Beyond equitable data sharing to improve tropical forest management

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SUMMARY

Tropical forest management and policy decisions are hampered by lack of reliable information about forest responses to timber harvesting and other silvicultural interventions. Although the necessary raw data from permanent sample plots (PSPs) mostly exist, the relevant results are generally unavailable due to lack of analytical capacities within data-holding institutions or lack of incentives to make the results available. Where analytical deficiency is the bottleneck, collaborative data-sharing agreements that go beyond the outsourcing of data-analysis to third parties can provide equitable and effective short- and long-term options. Simply outsourcing PSP data analysis to established scientists from extra-tropical countries might solve short-term problems, but does not prepare the community of scientists in tropical countries to address future research challenges. The design of such collaborative agreements that satisfy the needs and desires of the various parties involved is complicated by cultural and institutional differences, but progress on this front is evident.

Keywords: capacity-building, data ownership, data repository, forest policy, research collaboration

Au delà d'un partage de données équitable pour améliorer la gestion des forêts tropicales

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La gestion des forêts tropicales et les décisions de politique leur ayant trait sont bloquées par un manque d'informations sûres sur les réponses des forêts à la récolte du bois aux autres interventions sylviculturelles. Bien que les données brutes nécessaires provenant des lots d'échantillons (PSPs) existent à priori, les résultats pertinents sont en géneral indisponibles dû à une carence de capacités analytiques au sein des institutions recelant les données, ou à un manque de motivations pour rendre les données disponibles. Quand la déficience analytique est la cause de l'obstacle, les accords de partage des données collaboratives allant au delà du partage d'analyse de données à des partis extérieurs peut fournir des options équitables et efficaces à court et à long terme. Le simple partage d'analyse de données PSP avec des scientifiques établis des pays extra-tropicaux peut résoudre des problèmes à court terme mais ne peut pas préparer la communauté des scientifiques dans les pays tropicaux à faire face aux défis de la recherche future. Le but de tels accords collaboratifs satisfaisant les besoins et les désirs des différentes parties prenantes est compliqué par des différences culturelles et institutionnelles, mais le progrès sur ce terrain est néanmoins évident.

Más allá de compartir datos equitativamente para mejorar la gestión de los bosques tropicales

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Las decisiones para la gestión de bosques tropicales y las políticas relacionadas se ven obstaculizadas por una falta de información fiable sobre las respuestas de los bosques a la tala para madera y otras intervenciones silviculturales. Aunque, en general, existen los datos brutos necesarios de parcelas permanentes de muestreo (PPM), los resultados pertinentes generalmente no están disponibles debido a una falta de capacidad de análisis dentro de las instituciones responsables de los datos, o una falta de incentivos para diseminar los resultados. Cuando el cuello de botella son las carencias en el análisis, los acuerdos de colaboración de intercambio de datos que van más allá de la subcontratación del análisis de datos a terceros, pueden proporcionar opciones equitativas y eficaces a corto y largo plazo. La mera subcontratación del análisis de datos de PPM a científicos reconocidos de países no tropicales podría resolver problemas a corto plazo, pero no preparar a la comunidad de científicos en los países tropicales para hacer frente a los futuros retos de investigación. El diseño de este tipo de acuerdos de colaboración, que satisfagan las necesidades y aspiraciones de las diversas partes involucradas, se complica por la existencia de diferencias culturales e institucionales, pero el avance en este frente es indudable.

INTRODUCTION

Poor management of much of the 403 million hectares of tropical forests officially designated for timber production (Blaser *et al.* 2011) is partially due to paucity of reliable information about growth and yield. In the absence of accessible and reliable data on rates of tree recruitment, growth, and survival after logging, regulatory forest agencies seem prone to make unreasonably favourable assumptions about the rates of timber stock recovery (Adler 2005). It should therefore not be surprising that despite claims of sustainable forest management (SFM) and sustained timber yields (STY), commercial timber stocks typically decline with each harvest (e.g., Dauber *et al.* 2005, Schulze *et al.* 2008, Putz *et al.* 2012, Grogan *et al.* 2014).

Lack of information about growth and yield in managed tropical forests is especially deplorable given that most tropical forest agencies started to install and periodically re-measure permanent sample plots (PSPs) at least since the middle of last century. We conservatively estimate that in the countries from which most tropical timber from natural forests is sourced there are >1 000 ha of PSPs (e.g., see www.TmFO.org). If data from forest inventories are included, this admittedly imprecise estimate increases by orders-of-magnitude.

