Mediating Factors and Deforestation in Brazilian Amazonia: A Mixed-Method Analysis

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Extended Abstract

The novelty of the concept of *land-use and land-cover change* (LUCC) and the resource management approaches based on this concept is that LUCC brings together traditions in the humanities/social sciences and in the earth/life sciences perspectives as a means to assess the complexities of land transformation more broadly (Turner II and Meyer 1994). The concept of LUCC challenges researchers to conceptualize biophysical and social processes affecting the land not as independent from each other but interconnected. In recent years, demography has increasingly engaged in this debate.

This paper assesses the importance of the "population factor" as a cause of deforestation in a colonization area (Machadinho) in Brazilian Amazonia. The paper contends that a full account of the complex web of drivers involved in tropical deforestation needs to go beyond demographics *per se*. Based on a mixed-method approach for data collection and analysis, the paper examines how migrants' relationships with the local environment are mediated by social structure, cultural factors, and human capital involving education, managerial skills, previous rural experience, and integration to the local and regional contexts mediate.

Conceptual Framework

Demography has offered little insights beyond the Malthusian arithmetic, when the relationships between population and the physical environment are considered (Hogan 1992). The linear perspectives on population-environment relationships outlined by Malthus on the one side and by Boserup on the other still pretty much define the population-environment debate. As Marquette (1997) notes, Boserup does not entirely reject the Malthusian argument and there have been efforts to overcome the Malthus-Boserup divide, showing their complimentary positions (Lee 1986; Bilsborrow 1992).

Despite the elegance of models measuring population as population size, density or rate of growth, these measures are not sufficient. Demographic dynamics more broadly defined also including population characteristics such as nuptiality, household structure, migration, and rural-urban linkages are important but remain just a piece of the explanation. Moreover, it is important to recognize that population-environment relationships are mediated and shaped by socioeconomic, cultural, political, and institutional factors (Arizpe and Velásquez 1994, Bilsborrow 1992, Hogan 1992, McNicoll 1990, Schmink 1994).

The conceptual framework adopted in this paper draws from and integrates different bodies of literature. From demography, I adopt the *mediating perspective*, which points out that human population-environment interactions are not straightforward but mediated by social, economic, institutional, and cultural factors (Marquette and Bilsborrow 1997; Lutz et al. 2002). From environmental sociology, I borrow the concept of *conjoint constitution*, which contends that "nature and society give rise to one another" (Freudenburg et al. 1995). Therefore, I look not only at the human dimensions of population-environment relationships, but I incorporate their biophysical dimensions and the material-ecological realities of a given environment. The concept

of *conjoint constitution* has clear parallels with other theoretical efforts among environmental sociologist (Redclift and Woodgate 1994; Goldman and Schurman 2000).

Study Site, Data Sources, and Methods

The study site is a government-sponsored colonization project for migrant small-scale farmers in Machadinho D'Oeste in Rondônia, Brazilian Amazonia. This area, which is now divided in 1,742 parcels averaging 46 ha each, includes land which was previously inhabited by small contingents of rubber tappers, with migrants starting to settle there in 1984. Machadinho's population profile is representative of other areas in Amazonia and the centralized control of the colonization project is identical to other projects.

Data used in this paper are from four major sources. The 2000 demographic census was used to extract population size at the census tract level. The other primary data sources are: land-cover maps (1986-1999), a household survey (1995), and in-depth interviews (1986 and 2001).

Data on land-cover change are from the maps for 1986, 1994, and 1999 generated from Landsat imagery. The final land-cover classification scheme used in the maps includes seven categories: primary forest, secondary forest, transition, pasture, crops, bare soil, and water. Local communities participated in the process of producing the maps and accessing map accuracy. Results on map accuracy are within the standards defined by the remote sensing community.

