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Assessing carbon stocks using indigenous peoples' field measurements in Amazonian Guyana

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ABSTRACT

Accurate estimations of carbon stocks across large tracts of tropical forests are key for participation in programs promoting avoided deforestation and carbon sequestration, such as the UN REDD+ framework. Trained local technicians can provide such data, and this, combined with satellite imagery, allows robust carbon stock estimation across vegetation classes and large areas. In the first comprehensive survey in Guyana conducted by indigenous people, ground data from 21 study sites in the Rupununi region were used to estimate above ground tree carbon density across a diversity of ecosystems and land use types. Carbon stocks varied between village sites from 1 Tg to 22.7 Tg, and these amounts were related to stem density and diameter. This variation was correlated with vegetation type across the region, with savannas holding on average 14 MgC ha^{-1} and forests 153 MgC ha^{-1}. The results indicated that previous estimates based on remotely sensed data for this area may be inaccurate (under estimations). There were also differences in carbon densities between village sites and uninhabited control areas, which are presumably driven by community use. Recruiting local technicians for field work allowed (a) large amounts of ground data to be collected for a wide region otherwise hard to access, and (b) ensured that local people were directly involved in Guyana's Low Carbon Development Strategy as part of REDD+. This is the first such comprehensive survey of carbon stocks, carbon density and vegetation types over a large area in Guyana, one of the first countries to develop such a program. The potential inclusion of forests held by indigenous peoples in REDD+ programs is a global issue: we clearly show that indigenous people are capable of assessing and monitoring carbon on their lands.

1. Introduction

The importance of trees and forests, especially tropical forests, as carbon sinks and stocks is well established, with forests globally sequestering 2.4 ± 0.4 PgC yr^{-1} by one estimate (Pan et al., 2011). Forests are under multiple development pressures, including logging, fragmentation, and clearing for agriculture. The latter is particularly critical in tropical regions, where land conversion accounted for carbon emissions of 1.3 ± 0.7 PgC yr^{-1} between 1990 and 2007 (Pan et al., 2011). In addition to development stressors, climate change itself is a key threat to forests in the Amazon basin (Malhi et al., 2008), and in order to mitigate rapid climate change, it is essential that forests are kept as intact as possible so they can continue as carbon stocks (Gibbs et al., 2007).

Recognition and understanding of the global importance of forest carbon stocks and forest ecosystem functioning has led to the development of several schemes whereby the maintenance of forest cover and carbon sequestration is remunerated, such as the UN REDD/REDD+ program (Reducing Emissions from Deforestation and forest Degradation; http://www.un-redd.org). These schemes, and others, such as national and international carbon trading programs, and voluntary payments for carbon sequestration services, require the measurement of carbon stock baselines, and subsequent monitoring and reporting of carbon pools (Cedergren, 2009), through a combination of remote sensing and ground truthing methods. To achieve support for REDD+ schemes and ensure that they fairly compensate forest stewards, it is essential that local stakeholders understand the carbon measurement process. This has been achieved through participatory approaches whereby local, trained, citizen scientists provide useful data across large areas, as has been demonstrated (Butt et al., 2013; Danielsen et al., 2013; Torres, 2014).

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Guyana was one of the first countries to submit a REDD Readiness Plan for testing national payments for carbon storage to the Forest Carbon Partnership Facility, a global partnership between national governments and other entities focussed on REDD+ (Forest Carbon Partnership Facility, 2013), and also one of the first to establish a national REDD program. The Guyana REDD+ Investment Fund (GRIF) was set up as part of Guyana's Low Carbon Development Strategy (LCDS), as a climate finance mechanism by which avoided deforestation could be compensated until an international REDD+ mechanism became operational (www.guyanareddfund.org). The fund was capitalized by the government of Norway.

In order to become part of a scheme such as REDD/REDD+, Measurement, Reporting and Verification (MRV) activities need to be coordinated and carried out by capable people on the ground, to complement remotely sensed monitoring data. This partnership approach reflects the importance placed on both the rights of indigenous people as stakeholders, and their involvement in the REDD process, by the Guyana-Norway Agreement (Cedergren, 2009; Gutman and Aguilar-Amuchastegui, 2012). Citizen science and other participatory approaches to monitoring provide an effective method of forest monitoring, and in the Guyana context Amerindian communities manage their resources, inform other community members of carbon stocks on their land, and gain insight and training in forest monitoring, which should enable an informed decision-making process with regard to opting in or out of the REDD program within the LCDS.

