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Expansion of Mechanized Agriculture and Land-Cover Change in Southern Rondônia, Brazil[1]

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Tractors in the Amazon

Ranchers, gold miners, loggers and smallholder colonists have been clearing forest in the Brazilian Amazon since the late 1960s (Hecht and Cockburn 1990; Schmink and Wood 1992). In the 1990s, new agents of environmental change arrived in the region: mechanized commercial farmers. Some cite statistical correlations between increases in region-wide soybean production and deforestation rates to suggest that soybean farmers are the next destroyers or "relentless foes" of the Amazon (Branford and Freris 2000; Fearnside 2001; Rohter 2003). It is argued that soybean cultivation will spread into frontier forests, resulting in deforestation and consolidation of landholdings. In turn, this consolidation is feared to create a rural exodus of peasants, leading to even further advancement of forest destruction (Fearnside 2001; Bickel and Dros 2003; WWF *et al.* 2003).

Agro-industrialists, however, describe mechanized farming as a "win-win" scenario for development and conservation, arguing that it increases land-use intensification which reduces the need for clearing new land while allowing for economic development (EMBRAPA 2002; Mueller and Bustamante 2002). No published empirical study has used spatially explicit data, human or physical, to measure or explain the mechanisms of forest change due to mechanized cultivation.

Our current project engages this debate by seeking answers to three main questions: (1) To what extent are forests converted for mechanized annual cropping?; (2) What are the key human variables that explain land change patterns? (3) What is the relationship between land-use intensification and forest conversion? Our study area is a modern agricultural frontier in southern Rondônia, an area at the humid Amazon forest savanna transition that is poised to become another major soybean-producing region.

A New Farming Frontier

Southern Rondônia, the locus of recent soybean expansion in western Amazônia, is our study region (Figure 1).

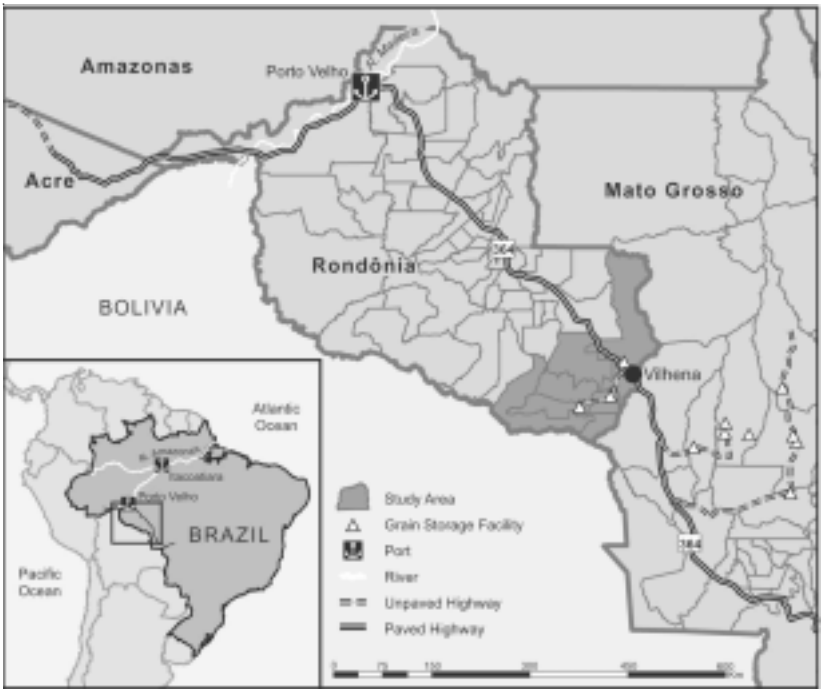

Figure 1. Study Area: Southern Rondônia

Chris Brown, doctoral student Matthew Koeppe, Master's student Benjamin Coles, and Kevin Price from the University of Kansas completed pilot research in one municipality of the region in 2002 (Brown *et al.* in press). The greater region includes the municipalities of Vilhena, Cabixi, Colorado do Oeste, Cerejeiras, Corumbiara, Pimenteiras, and Chupinguai.

