strengths, costs, and performance of multiple remote sensing technologies, balancing technological strengths with operational costs.

The market for trading carbon sequestered in forests will use voluntary carbon standard (VCS) credits. VCS are defined and compatible with the Kyoto Protocol. However, much of the data used to define VCS is self reported – meaning the nations and organizations attesting to the value of the VCS are determining those values using their own methods of calculation. This could lead to inconsistency in reporting, or worse, corruption and fraud [6]. A third-party audit and assurance process for VCS credits is necessary if a trading system is to be transparent and robust.

One principal of the audit profession is that the auditor cannot attest to data he or she has had a hand in creating. Thus, the REDD+ participants will need to be assessed by a community of trained examiners who also have access to reliable ongoing sources of independently derived data. Use of a third-party verification system allows for consistency and standardization of the audit and assurance process. An outside system also allows for specialized expertise selecting appropriate remote sensing technology to be brought to bear on this issue. An external audit solution could also help spread the costs of assurance among all program participants reducing audit costs and avoiding the creation of new bureaucratic institutions.

IV. CONCLUSION

The goal of REDD+ is to keep forests clean and green. Remote sensing experts and technology will be key to providing effective and efficient assurance of the VCS markets as they emerge and mature.

The VCS capital market will have to serve many stakeholders: not only the nations and corporate sequestering carbon, but also the investors making investments in carbon assets. Investors in any market demand and require transparency to achieve confidence; forest carbon value is no exception. Such reporting would have to be validated by a reliable third party to ensure the accuracy and transparency of the information. Confidence in the VCS markets means international accounting rules are followed. Otherwise, institutional stakeholders expecting this level of reporting and good governance will not invest [7].

REFERENCES

[1] Global Oils and Fats Business Magazine, vol. 7, issue 1, 2010, pp. 7-10.

[2] R. Moore, Google initiatives for SFM/REDD+, GEF STAP SFM-REDD, September 2, 2010.

[3] J. Kellndorfer, "REDD: Reducing emissions from deforestation and forest degradation," United Nations Framework Convetion on Climate Change, Conference of the Parties, Thirteenth Session, 3-14 December 2007. Bali Indonesia.

[4] J. Kellndorfer, W. Walker, D. Nepstad, C. Stickler, P. Brando, P. Lefebvre, A. Rosenqyist, and M. Shimada, "Implementing REDD: The potential of ALOS/PALSAR for forest mapping and monitoring," GEOSS Asia-Pacific Symposium, 15 April, 2008.

[5] M. Teobaldelli, "Relationship & synergies between monitoring systems for carbon stock change and multiple benefits," MRV Joint Workshop, Guadalajara, Jalisco, Mexico, 22-24 June 2010.

[6] A. Thorpe and L. Ogle, "Staying on track: Tackling corruption risks in climate change," United Nations Development Programme, November 2010.

[7] J. Rohleder, "The Role of Third-Party Verification in Emissions Trading Systems: Developing Best Practices," Sustainable Law & Policy, Winter 2006, 26-29, 69.