The primary source of quantitative socioeconomic data is a household survey conducted in 1995 in the study site by CEDEPLAR-UFMG, Brazil. The 1995 household survey is a ten-year follow-up survey of the project “Malaria on the Amazon Frontier” (Sawyer and Sawyer 1987). Although the study focused on malaria, questionnaires incorporated a variety of other issues, including household size and composition, literacy, population mobility, migratory history, labor force, income, land use, agricultural production, livestock, farm infrastructure, parcel microenvironment, housing conditions, and available services. In 1995 a total of 1,130 questionnaires were administered and 5,265 individuals interviewed.

Qualitative data derive from in-depth interviews I conducted in 1986 among 24 farmers living in the study site. These interviews were part of a research project examining family arrangements, fertility, and settlement strategies in the agricultural frontier (Sydenstricker-Neto 1990). The interview notes of this former project were re-examined using a category system on local organization and management of natural resources (Sydenstricker-Neto 1997b). In 1999, I visited the families interviewed in 1986 and conducted follow-up interviews.

The statistical analysis presented in this paper uses the fuzzy set model known as “Grade of Membership” (GoM) (Manton et al. 1994). From analysis of medical diagnosis systems GoM analyses expanded to studies in psychology, gerontology, demography, remote sensing analysis, climatology, and forestry (Davidson et al. 1988; Berkman et al. 1989; Lamb 1996; Piccinelli et al. 1999; Portrait et al. 1999; Talbot et al. 1999; Portrait et al. 2001).

The full GoM deforestation model used in the broader research this paper is based on (Sydenstricker-Neto 2004) is a four pure type model with 40 variables extracted from the household survey, land-cover map, and generated from geographic information system analysis. The variables are divided into four major constructs: production systems (land-cover and land-use), biophysical and spatial characteristics of the parcel, population dynamics, and mediating factors (culture, human and social capital, and socioeconomic status). This model resulted from extensive exploratory work and was the best model based on consistency and greater interpretability. This paper presents and discusses results on land-cover, population dynamics, and selected mediating factors.

In-depth interviews were analyzed using an interpretivist/constructionist framework (Guba and Lincoln 1989, Schwandt 1994). Based on a conceptual framework previously developed (Sydenstricker-Neto 1997b), I examined complementarities and tensions between contrasting views of human-nature relationships and formation of local alliances and social network.

Results and Discussion

Regarding land-cover, there were dramatic changes in the study site over the 1986-1999 period. The region predominantly covered by primary forest was deforested and agropastoral systems – mainly pasture and coffee trees – became the predominant land-use practice. It was estimated a total conversion of 34,358 ha of primary forest or 52.8% of the parcels in the study site (1986-1999).

Data on land-cover and population size at the census tracts level in Machadinho in the rural area show that as human population increases so does deforested area (Pearson correlation = 0.74, 0.01 level). This case is one among others for Amazonia and shows that population size matters. Generalization of findings such as the above can lead to the conclusion that population size is beyond doubt ***the*** driving force in deforestation in the tropics. This evidence has to be taken with caution, however. If for no other reason, direction of causation is not established. Even though several studies have correlated population size, growth or density with degradation of natural resources (Allen and Barnes 1985, Cropper and Griffiths 1994, Cropper et al 1999, Myers 1984), scholars are increasingly questioning these findings. The methodologies used in studies, including issues such as geographic and temporal scales, limited number of variables incorporated into the models and chain effects and feedbacks not taken into account, are at the root of heated debates. Also, it has been stressed that population is an endogenous factor and population migration occurs as a response to economic incentives.

Closer examination of deforestation patterns in the study site suggests a continuum regarding deforestation ranging from parcels mainly covered in primary forest and little "development" to parcels in which pasture dominates and few remnants of primary forest are left. This empirical evidence and other analyses offer a basis to contrast land-cover and land-use as a means to conceptually approximate the deforestation continuum and propose empirical profiles of farmers.

The GoM model separated farmers in four distinct groups (pure types) showing a clear trend in terms of area deforested, area in pasture, and area in crops.