Data from trees measured repeatedly over time in PSPs in managed forests can be used to estimate the demographic parameters (i.e., rates of survival, recruitment, and growth) needed to evaluate the impacts of harvesting and other silvicultural interventions on timber stock recovery, carbon fluxes, and biodiversity. Where PSPs have been subjected to silvicultural treatments, the efficacy and cost-effectiveness of these interventions can be revealed through analysis of long-term data sets. PSP data are also useful for assessment of the impacts of climate change and other stressors that often become apparent only over long periods of time. In this paper we explore what we perceive to be the major impediments to the release of information available in sets of PSP data from managed tropical forests. We discuss the benefits to tropical forest management of PSP data sharing and highlight some recent advances on this front that indicate ways to move beyond simply data outsourcing to enhancement of research capacities in PSP data-owning institutions.

DATA-SHARING ISSUES

Data sharing and archiving: Moving science forward

Proponents of data-sharing argue that access to data permits re-analysis as well as meta-analyses that extend the benefits of the research beyond the interests, intentions, and capabilities of the original data collectors (Gardner *et al.* 2003, Hand 2010). Sharing data provides opportunities for evaluation of new hypotheses as well as for re-examination of previously tested hypotheses with larger sample data and new statistical methods (Gardner *et al.* 2003). The larger scientific community benefits because sharing data encourages multiple perspectives, helps identify errors, discourages fraud, is useful for new researchers, helps avoid duplicate data collection, and increases the efficiency with which research funds are used (Piwowar *et al.* 2007). Recent increases in the volume of publicly available data resulted in part from adoption of policies by government institutions, funding agencies, and journals that require data archiving in open access online repositories (e.g., Bruna 2010, Dryad Digital Repository: datadryad.org; NatureServe; www.natureserve.org/getData/ecologyData.jsp).

Data archiving and sharing are already common in the health sciences (Lang 2011, National Institute of Health 2003, but see Pisani and AbouZahr 2010, Tangcharoensathien *et al.* 2010), genomics (Wheeler *et al.* 2006, Kaye *et al.* 2009), proteomics (Barsnes *et al.* 2009), and dendrochronology (NOAA 2014), with the trend growing in other fields (Hand 2010). The benefits of rapid data archiving and sharing were revealed by the faster-than-anticipated progress of the Human Genome Project (Collins *et al.* 2003). Even in tropical ecology, a field close to tropical forestry, data from PSPs in unmanaged forests are starting to be archived and shared (e.g., Malhi *et al.* 2002, Condit *et al.* 2005, Lewis *et al.* 2013, 2004, ter Steege *et al.* 2013). It should nevertheless be mentioned that despite the well-recognized benefits and increasingly strict requirements, compliance with data-sharing requirements is not perfect (Nelson 2009, Savage and Vickers 2009) and resistance lingers in fields other than just tropical forestry (e.g., Laine *et al.* 2009).

In regards to data sharing in forestry, our temperate counterparts have made much of their national forest inventory data publically available. Forest inventory data sharing initiatives are reportedly motivated by concerns about sustainability, wood production, climate change, and carbon balance (Schelhaas *et al.* 2007). The creation and maintenance of a detailed public forest inventory database in Europe started early in the 20th Century; those data are currently stored in the European Forest Institute's virtual library (http://www.efi.int/portal/virtual_library/databases/efiscen/). Across the Atlantic, forest inventory data are publically available through the Forest Inventory and Analysis program of the U.S. Forest Service (FIA, http://www.fia.fs.fed.us/tools-data/, Van Deusen *et al.* 1999). The European and American forest inventory data-sharing programs are driven by forest users (generally domestically-owned logging companies) while governments provide the funds needed to assure access to the high quality data needed to address sustainability and other issues.

Potential benefits to tropical forest management of PSP data-sharing

One reason to promote sharing of data from managed tropical forests is that research capacities in many PSP host countries are limited and traditions of publishing are weak (Ng 2010). As tropical foresters, we make this claim while we personally

struggle with the application of new approaches to data analysis (e.g., Bayesian methods), learn to deal with large and error-ridden data sets with insufficient meta-data, try to master the statistical methods needed to mitigate the consequences of flawed experimental designs (e.g., pseudo-replication; Ramage *et al.* 2013), and grapple with the many challenges associated with preparation of manuscripts suitable for publication in international journals.

