Carbon Management ›

Volume 4, 2013 - Issue 5

Editorial

Icarus revisited: tropical forests, REDD+ and ecosystem dynamics

Daniel M Alongi

Pages 469-472 | Published online: 10 Apr 2014

Cite this article https://doi.org/10.4155/cmt.13.48

Keywords::

carbon storage | ecosystem thermodynamics | forested ecosystems | land-use change | REDD+ | tropics

Managing change in tropical forests and developing a viable REDD+ strategy for alleviating climate change is a highly complex, intricate process necessitating the expertise of managers, the local community and scientists. Various conservation and economic policies and legal frameworks have been developed, especially in recent years, to manage the process of affecting positive change on tropical forests [1,2]. Such strategies have also included forested wetlands, such as mangroves. Degradation and deforestation are proceeding at a frightening rate in the tropics, and scientists agree that governments, NGOs and regional conservation agencies must deal with the problem promptly. But the question needs to be asked: is the best possible scientific advice being fully integrated into REDD+ strategies? I am fully convinced of the good intentions of various organizations involved with the REDD+ process, but I am less sanguine that managers and scientists are in sync with the critical ecological issues.

There is no doubt that the science of quantifying and monitoring relevant ecological components of forests, such as measurement of carbon emissions and forest stocks, must conform to the practical realities and limitations of implementing mitigation strategies [3], and there are a number of practical manuals and book chapters to help with measuring, reporting and verification [4]. As pointed out by Donato, the sheer complexity of tropical forest ecosystems is a confining factor in how REDD+ projects are currently being implemented [3].

REDD+ project plans clearly need to evolve now that the first headlong rush to implementation and subsequent sober analyses are over [5]. Early and some current projects have focused on and been determined by:

- Location criteria based on biodiversity, climate and community benefits, threat of deforestation, environmental value, demonstrated user need, government/NGO interest, good governance, prior relation and experience with similar projects;
- Land tenure and concessional issues;
- Deforestation drivers;
- Financial arrangements and payment for environmental services;
- Political and legal constraints and policies.

All of these issues are linked to the question of carbon rights and benefit sharing, all of which differ among countries (as does the meaning of REDD+).

Naturally, prosaic issues such as how to replant, restore or maintain forests, as well as how best to measure carbon emissions and changes in forest carbon stocks, have been well considered [6].

How forests change in the face of deforestation and degradation is a central issue for REDD+. Angelsen et al.[2] points to the forest transition theory of Mather [7] as a guide for REDD+ schemes, in which five different stages can be identified in terms of level of forest cover and rate of deforestation, beginning with high forest cover and low deforestation rates that evolve to low forest cover and negative deforestation rates. This theory adequately describes the net results of changes in forest cover as a consequence of deforestation, but how helpful is it in terms of the need to incorporate ecosystem theory? Changes in forest carbon stocks vary over time in more complex ways [6] than proposed by Mather. As a result of deforestation, carbon stocks drop to very low levels, but when allowed to regenerate and grow naturally over time, forest carbon stocks will recover as rates of forest productivity gradually increase; forests that are selectively logged or grown as plantations exhibit more regular patterns of carbon stock change, corresponding to cutting and rotation cycles [8]. Some forested ecosystems, such as mangroves and freshwater peat swamps, do not necessarily respond to disturbances in ways that terrestrial forests do [9].

Despite limitations of time, effort and money, REDD+ projects must abide by ecological laws and thermodynamic constraints imposed on all ecosystems. I suggest that failure to recognize and address these limitations has been one of the primary causes of serious scientific problems in some REDD+ schemes, such as sustaining the link between carbon stocks and financial incentives over long time periods [10,11]. Such errors have resulted in resistance and subsequent failure of local communities to embrace REDD+ in Java, Malaysia and Thailand [12,13]. Financial arrangements must take into account the scientific reality that tree growth slows with time, slowing the rate of carbon accumulation.

The rush to set up such schemes and the use of trial-and-error tactics reminds me of a cautionary essay written by the great philosopher and mathematician Bertrand Russell, who invoked the tale of Icarus to warn of possible misuse of science in the future [14]. According to this Greek myth, Icarus, the son of the master craftsman Daedalus, attempted to escape from Crete using feather and wax wings constructed for him by his father, who warned him not to fly too close to the sun. Icarus ignored his father's warning and so the wings melted causing Icarus to fall into the sea and drown. Good intentions gone awry have often led to tragedies large and small in conservation projects.