Southern Rondônia has emerged as an important soybean cultivation frontier in Amazônia, attracting investments by agri-business and the attention of scientists concerned about the threat soybeans pose to forests (Oliveira *et al.* 2002; Fearnside 2001: 26). Since the early 1990s, soybean production in Rondônia has grown considerably. First introduced to the state experimentally in the early 1980s, the area planted grew dramatically from 4,640 to almost 30,000 hectares between 1997 and 2002 (IBGE 2003). Fieldwork by Koeppe in 2004 indicates that new commercial farms open every year (Figure 2).

One major factor allowing for skyrocketing growth has been the establishment of storage and purchasing facilities and development of new tropical soybean varieties for southern Rondônia. Moreover, in 1996, the agro-industrial André Maggi Group provided the initial investment to construct a grain shipping port in Porto Velho, thus reducing greatly overland transport costs and making Rondonian soybean production profitable. Since 1997, all Rondonian soybeans are transported through Vilhena to Porto Velho where they are sent down river to Itacoatiara near Manaus for processing. Cargill has established

Figure 2. Bulldozer clearing field for annual production, Vilhena, Rondônia, November 2003 (photo by Matthew Koeppe)

its own shipping facility in Porto Velho.

From Itacoatiara, soybeans are transported to European and Asian ports. The region's commercial agricultural economy is poised to continue its rapid expansion, with officials from the agro-industrial André Maggi Group believing that production in our study region can expand to 300,000 ha in the coming years (pers. comm., Matthew Koeppe, 2004).

Expectations for increased production are attracting investors for soybean processing plants, poultry and hog "factory farms," and meat-packing (Brown *et al* in press). While relatively small and traversable in Amazonian terms, the region presents great variability in terms of physical and human geography. For example, numerous natural land-cover types can be found, including savanna-woodlands (*Cerrado-Cerradão*), dry tropical forests (*Mata Seca*) and humid forest (*Floresta Amazônica*). In the 1970s and 1980s, thousands of families from Brazil's southern states migrated to the study region when it became the focus of colonization efforts and cattle ranching. This history of modern settlement created differentiated land-use geographies (Moran 1984; Mahar 1989; Millikan 1992). In Vilhena and Chupinguaia, land holdings are commonly more than 2,000 hectares, whereas in other municipalities such as Colorado do Oeste and Cerejeiras, colonist farmers settled on lots of 50 to 100 hectares. Four protected areas (all indigenous areas) are present in the region.

New agents of land-cover change

Current models of land-use and land-cover change in the Amazon are based on colonist production systems. Highway construction and frontier settlement programs in the 1960s and 1970s attracted migrants to the region. Small farmers practiced agriculture that caused "fish-bone" deforestation patterns in colonist areas, and deforestation was explained as situationally rational considering state policy and wider political economic forces (Schmink and Wood 1992; Browder 1994). Quantitative research has focused recently on endogenous causes of colonist land change patterns. Household economic status and age-sex profiles have been used to explain the proximate causes of land-cover change, particularly shifts from subsistence farming to small-scale ranching, agro-forestry, changes in fallowing practices, forest burning strategies, and regeneration of secondary forest cover (Moran *et al.* 1994; Moran *et al.* 1996; Walker 2003).

Our previous research demonstrates that four characteristics broadly distinguish mechanized agriculture from the colonist system (Jepson 2003; Brown *et al.* in press). First, mechanized farming is based on commodity production that involves the rotation of pasture with soybeans, maize, rice, millet, and cotton. Second, mechanized production is not constrained by household labor because farmers use machines and wage workers for key tasks. Third, mechanized production requires considerable capitalization to purchase the necessary machines, farm implements, technologies, and chemical inputs. These demands require farmers to marshal a broad range of political, social and economic resources from multiple sources, such as private banks, cooperatives, farmers' associations, government agencies, and agro-industrial corporations, to gain access to credit and inputs. Finally, the institutional arrangements that structure access to land are based on clearly defined property rights and land-leasing contracts. This is in stark contrast to colonist property regimes where rights are often precarious and violence over land is more common. Land leases, or contracts, allow capitalist tenant farmers, who may own machinery but not land, to rent land from a neighbor, relative, local cattle rancher, absentee landowner, or a multi-national corporation. The common arrangement allows capitalist tenant farmers to access land and to expand their production area without bearing the cost or risk of purchasing land. This important institutional dynamic effectively "decouples" land and farmer. Therefore, any research to explain land change must take into account two decision-making regimes, those of the mechanized farmer and the landowner who leases property for production.