Project Fauna was a Guyana-based initiative developed by a team of researchers from various research institutions and local indigenous leaders to examine the connected nature of indigenous people and their environment (Fragoso et al., 2005; Luzar et al., 2011). The main goal of the project was an assessment of how biodiversity influences, and is influenced by, changes in indigenous human culture, and of how land use change affects these elements of coupled human natural systems (Luzar and Fragoso, 2013; Read et al., 2010; Luzar et al., 2011). Socioeconomic and biodiversity variables were measured on titled lands using a participatory approach. The project also measured above ground vegetation carbon to (1) address the issue of links between carbon and biodiversity and contribute to the discussion of bundled ecosystem services, and (2) advance indigenous community understanding of carbon, carbon politics and REDD+ programs, thus enabling their participation in the national discussion on carbon value and payments.

From 2007 to 2010, Project Fauna trained 335 indigenous technicians across 30 Amerindian communities in the Rupununi region (Fig. 1) to monitor wildlife populations and hunting patterns, and to describe vegetation structure. The success of this program (Luzar and Fragoso, 2013; Luzar et al., 2011; Read et al., 2010) led Project Fauna to initiate a vegetation and carbon assessment pilot study (http://www.stanford.edu/group/fragoso/), which aimed to: (1) build the scientific capacity of local communities in understanding the sources and stocks of carbon in the environment, and how to measure carbon in above ground vegetation (AGB); (2) estimate the carbon densities in distinct vegetation types and on titled lands, and; (3) compare tree carbon around villages to that in areas unused by people. Here we describe the results of the tree measurement/carbon assessment program carried out in the Rupununi region of south western Guyana, and outline the implications for the inclusion of indigenous people in monitoring their own carbon stocks in REDD+ schemes globally.

2. Methods

2.1. Study area

The Rupununi region is classed as 'moist tropical forest' by the IPCC (2003), with 2000–4000 mm yr^{-1} rainfall, and is dominated by savannas and forests (Read et al. 2010; Hammond, 2005). Ten types of vegetation were described in the study area (Cummings, 2013; Levi et al., 2013), and these were grouped into eight categories to maintain adequate sample sizes: High Forest Flooded, High Forest Upland, Ite Swamp, Low Forest Flooded, Low Forest Upland, Muri Shrub Upland, Savanna Flooded and Savanna Upland (Table 1). The 2006 Amerindian Act establishes land rights for Guyana's indigenous people (Fig. 1), who may claim title of their community lands. Indigenous communities that have received 'titled lands' have rights to forest and above ground resources within their boundaries (Cummings, 2013). Although rights to carbon stocks have not been defined, the government has acknowledged these rights by giving Amerindian communities the choice of opting in or out of enrolling their lands in Guyana's national REDD program and to receive compensation from government under a REDD+ agreement (http://www.lcds.gov.gy March 2013 report).

Of the 23 villages in the larger study (Luzar et al., 2011), members of 17 communities carried out the tree measuring work in the 20 sites: 15 'village' sites and 5 'control' sites. Records from one village were omitted, due to inexplicable tree size discrepancies between this site and both the literature and data from our study for the local forest types (see Section 4 for more detail) (Table 2; Fig. 1). Transects 4 km long were placed in a stratified random design around the villages and in five control areas identified as regions where no hunting, logging or gathering (of poles or non-timber forest products) occurs (see Levi et al., 2013). 111 transects and 604 plots of 0.01 ha were sampled overall, up to eight plots per transect (Table 2). This provided 6.04 ha of AGB (tree) data. The frequency of vegetation types varied widely by site and by region, with High Forest Upland and Low Forest Upland the most common types across the sampled plots. Ite Swamp and Savanna Flooded were the least common vegetation types (only two plots for each of these types) (Table 2).

2.2. Training and data collection

Three-day training sessions were held in three locations across the region over a two-week period (villages 6, 14, 19; Fig. 1), and comprised both classroom instruction and field demonstrations and practise. Common sampling protocols for major carbon pools were used, in line with other forest assessment projects, such as IPCC (2003), and RAINFOR (Metcalfe et al., 2009; Marthews et al., 2012): tree diameters were standardly measured in cm at breast height (1.3 m). Lianas were not included in the analysis. On average, 14 volunteers were trained at each of the three training sessions. The first part of the workshop focussed on carbon definitions, the carbon cycle and the measurement of carbon in the field. Two field workers per site sampled trees $\geqslant$10 cm DBH in the plots in their transects, and met with Project Fauna staff monthly to hand over data sheets and resolve any technical problems which might have arisen.

2.3. Data analysis

To reflect the fact that the Rupununi region covers two distinct geographic and political regions, separated by the Kanuku Mountains (Fig. 1), plot data were divided into 'north' (North Rupununi and South Pakaraimas) and 'south' (South Rupununi), based on differences in coarse vegetation types (Huber et al., 1995) and geology. The north Rupununi is dominated by continental sands and silts, the south Rupununi by younger granites and volcanic formations (Government of Guyana, 2001). Thus, in addition to the eight categories of vegetation types, and a comparison between village and control sites, we also consider differences between the north and south region (Table 2). The distinction between north and south is also important politically, as the north is inhabited by