The cautionary note I make is that REDD+ schemes must be designed to conform to scientific constraints and levels of uncertainty of ecosystem dynamics of tropical forests. Knowledge of forest ecology and disturbance theory can be used to avoid failure. There are a few key features of ecosystems that must be acknowledged as fundamental to successful reforestation and regeneration [15]:

- Ecosystems obey certain natural laws, such as the second law of thermodynamics;

- Ecosystems are often not in equilibrium and predictable;
- Multiple control systems and feedbacks regulate ecosystems;
- Ecosystem processes (photosynthesis, respiration and trophic links) and individual species are equally important and both must be preserved;
- Ecosystems change and continually re-adapt naturally over time, often having multiple stable states.

Let’s look at an admittedly rare (area wise) forested ecosystem – the tropical mangrove forest. These forested wetlands are at the forefront of REDD+ schemes due to their heavy human use and rapid rates of deforestation. While mangroves are wetlands, they possess many of the same ecosystem attributes as tropical terrestrial forests. Similar to other forested ecosystems, mangrove forests develop over time periods greater than the average life of REDD+ projects, and attain maturity between 10 and 20 years depending on whether or not they are left undisturbed [9].

Forest succession, the directional and sequential change in both species composition and system complexity, was originally thought to be more predictable than it actually is [16]. The original idea was that the early recruits that colonize a given area are rapid growers, increasing in biomass quickly with a large photosynthesis/respiration ratio. This early assemblage is eventually replaced by slower-growing, longer-lived species that form a mature, stable forest characterized by low rates of photosynthesis but large biomass. We now know that some ecosystems do not conform to this model. Mangroves are a good example of nonconformity, as they develop in relation to changes in shoreline evolution. Mangrove forest succession can therefore be unpredictable, with the clock being reset by each disturbance; if disturbances are frequent enough, a mangrove forest may never reach maturity. Thus, these natural variations must be accounted for in any REDD+ scheme.

Carbon sequestration in tropical forests including mangroves varies greatly both within and among forests [17], therefore REDD+ projects will have to orchestrate ways to maximize carbon gains and minimize carbon losses. For mangroves, rates of sediment (and carbon) accretion vary in relation to changes in sea level, as well as location (e.g., fringing vs riverine areas) and decline with increasing distance from the shoreline. Thus, as rates of carbon storage decline with increasing forest age, so will the size of payments for carbon sequestration. Payment schemes must therefore have multiple income streams such as payment for maintaining biodiversity, law enforcement, reducing carbon emissions and reducing water loss, in addition to payment for carbon sequestration.

REDD+ schemes must be able to deal with the issue of uncertainty, which is linked to the ecological reality of natural variability. Large uncertainties exist for rates of forest production, respiration and carbon balance, and these will change over time within any given forest. This is reflected in large uncertainties in global carbon budgets for forests [18,19]; some carbon is unaccounted for owing to rounding error or inadequate knowledge of processes such as faunal production and chemical defenses. In any event, any REDD+ scheme must reckon on uncertainties of up to 50% of some processes, not to mention nonlinearity, which is a common ecosystem trait [20].

What must REDD+ schemes do to conform to ecological reality? I have identified a few actions to take:

- The most crucial issue is geography in that, at the national level, not all sites will not be amenable to restoration due to permanent changes to hydrology, extensive damage, and so on; REDD+ efforts should be prioritized based on factors such as biodiversity, quality and quantity of remaining forest (e.g., mature old forest) and the value of ecosystem services;
- Spatial and temporal variability must be continually mapped and monitored, with a clear set of indicators to rapidly determine if changes in ecosystem structure and function are negatively impacting on REDD+;
- Community participation is crucial as REDD+ or any other conservation schemes will not work without local community involvement, support and enforcement;
- Changes in land use must be monitored, perhaps via remote sensing techniques, as a method of revising REDD+ plans and strategies;
- There must be greater effort to plant multiple species, not develop monotypic plantations, to develop biodiversity of both flora and fauna and to facilitate multiple feedback loops and regulatory mechanisms;
- Import of keystone species is similarly recommended, where possible, to restore key trophic links as soon as possible;
- The measurement of changes in carbon stocks and carbon storage must be standardized to limit uncertainty and systematic error;
- REDD+ schemes must incorporate predictions of future environmental change, preferably using modeling techniques;

■ Priority must be given to conserve any remaining old growth and/or high diversity forests, even patches;

■ Parallel measurements must be made of environmental conditions such as weather, soil status, possible diseases, and so on.