As population size increases, number of adults in the household (proxy for available labor force) and age of head of households (proxy for life cycle) also increase, showing statistically significant outputs for all variables. Because most parcels have agricultural systems that include both pasture and crops, it is hard, if not impossible, to disentangle the specific impacts of each system. However, there are striking differences in labor requirement if a same area in primary forest is to be developed and maintained as pasture land or planted with crops. Deforested patterns are better explained in relation to available labor force (number of adults in the household) rather than population per se.

Regarding social structure, increase in household income and quality of the dwelling (proxy for quality of life) have a statistically significant relation with deforested area. In Machadinho, socioeconomic status of farmers and their ability to maintain their farm as a healthy business was directly tied to out-of-farm opportunities. In 2000-01, interviews with farmers clearly showed that farm activity by itself was seldom sufficient to provide the needed resources

for family livelihood and farm investments. Households with external income sources, particularly if these income sources were stable throughout the year, gave farmers a remarkable edge. This was the case of households where one of the spouses was an elementary teacher, a bus driver, or had another permanent job nearby.

Results on education provided few statistically significant categories and no clear trend to strongly build upon. This might convey the tenuous and nebulous connections between education, appropriate knowledge, and environmental behavior.

Landownership before arriving in Machadinho (proxy for managerial skills that the settlers bring into play in the new context) showed no significant result across pure types. However, in-depth interviews clearly indicated that these managerial skills have a positive impact on establishing more successful production systems.

Regarding rural experience, results show that previous background in rural areas and particularly in Brazilian Amazonia is related to deforestation and development of production systems on the farm. Farmers with no rural background are the ones with the largest deforested area, including the business-oriented farmers pursuing the rancher path not requiring previous knowledge of cropping systems. On the other end, farmers with rural background and more experience in Amazonia, are the ones with the more diversified production systems.

Number of years in the state and in Machadinho has a limited potential to capture integration into the regional and local culture. Unfortunately, better variables for this purpose did not work or were not available. Results on number of years in the state and in Machadinho are difficult to interpret and variable outcomes are mixed. More than integration, results suggest that the longer farmers are in the area, the more likely they are to expand deforested areas. This is clearly the case for data on the number of years in Machadinho and expected as farmers need a minimum number of years to establish a farm and farm development needs a longer span of time to mature.

To overcome the constraints imposed by the limited number of variables on environmental attitudes and behaviors on the survey, I used qualitative interviews to go into more depth about issues that seem relevant and qualify results provided by the quantitative analysis presented above. In order to illustrate how culture and other factors mediate farmers' interactions with the environment and development of parcels, I examined more closely farmers living in neighboring parcels. In summary, gathered data show that farmers with similar household size led to quite different outcomes. Cultural factors played a crucial role in mediating settlers' relation to the environment and explain these distinct outcomes regarding primary forest conversion and agrosilvopastoral systems in place. The qualitative analysis focused essentially on the individual characteristics and responses. However, they are part of a broader context, which includes collective action and community behavior as well. The link between entrepreneurship and a "rancher" suggests a view of local development project more identified with traditional agricultural expansion rather than environmental management. This perception and the social construction of a "successful farmer" is informed by policies and incentives operating in the region and the outcomes could be different if mechanisms such as a credit for carbon sequestration or more robust incentives promoting agroforestry systems were in place.

Conclusion

In summary, studies on LUCC as the one presented in this paper offer venues to promote better understanding and action on society/population-environment interactions. A full account of society/population-environment relationships, including quite varied linkages and quite

complex underlying dynamics has to place the demographic dynamics of a given human population in the specific biophysical and historical context. By doing so, one assesses how historically grounded local social relations and specific conditions of natural resource systems jointly shape the ways in which population-environment relations occur. This approach allows uncovering the population-environment interconnections in terms of their conjoint constitution and the mediating factors. This approach reinforces the complex and synergetic dynamics operating at different levels – micro, meso, and macro – in various areas in the tropics as shown by review studies (Geist and Lambin 2001, 2002; Kaimowitz and Angelsen 1998).

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