Mechanization and land-use intensification in Amazônia

Land-use intensification has been central to forest conservation concerns. In the late 1980s and early 1990s, the deleterious effects of extensive cattle ranching and short-fallow production of early colonist farmers, which resulted in land abandonment and further advancement of the "peasant pioneer" frontier, caused policy makers to consider ways to induce intensification. Some strategies, such as applying agro-ecological principles or collecting non-timber products, were supported to increase on-farm incomes and reduce the need to deforest land (Anderson 1990; Futemma and Brondízio 2003).

Two contrasting perspectives characterize the intensification debate vis-à-vis mechanized farming in Amazônia. The first view is that increasing land-use intensification, defined as increased levels of inputs and increased output of products per unit area and time, will take pressure off of natural vegetation and may lead to increased secondary forest generation (EMBRAPA 2002; WWF *et al.* 2003). The second view is radically opposed to any mechanized, capital-intensive cultivation in Amazônia, arguing that the new land-use is extensive and unsustainable for three reasons. First, continual movement into new forest areas is required in order to maintain profitability due to collapsing yields. Second, higher income from higher yields simply encourages expansion into new lands for profit. Third, land consolidation under mechanized annual cultivation may expel small farmers from their lands, forcing a rural exodus further into the forest frontier (Carvalho 1999; Branford and Freris 2000; Fearnside 2001).

Our ongoing research, which integrates spatial quantitative and qualitative data to explain how land intensification impacts forest conversion, promises to move the debate beyond the theoretical impasse of intensification and land use change. We are applying current methods in remote sensing developed by the Kansas Applied Remote Sensing Program (KARS) in conjunction with computer-assisted qualitative data analysis (CAQDA) to develop a methodology to map and analyze land-intensification levels of mechanized

farming using high-temporal resolution data. We intend to combine land-conversion with land-modification data in a geographical information system; this novel integration will allow us to determine empirically the impact of land-use intensification on forest conversion in our study region.

In addition, our analytical framework on access to resources is based on the concept of commodity chains. Commodity chains are transactionally linked sequences in which each stage or node adds value to a good and involves a market (Gereffi *et al.* 1994). The *filière* approach, drawn from French industrial and agricultural economics, allows for an empirical analysis of organizations and institutions that structure economic life, such as markets and resource access (Bernstein 1996; Ribot 1998; Raikes *et al.* 2000). For our study, we have adapted this perspective of commodity chains, one that reconsiders abstract neo-classical markets (*i.e.* perfect) in terms of access to resources in a broader political economic framework of social relations (Ribot 1998; Ribot and Peluso 2003). This approach helps focus research on important trends in agro- environmental geography by reconnecting farmers as agents within larger agro-food networks and making visible the political economy of commodity production embedded within processes of supply (Winter 2003: 508-510).

Continuing Research

In the coming years our research team will continue its work to explore this new process of landscape change in Amazonia. Jepson and Brown will interview key participants in mechanized agriculture, consult archives, and collect ground data for remote sensing analysis in our study region. The qualitative and quantitative data collected in interviews will capture independent variables. Land-cover change data from high spatial resolution LANDSAT TM data, and land-intensification analysis from high temporal resolution MODIS/NOAA-AVHRR data, will measure dependent variables. Taken together, the research promises to become the empirical basis for a major reconsideration of the process and patterns of land-cover change due to mechanized agriculture in Amazônia.

Note

[1]Authors listed in alphabetical order.

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