Sustainable conservation of replanted and restored forests will be successful only if ecological laws are enforced; the room for error is very small in every human endeavour to mimic nature.

Financial & competing interests disclosure

The author has no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

References

1. Hunt CAG. Carbon Sinks and Climate Change: Forests in the Fight Against Global Warming. Edward Elgar Publishing Ltd, Cheltenham, UK (2009).

   Google Scholar

2. Angelsen A, Brockhaus M, Kanninen M, Sills E, Sunderlin WD, Wertz-Kanounnikoff S. Realising REDD+: National Strategy and Policy Options. Center for International Forestry Research, Bogor, Indonesia (2009).

   Google Scholar

3. Donato D. Perspective and parsimony in forest carbon management. Carbon Management3(3),227–230 (2012).

   Web of Science ® | Google Scholar

4. Zhang X, Zhao Y, Ashton MS, Lee X. Measuring carbon in forests. In: Managing Forest Carbon in a Changing Climate. Ashton MS, Tyrrell ML, Spalding D, Gentry B (Eds). Springer Science, Dordrecht, The Netherlands, 139–164 (2012).

Google Scholar

5. Angelsen A, Brockhaus M, Sunderlin WD, Verchot LV. Analysing REDD+: Challenges and Choices. Center for International Forestry Research, Bogor, Indonesia (2012).

Google Scholar

6. Devries B, Herold M. The science of measuring, reporting and verification (MRV). In: Law, Tropical Forests and Carbon: The Case of REDD+. Lyster R, MacKenzie C, McDermott C (Eds). Cambridge University Press, Cambridge, UK, 151–183 (2013).

Google Scholar

7. Mather A. The forest transition. Area24,367–379 (1992).

Web of Science ® | Google Scholar

8. Herold M, Skutsch M. Monitoring, reporting and verification for national REDD+ programmes: two proposals. Environ. Res. Lett.6,014002 (2011).

Google Scholar

9. Alongi DM. Carbon payments for mangrove conservation: ecosystem constraints and uncertainties of sequestration potential. Environ. Sci. Policy14,462–470 (2012).

Google Scholar

10. Sunderlin WD, Atmadja S. Is REDD+ an idea whose time has come, or gone? In: Realising REDD+: National Strategy and Policy Options. Angelsen A (Ed.) Center for International Forestry Research, Bogor, Indonesia (2009).

Google Scholar

11. Clements T. Reduced expectations: the political and institutional challenges of REDD+. Oryx44,309–310 (2010).

Google Scholar

.2. Peluso NL. Rich Forests, Poor People: Resource Control and Resistance in Java. University of California Press, CA, USA (1992).

Google Scholar

.3. Barr CM, Sayer JA. The political economy of reforestation and forest restoration in Asia-Pacific: critical issues for REDD+. Biol. Conserv.154,9–19 (2012).

Web of Science ® | Google Scholar

.4. Russell B. Icarus or the Future of Science. Kegan Paul, Trench, Truber & Co., Inc., London, UK (1924).

Google Scholar

.5. Petraitis P. Multiple Stable States in Natural Ecosystems. Oxford University Press, Oxford, UK (2013).

Google Scholar

.6. Odum EP. The strategy of ecosystem development. Science164,262–270 (1969).

PubMed | Web of Science ® | Google Scholar

.7. Alongi DM. Carbon sequestration in mangrove forests. Carbon Management3(3),313–322 (2012).

Web of Science ® | Google Scholar

.8. Malhi Y. The carbon balance of tropical forest regions, 1990–2005. Curr. Op. Curr. Environ. Sustain.2,237–244 (2010).

Web of Science ® | Google Scholar

.9. Malhi Y. The productivity, metabolism and carbon cycle of tropical forest vegetation. J. Ecol.100,65–75 (2012).

Web of Science ® | Google Scholar

20. Barbier EB. Capitalizing on Nature: Ecosystems as Natural Assets. Cambridge University Press, Cambridge, UK (2011).

Google Scholar