

## COMPARISONS OF TROPICAL FOREST REGENERATION PATHWAYS AT TWO SITES IN BRAZILIAN AMAZONIA

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**Abstract.** Previous studies at Manaus (Lucas *et al.* 2002) indicated that different pathways of tropical forest regeneration existed as a function of differences in prior land use and that these pathways could be differentiated using remotely sensed data. In this study, further analysis of inventory data collected at Manaus, Amazonas (1995) and Santarém, Pará (2002) confirmed the existence of several pathways of regeneration, with those dominated by the pioneer genera *Cecropia* and *Vismia* being common to both. Differences in regeneration pathway could be attributed to differences in prior land use. The study emphasizes the benefits of considering pathway when mapping regenerating forests using remotely sensed data and for understanding/modeling succession and carbon dynamics. The use of remote sensing for understanding the processes of regeneration is also highlighted.

**Keywords:** remote sensing, community analysis, pathway of forest regeneration

### 1. Introduction

Based on a study (Lucas *et al.*, 2002) undertaken previously at Manaus, Amazonas, several pathways of tropical forest regeneration were identified, with their existence explained largely by prior land use history, as determined through ground interviews and analysis of time-series of Landsat sensor data. Forests dominated during the early stages of regeneration by the pioneer genera *Cecropia* and *Vismia* were particularly common, with the former favoring the least intensively-used sites.

Based on the analysis of data collected in 1993 at Manaus (Lucas *et al.*, 2002), an opportunity arises for better understanding the succession and carbon dynamics of forests regeneration on abandoned agricultural land using remote sensing data. Specifically, time-series of medium (10-30 m) spatial resolution (e.g., Landsat TM) data can be used to establish the history of prior land use, including the period of active land use prior to abandonment, the fire history and the frequency of vegetation reclearance. Spectral data from the same time-series can be used to establish reflectance trajectories for different forests from which the species composition of the early regeneration forest community can be inferred. Airborne/spaceborne SAR can also potentially be used to derive forest biomass (Luckman *et al.*, 1998). Through integration of these components, with field data and across a landscape, a spatial understanding of the recovery of forests following clearance, in terms of changes in community composition and biomass, can be obtained. Furthermore, the resulting datasets provide a better foundation for interpreting coarser spatial resolution data (e.g., MODIS) for purposes of regional assessment and mapping of regenerating forests.

For this approach to be implemented, however, we need to establish whether the pathways of regeneration at Manaus are similar to those observed at other sites across Amazonia and whether these also occur as a result of prior land use history. As a first step towards this, we have analyzed data collected in 2002 from near Santarém, Pará, together with data acquired in 1995 from Manaus.

## 2. Study Areas

In 2002, field data were collected from 16 100 x 10 m plots located within regenerating forests near Km 114 of the Santarém-Cuiabá Road and within the Tapajós National Forest (2°56'S, 55°01'W). Within this area, most forests were regenerating on land that had been used for small-scale agriculture and logging. In 1995, data had been collected within 22 plots of identical size and in regenerating forests near Manaus (2°20'S, 60°00'W) and were made available for the analysis. These forests were of varying age and established on land with different intensities and periods of prior land use.

## 3. Methods

To establish differences in the regeneration communities at both Tapajós and Manaus, the species data from both sites were analysed using Detrended Correspondence Analysis within the Multi Variate Statistical Package (MVSP; Kovach Computing Services 1985-2002). This technique, which is used commonly in community ecology, is an indirect ordination based on analysis of floristic data and is independent of any preconceived environmental factor (Kent and Coker; 1992). Basal area measurements were used for the analysis.

## 4. Results

Based on the 1995 Manaus data, the MVSP suggested the existence of five different groups of regenerating forest. Group 1 forests ranged in age from 3 to 18 years and were (or had been) dominated by *Cecropia*. Groups 2 and 3 were distinguished from other groups as they contained a high proportion of *Vismia*. Group 2 forests, which were located on abandoned tree crop plantations, were more mixed in composition compared to Group 3 forests, which were regenerating on abandoned cattle pastures. Groups 4 and 5 represented highly diverse mixed species forests and included the majority of the older regenerating forests. From these groups, two main pathways, dominated by *Vismia* and *Cecropia* respectively, could be discerned. At Tapajós, the MVSP suggested the existence of six groups (Figure 2). Group 1 was dominated by *Cecropia* whilst Groups 3 and 4 were dominated by *Vismia*, with *Inga* common in Group 4. Groups 2 and 5 were dominated by *Vismia* although *Cecropia* was well represented, suggesting the existence of a transitional or mixed forest community. Group 6 represented older secondary forests of mixed species composition. As with Manaus, the regeneration pathways were dominated by either *Cecropia* or *Vismia*.

## 5. Discussion and Conclusion

Although preliminary, the analysis of the community composition at Tapajós confirmed the dominance of *Vismia* and *Cecropia* within many of the pioneer communities and therefore the existence of different pathways of regeneration. This was not unexpected given that *Cecropia* and *Vismia* are amongst the most common genera of pioneer trees in the neo-tropics (Fearnside, 1988; Alvarez-Buylla and Garcia-Barrios, 1991) and their dominance has been

reported elsewhere (Uhl *et al.*, 1981, Buschbacher *et al.*, 1988; Alves *et al.*, 1997; Parotta *et al.*, 1997). The analysis of the 1995 Manaus data also confirmed that most forests were dominated in the early stages by either of these two genera.

Knowledge of land use at Manaus suggested that the fire history, period of active land use, frequency of vegetation reclearance and the type of land use were important determinants of the composition of the pioneer community (Lucas *et al.*, 2002). Specifically, *Cecropia*-dominated forests were located on land used for shorter (i.e., < 2 years) periods and at lower intensities whilst *Vismia*-dominated forests were located on the more intensively used sites. Similar influences of land use were also evident at Tapajós, although further analysis is required.

Data from other sites across Amazonia needs to be analyzed, but the research highlights the existence of different regenerating forest communities and pathways and the importance of prior land use in determining these pathways. Although studies are ongoing, remote sensing can also play a key role in understanding the processes of regeneration across a landscape as common pathways can be discriminated using reflectance data, land use history can be determined through time-series of these data and biomass can be retrieved using radar data.

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