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A resource demand model of indigenous production: The Jivaroan cultivation systems of Western Amazonia

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ABSTRACT

This study examines the demand for land resources and agricultural production in the lower Pastaza River Basin of the Ecuadorian Amazon. Specifically, we concentrate on two territories controlled by Jivaroan indigenous groups. First, the analysis compares the structural characteristics of riverine and interfluvial cultivation systems in the region. Second, the study investigates the connections between agricultural intensity, population pressure and composition, and terrain conditions at the household level through the integration of geographic information systems, remote sensing, socio-economic surveys, and regression analyses. The study shows that although cultivation practices and the proportion between consumers and producers at the household level are not significantly different among riverine and interfluvial groups, riverine cultivators produce more intensively than interfluvial landholders. In general, the demand for agricultural production at a household level is positively correlated with population pressure and soil quality. In this region, the extent of cultivation is significantly associated with the proportion between consumers and producers along the household's developmental cycle. These findings provide support for the view that land use intensification among indigenous peoples is similar to the dynamic among non-indigenous market-oriented producers.

1. Introduction

Agricultural expansion, intensification, and the consequent land cover change are some of the main processes implicated in environmental problems ranging from climate change to land degradation (Barraclough and Ghimire, 2000; Keys and McConnell, 2005; Walker, 2004). These processes are expected to accelerate the transformation of forests to agricultural lands in the next three to four decades (Keys and McConnell, 2005). Some researchers have suggested that agricultural production will grow four or five times more than current levels to meet increasing human demands for food (Alexandratos, 1995; Tilman, 1999). However, a large part of the land surface is unsuitable for agricultural production due to limitations in the length of the growing season, precipitation, soil characteristics, or topography (Lawrence and Schlesinger, 2001). Humans, when facing land scarcity problems, usually rely on technological innovations such as irrigation, fertilization, or terracing to overcome these limitations (Turner and Brush, 1987). However, in certain areas of the world, where population densities are low and access to technology is constrained by high costs or lack of incentives, production levels are usually associated with demographic factors and the ecological conditions of places wherein production occurs (Lawrence and Schlesinger, 2001; Turner and Brush, 1987). This study focuses on traditional subsistence-based production systems in the tropical lowlands of Latin America. The focus is on the analysis of the demand for land and food resources of two Jivaroan indigenous groups of Western Amazonia.

Much of the evidence of the impacts of agricultural activity in the Amazon region comes from the analysis of peasant farmers in relatively new settlements in frontier lands, who are often considered the main agents of environmental change (Walker et al., 2004; Wood, 1983). However, about a quarter of the Amazon forest region lies within indigenous territories (Richards, 1997; Zimmerman et al., 2001; Nepstad et al., 2006) and little evidence exists that the models and theories that apply to colonists also apply to indigenous agents. In many of these areas, for instance, where land is communally held, production areas overlap, and the presence of markets is minimal, the goals of production do not necessarily follow a profit-maximizing pathway as they do in most colonization fronts (López and Sierra, 2010). In this case, agricultural production is more likely influenced by endogenous conditions of households (e.g. demographics) rather than by exogenous factors (e.g. markets).

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In the context of subsistence cultivators, some researchers suggest that changes in population is a determinant of agricultural intensification as innovation and technological shifts occur and allow to sustain the growing numbers (Boserup, 1965; Netting, 1993; Turner et al., 1977; Turner and Shajaat, 1996). Other researchers have focused on demographic factors to determine how much people produce (Chayanov, 1966; Thorner et al., 1986; Turner and Ali, 1996). This recognition has motivated the development of household models of agricultural intensification that explicitly link household's production and consumption decisions to land use allocation patterns (Vance and Geoghegan, 2004). However, there has been little empirical research on the effect of demographic factors, especially life-cycle factors, on land management of forest-based societies in tropical America. This research tries to shed some light on these effects in an area of the Amazon region controlled by indigenous groups.

If indigenous populations continue to grow and pressure on natural resources increases, production systems could experience changes in productivity targeted to satisfy the food demands of the growing populations. One way to increase production is through extensification, which implies the clearing of additional area and its inclusion in the agricultural system (Walker, 2003). Another option is through intensification, which increases agricultural yields in already cultivated areas. Intensification can be endogenous to the household or exogenous to the production system (Laney, 2002). The endogenous thesis emphasizes the smallholder's capacity to respond to pressures through innovative technological changes (e.g. terracing, irrigation, or improved weeding) (Boserup 1965; Gray and Kevane, 2001; Netting et al., 1993). The exogenous view focuses on those external forces that set the conditions of opportunities and constrains for cultivators and usually emanate from the state, market, or other institutions (Laney, 2002; Rocheleau et al., 1995). In some instances environmental constraints may be also present, which could change land-labor ratios, driving up the intensity of cultivation and, where possible, shifting production toward the market and higher value products (Lambin et al., 2001). However, in the Amazon region, it is believed that most parts of the basin are not well suited for intensive agriculture without external outputs (Colchester and Lohmann, 1993). Thus, environmental constraints in these areas may push households towards migration, accelerate impoverishment, or change labor and tenure institutions (Boyce, 1987; Coomes and Burt, 1997).