PSP data-sharing might also have the added potential benefit of leading to a source of financial support for plot maintenance and data management. Due in part to lack of funds, many PSPs in managed tropical forests are abandoned, seldom re-measured, and unprotected. Many PSP data languish in field books or are stored on outmoded (or soon to be outmoded) digital devices. If extra-tropical scientists with the interest and analytical capacity to deal with PSP data also have access to funds, data-sharing agreements might quite reasonably also include their assumption of some of the financial responsibilities for plot maintenance. While we do not believe that such funds should substitute for high-level capacity building in host institutions, they might serve to save important data that would otherwise be neglected and lost.

Over the long-term, forest regulatory agencies that financially depend on royalties from timber harvests will benefit the most from improved yield regulations that are based on rigorous analyses of ample field data. We need to move towards a culture in which these agencies drive the demand for public data availability and not the current situation in which extra-tropical academics and NGO representatives are the principal supporters of forestry data sharing.

All potential beneficiaries should recognize that while PSP data increase in value as the period of monitoring increases, so do the risks that the data will be lost. These risks are elevated by staff turnover, inadequate meta-data, and high rates of change in data archiving technologies. These risks and challenges are reduced if the data are shared (Vines *et al.* 2013).

Impediments to sharing PSP data from managed tropical forests

Despite apparent consensus in the scientific community that public archiving of data is good for science insofar as it increases scrutiny and research quality, the custodians of tropical forestry data seem un-phased by this discourse. Here we explore what we perceive to be the principal barriers to sharing data from PSPs in managed tropical forests and highlight some on-going efforts to circumvent these barriers.

Given the diverse natures of reward systems used in research and academic institutions involved in tropical forest management, it is challenging but necessary to assure that the benefits of data-sharing to data collectors, data managers, and data analysts are fair, equitable and sufficient. Where professional advancement requires publication in high-profile scientific journals, there are obvious benefits to the authors of papers based on PSP data (Ng 2010). Although most rewards accrue to senior authors, even junior authors of multi-authored papers may benefit professionally. Publication-based reward systems have been adopted by many research institutions in the tropics, but their effectiveness at stimulating research productivity varies. In many cases, authorship might not represent a suitable or sufficient motivation for sharing raw data, even if the only requirement is provision of the corresponding meta-data needed for their interpretation. Other indirect benefits of data-sharing might accrue to researchers from tropical and extra-tropical countries, but the natures and magnitudes of these benefits will vary among institutions and individuals.

For representatives of forest regulatory agencies in many tropical countries, authorship generally brings few benefits. Furthermore, the potential that released data might expose policy problems and thus cause embarrassment might actually constitute a disincentive to publish. For example, the finding of much lower-than-expected timber volume recovery rates might embarrass the governmental agencies responsible for policies that permit over-harvesting. Suppression of growth and yield data is one sure way to avoid this sort of scrutiny. Such disincentives might be compounded by politics within forestry institutions, especially if control over data is a source of perceived or real power. From the perspective of decision-makers, access to analyzed data from PSPs might be beneficial or not, depending on whether the institutions those decision-makers represent benefit from clarity or from continued obfuscation.

Ownership ambiguity is another reason why PSP data from managed tropical forests are not often shared. Funders of initial plot establishment might justifiable lay claim to the data, as might the funders of subsequent re-measurements. The individuals that designed the study, conducted the field work, and handled the data all have legitimate claims as well, as do the institutions for which they worked. With data that span decades, both the institutions and the individuals involved are likely to be numerous and to have changed, which complicates the ownership issue. Even when ownership is uncontested, many owners of the PSP data needed to inform forest management decisions lack the tradition of publication, feel no motivation to publish, or lack the capacity to do so.

Although the costs and expertise required to validate, archive, and share data are declining (Gardner *et al.* 2003), the possessors of PSP data may nevertheless be constrained by all three. Furthermore, the idiosyncratic nature of much forestry data and the need for quality-assurance mechanisms make data retrieval and streaming more challenging than with, for example, DNA sequences (Condit *et al.* 2013).

