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Monitoring systems to improve forest conditions

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There is a lack of generalizable empirical analyses of whether particular types of monitoring promote effective forest governance, and under what circumstances. We reviewed a specific sample of the peer-reviewed literature on how monitoring, including state-level, participatory, and third-party monitoring, might affect forest conditions. Examining 25 cases, we found three trends which limit our understanding of the effect of monitoring. First, there was a bias toward studies in Brazil and India, indicating that the literature might not be globally representative. Second, no studies compared different types of monitoring. Third, the majority of studies relied on qualitative approaches, making comparison across cases difficult. These insights suggest focusing research agendas on comparative assessment across sites and monitoring systems.

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Introduction

Forests provide a suite of benefits at local, regional, and global scales, including biodiversity conservation and climate regulation, as well as more direct livelihood contributions to millions of people world-wide [1,2]. Yet, increasing and competing demands for food, biofuels, and timber are posing severe challenges to effective forest governance and sustainable forest management, especially in conjunction with the direct and indirect impacts of climate change [3,4]. As effective forest governance is key for attaining sustainable use of forest resources, international donors have considerably expanded their forest sector portfolios in recent years to support multiple types of interventions aiming at improved forest governance. Examples are market-based instruments such as payments for environmental services (PES), including Reduced Emissions from Deforestation and forest Degradation (REDD+); market demand-related strategies (e.g. certification schemes); command-and-control instruments such as spatially explicit designations (e.g. protected areas); and granting of rights (e.g. forest use, access, or property rights). The effectiveness of a given governance intervention may depend in part on the monitoring system in place to track intervention performance and forest conditions because a) the act of monitoring can encourage compliance with laws, b) enforcement, fines or sanctions that may be associated with monitoring provide disincentives for non-compliance, and c) the information derived from the monitoring can serve to inform better policies as well as adapt the intervention [5]. The very purpose of monitoring can thus be either 1) compliance with governance institutions or a given intervention [6] or 2) information gathering for evidence-based improvement of policies and adaptive management [7,8]. While an emerging body of scholarly work has identified community-organized monitoring of forest conditions as a promising avenue for ratcheting up forest governance performance [9,10••,11], there is a lack of rigorous and generalizable empirical analyses of how different monitoring systems influence the effectiveness of governance interventions [12] — despite the recognition that monitoring might be crucial for improved forest conditions [13••].

In this article, we examine whether particular types of monitoring promote effective forest governance, and under what circumstances. We do so through a review of scientific literature that empirically assesses how forest monitoring may influence forest conditions. We begin by describing key characteristics of the monitoring systems addressed in the set of articles included in our sample. We focus on the geographical location of the monitoring and the temporal resolution, spanning near real-time, continuous monitoring to annual or coarser snap shots, as well as recalled personal observations by relevant stakeholders. Next, we categorize articles according to spatial extent and monitoring actors. The spatial extent may vary from small community-level forest monitoring, through national surveillance to global scale monitoring such as the satellite-based initiative Global Forest Watch (www.globalforestwatch.org). Evidently, the spatial extent of the monitoring is associated with the organizational level of the monitoring institution; local communities typically rely on ground-based monitoring of local forests, perhaps

only covering a fraction of the total forest area, while nation states may apply satellite remote sensing for a full coverage of forest areas. For example, the availability of satellite-based monitoring capabilities like those conveyed by Landsat has enabled mapping of tree cover losses and gains on an annual basis at the global scale [14] and the Food and Agriculture Organization of the United Nations (FAO) has advanced monitoring efforts across the globe through National Forest Inventories (NFIs) and National Forestry Monitoring Assessments (NFMAs). Monitoring thus also differs in who is conducting the monitoring, that is, it can be organized at the state or national level, as a site-based effort carried out by institutions instigated by the forest users themselves [5,10••], or by third-party agents not formally involved in intervention design and forest management.

We then look at what is being monitored. Common examples include monitoring of 1) forest area change, 2) commercial extraction of forest products which can, for example, build upon the combined use of satellite data, forestry concession data, forest inventories, and market data; 3) carbon stock changes; and 4) people's perceptions of forest conditions. Following this, we examine the reported effectiveness of different monitoring systems across various contexts. In line with Lambin *et al.* [15], we define effectiveness in terms of the ability to generate on-the-ground impact. Impacts may be direct, if the governance instrument in question contributes to solving the particular problem it was intended to, or indirect, if the instrument induces unintended favorable changes. Specifically related to forest monitoring, effectiveness is a measure of positive changes in forest conditions as a result of the forest governance intervention. However, following Andersson *et al.* [16••] and Agrawal *et al.* [17], we note that monitoring is only one among many factors affecting the effectiveness of governance instruments within the forest sector. That is, although monitoring may be an important predictor of forest governance performance, focusing solely on monitoring can be misleading because it might leave the impression that monitoring alone is sufficient for good forest conditions. Hence, forest governance performance is a complex phenomenon and its effectiveness is only partly explained by the level and type of monitoring [18,19].

In the final section of the paper, we consider the implications of our findings in terms of the design of monitoring systems to pursue effective forest governance. However, we note that because of the limited attention devoted to the exploration and comparison of monitoring efforts carried out by different stakeholders and in different contexts, our review remains an exploratory analysis. Yet, it points to the need to look deeper into the effectiveness of different types of monitoring mechanisms and compare how these shape forest conditions under various circumstances. Such efforts are paramount if forest managers are to make better choices about forest governance and address future challenges related to sustainable conditions.

Method

To identify research articles on how monitoring approaches may enable effective governance in the forestry sector, we undertook keyword searches in April 2017 on Web of Science combining terms associated with assessment approaches (assessment* OR monitor* OR evaluat* OR measur*) with the term 'governance'; as well as terms specifying the forestry sector (forest*) and the focus on the effectiveness of various governance instruments (effective*). We note that the full range of relevant literature was not captured by our method, since we chose a rather narrow string rather than running a comprehensive search using all possible key words related to the effectiveness of forest governance. This strategy was chosen as our aim was to draw a sample from the literature published since 2000 rather than providing a complete overview of all studies, as is often the case for systematic reviews. We screened papers from an initial pool of 168 hits based on three inclusion criteria:

1. The article described one or more types of forest monitoring
2. The article dealt with the effectiveness of monitoring in terms of changing forest conditions, including, for example, changes in forest cover and people's perceptions of forest conditions
3. Empirical evidence on forest governance was explicitly documented from one or more geographical locations

Of the 168 articles initially identified, 21 met the above two screening criteria (Appendix A). Additionally, we expanded the sample of articles by tracking references in already selected articles and include articles known to the authors but not captured by the search string. This resulted in the inclusion of four additional papers [10••,20,21,22], of which one was cited by 38% of the already selected articles and the others were considered seminal contributions within the field of forest monitoring.

Results

The number of published articles on assessment and monitoring within the field of forest governance has increased rapidly in recent years, with peak publication rates in 2014 (Figure 1a). In our pool of articles, there was a high representation of articles including at least one site from South America (n = 12, especially Brazil (n = 8)) and Asia (n = 12, especially India (n = 8)). Africa, North America, and Australia were less represented (28, 24, and 4% of articles, respectively) (Figure 1b). There were more geographical locations than research articles because