Agricultural intensity can be affected by environmental and technological constraints (Turner et al. 1977; Turner and Ali, 1996). Brookfield (1972) pointed out that the environment acts as a constraint on agriculture in that it offers various kinds and levels of resistance to production. In the context of Amazonian lowlands, for instance, Lathrap (1970), Meggers (1971), and Denevan (1996, 2001) suggest that agricultural intensity could be higher in riverine areas than interfluvial habitats since recent alluvial terraces have richer soils and therefore are more attractive for agriculture. In fact, Heckenberger et al. (2003) presented clear evidence that some riverine areas in the Upper Xingu basin (Mato Grosso, Brazil) hosted large, regional agriculturalist settlements that transformed much of the local forest cover. Other researchers found that interfluvial habitats may provide sufficient food resources for large populations if adequate technologies such as improved weeding, agroforestry, fertilizers, or rotation of acid-tolerant cultivars are applied (Sánchez et al., 1982; Sánchez and Benites, 1987). A good example of soil improvement by indigenous populations in Amazonia is the type of soil known as dark earths (*terra preta*), which mainly exist along main rivers but have also been found in interfluvial areas (Lehmann et al., 2003). However, there is little empirical research that tests the hypothesis about the relationship between impoverished soils and agriculture from a socio-spatial perspective within the context of subsistence cultivation systems in the Amazon region.

This study asks the following research questions: What are the structural characteristics of riverine and interfluvial indigenous cultivation systems in the Pastaza River basin? What are the effects of population pressure, household dynamics, and soil quality on the demand for land resources in contemporary subsistence-based societies in Western Amazonia? The expectation is that the riverine biotope supports more intensive agriculture than interfluves, which is translated to a significant differentiation in production yields. In the context of subsistence societies, this difference is perhaps explained by demographic variation. We also expect that population pressure and soil quality are positively associated with variations in the demand for agricultural land use. The demand for land resources is likely to be positively correlated with the proportion between consumers and producers (i.e. commonly called the *dependency ratio*) at the household level.

2. Study area

This study focuses on the lower watershed of the Pastaza River Basin in the Ecuadorian Amazon (PRBEA) and analyzes the structural characteristics of the Achuar and Shiwiar cultivation systems. The Achuar and Shiwiar populations belong to the Jivaroan culture and practice similar resource management (Bolla, 2003; Descola, 1994). The Ecuadorian Achuar are represented by the *Nacionalidad Achuar del Ecuador* (NAE). NAE consists of nine grassroots associations and 64 communities, embraces approximately 6000 people, and controls a territory of 700,000 ha (NAE, 2007). The Shiwiar are represented by the *Nacionalidad Shiwiar del Ecuador* (NASHIE). Currently, NASHIE represents 1200 Shiwiar and nine *centros* (NASHIE, 2007). Two *centros*, Bufeo and Kurintza, contain more than 50% of the total population. The Shiwiar territory in the PRBEA comprises an area of approximately 230,000 ha. Fig. 1 shows the location of the study area and research sites. The access to these territories is only possible by aircraft or by river during the rainy season. Aircraft transportation is typically used for emergencies or health related issues. Access by land is extremely difficult since roads do not exist and it is generally restricted to outsiders without the permission of the indigenous organizations. These factors have kept these populations relatively isolated from market influences.

The Ecuadorian Achuar occupy the low terraces of the Pastaza River and some of its tributaries such as the Copataza, Capahuari, Kapawi, Huasaga, and Bobonaza Rivers. These terraces present alluvial volcanic soils (Fluventic Tropaquepts), or black soils that have a relatively high potential fertility (Custode, 1983). Their physical and chemical characteristics make them the best soils in the entire PRBEA: the pH is not overly acid ranging from 5.5 and 6.5 (Descola, 1994), the interchangeable aluminum rate is low, and their content of organic matter is high. However, poor drainage conditions become an important constraint to agriculture. The Achuar also occupy the high alluvial terraces of the upper Capahuari River and its tributaries, upper Bobonaza River, upper Copataza River, and upper Corrientes River. These are composed of red soils of ferralytic origin (Typic or Oxic Dystropepts) with high aluminum content or of a mixture of red soils and sandy soils produced by the erosion of the hills and mesas. These two latter types of soils have a very low potential fertility (Custode, 1983) and correspond to the interfluvial habitat. Finally, they also occupy two other geomorphologic features that are included in the same group for simplification purposes: the recent alluvial terraces and swampy alluvial floodplains. Although these two areas are geomorphologically different, the soils of both are almost identical (Custode, 1983; Descola, 1994). The vegetation type found on the flat areas of recent alluvial terraces corresponds to the 'Amazon lowland