One concern of PSP data owners is that the considerable personal and institutional investments required to monitor PSPs might easily be disregarded by data recipients. In addition to financial costs, the dangers, discomforts, and depredations suffered by field crews need to be considered when the values of PSP data are reckoned. Paying these costs unfortunately breeds a culture of protectionism among

tropical foresters who view "their" data as a type of currency. This tendency could be compounded by concerns about sovereignty if PSPs were established by former colonial powers. Related are the fears that foreign scientists provided with PSP data will give little or no credit to the original data collectors or the institutions that, over the years, were responsible for the PSPs and their data.

Finally, it may sound trite but there are some concerns that public availability of PSP data will promote proliferation of scientists that subsist on open-access data but lack first-hand experience with the complexities of field data collection and that have no personal familiarity with the field sites. Ignorance of natural history, for example, is likely to lead to a plethora of incorrect conclusions ostensibly supported by data and rigorous statistical analyses. On the other hand, claims that PSP data are so idiosyncratic as to be interpretable only by the original data collectors may belie insecurity about data quality or inadequate documentation and should not impede their release. After all, unused data benefit no one.

RECOMMENDATIONS

Fair-sharing of tropical forest management PSP data

Exactly how participants in PSP data-sharing agreements should be rewarded is a difficult question for which there is no single answer. Among academics in many countries and institutions, authorship of articles published in reviewed journals is the currency upon which promotions and salary increases are based (e.g., Clapham 2005). As previously mentioned, the ineffectiveness of publication requirements adopted by many tropical forestry research organizations (Ng 2010) suggests that authorship is not highly valued (for the Amazonian exception, see Malhado *et al.* 2014).

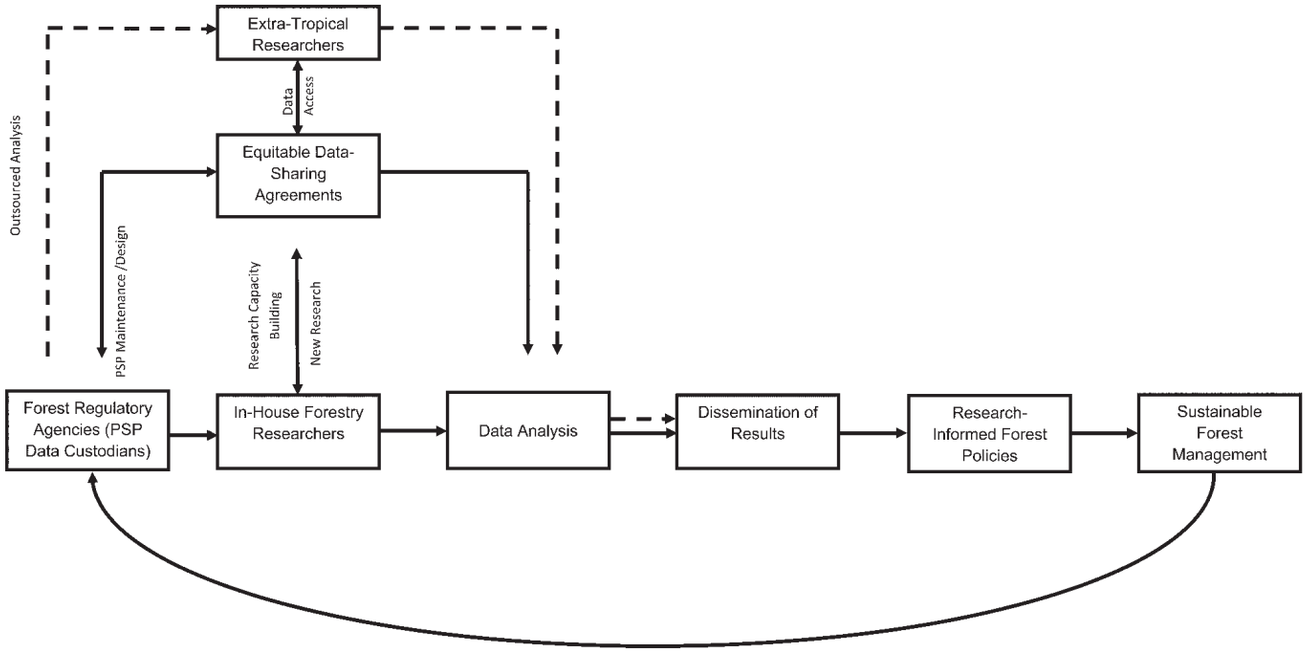
The diversity of possible data-sharing agreements may represent an impediment to their advancement in tropical forestry. At one extreme, raw plot data might be made available on publically accessible websites soon after they are collected, which is the current practice in molecular genetics. Recent efforts to render release of raw data a recognized form of publication (e.g., http://esapubs.org/archive/instruct_d.htm; Lopez-Gonzalet *et al.* 2011) should increase the attractiveness of this option to some PSP-owning institutions and individuals. At the other extreme, a PSP data owner might provide one researcher access to raw data for one purpose and for a limited period of time. Intermediate between these extremes, the approach used by the recently constituted Tropical managed Forests Observatory (TmFO; www.tmfo.org) is to assist representatives of PSP-owning institutions with basic data analyses through code-sharing and workshops, after which the summary data are shared and used for cross-site comparisons on which all data-contributors are co-authors (Sist *et al*. in press). In this system, raw data are managed and maintained by the data-owning scientists or institutions while analytical capacity is built.

As in other disciplines (Cragin *et al.* 2010), policies designed to foster PSP data sharing in tropical forestry should reflect the complexities and contexts of those data. Simply giving PSP data to qualified foreign researchers could admittedly solve the immediate need for research results to inform forest management policies and practices. In defence of this straightforward approach, there are indeed instances in which publications by extra-tropical researchers have influenced tropical forest management policies. As long as in-country expertise is lacking, the decision-makers who decide the fates of tropical forests will justifiably need to rely on foreign scientists for research-based input. Unfortunately, even if their input is relevant, politically and economically reasonable, and efforts are made to deliver it in culturally appropriate manners, such input is easily discredited or more often disregarded due to its source. Furthermore, the failure to build local research capacity means that when new researchable issues arise, the services of foreign researchers will again be needed. That said, even when there is sufficient in-house capacity to establish PSPs and deal with their data, that local capacity is not always employed for reasons that are often elusive. Why is it, for example, that the relatively straightforward task of tropical forest carbon accounting is often outsourced to extra-tropical researchers? Certainly there is no lack of tropical foresters from tropical research institutions who know how to design sampling protocols, measure trees, and apply allometrical equations.

Research capacity building in tropical countries should continue to include data collection, handling, and basic analysis, but we believe it is time for forest scientists from tropical countries to assume leadership roles in research agenda-setting and dissemination of results (Figure 1). Overall, training forest technicians and labourers to collect high quality PSP data is a good first step towards building local capacity, but substantial contributions to development of high-level research capacities in tropical countries should be a central goal of PSP data-sharing agreements.

To overcome the impediments to tropical forest management data sharing, the many different perspectives of the diversity of involved parties must be addressed. Although data sharing is a complex issue with multiple technical, sociocultural, financial, and legal facets (Marshall 2002), it will yield benefits to anyone concerned about the sustainability of tropical forest management. It will also help if, in their long-term interest, forest regulatory agencies that depend on timber royalties promote capacity-building, data sharing, and research. Furthermore, while it is unavoidable that the priorities of extra-tropical researchers will often not match those of researchers in their host countries, research agenda-setting should be recognized as a component of true collaboration. Finally, donors should be gratified if sharing data results in the release of the information for which they invested. Other uses for these data will undoubtedly emerge after initial analysis, which is one of the benefits of data sharing. Overall, we believe that decision-makers in governments in tropical countries will be less prone to disregard research delivered by resident researchers; all too often it seems that visitors are politely listened to but after they depart, their messages are disregarded.

FIGURE 1 *Approaches to sharing of PSP data from managed tropical forests. Solid lines represent ideal scenarios in which extra-tropical researchers build capacities in tropical institutions for data analysis, data archiving, and the higher-level processes of scientific research (e.g., topic selection, hypothesis formulation, experimental design, and publication). Broken lines indicate short-term and unsustainable solutions to the problem of unavailability of analysed data from PSPs in managed tropical forests. Policy recommendations originating from local institutions and researchers that are based on results from PSP data analysis may enhance uptake at the policy stage, and catalyse the cyclic research process*



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