Shifts in determinants of fertility among women living in the Amazon

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EXTENDED ABSTRACT

INTRODUCTION

Fertility rates among women of child-bearing age (WCBA) in frontier areas is very high (Weil 1981; Rundquist and Brown 1989; Carr et al. 2006), with total fertility rates exceeding 8 births per woman in several frontier regions in the Amazon (Murphy et al. 1999). Despite implications for human development and environmental conservation of such high fertility in these biologically rich areas, a scant body of research examines fertility determinants in rural agricultural frontiers. High frontier fertility may be related to poor infrastructure, child and maternal health care availability, scarce educational opportunities, and a virtual absence of wage employment for women. Moreover, a major portion of deforestation on the earth occurs in such environments (Myers 1994; Geist and Lambin 2001) and household size has been associated with deforestation at the farm level in numerous studies (e.g., Pichón 1997; Carr 2002). In this paper we attempt to address both of these challenges by (1) explicitly examining determinants of changing fertility over time in a frontier area; and (2) determine temporal and spatial effects of fertility and migration on rates of deforestation.

BACKGROUND

Literature pertaining to fertility determinants is extensive. Demographers have long recognized declining fertility rates as signals associated with the initiation of the demographic transition among today's developed and developing counties during the 19th, 20th and 21st centuries. In today's developing world, many countries entered the phase of declining fertility in the early half of the 20th century that were followed by a subsequent decline in mortality rates during the last 50 years (Teitelbaum 1975; Coale 1984). Much research has been devoted understanding how behavioral and biological *proximate* factors influence fertility. Proximate determinants, heralded by Davis and Blake, Bongaarts, and others, can be broadly classified into three categories: *exposures*, which measure timing and duration of regular sexual intercourse in women and is generally measured as the proportion of women married or in consensual union, as well as the age and duration of marriage; *fertility regulation*, which includes use of contraceptives, sterilization and abortion; and *natural fertility factors*, which includes lactational infecundability, frequency of intercourse, sterility, spontaneous abortion or stillbirth, and duration of the fertile period (Davis and Blake 1956; Bongaarts 1978; Hobcraft and Little 1984; Singh et al. 1985). More recently, and specific to rural areas, researchers have identified quality and access to social services, empowerment of women through employment and education, and diffusion of ideas and behaviors as additional concepts in explaining trends in fertility (Mauldin 1982; Easterlin and Crimmins 1985; Caldwell and Caldwell 1987; Hirschman and Guest 1990; Montgomery and Casterline 1993; Rosero-Bixby and Casterline 1993; Singh 1994; Diamond et al. 1999). All of these are important theories to explain fertility differentials and declines, but as van de Kaa points out, none have led to a consolidated narrative that is fully applicable in all settings (van de Kaa 1996).

Thus, a central question that we pose is what entities of the current state of fertility theories can be applicable in a frontier setting? A forest frontier refers to the world's remaining large intact natural forest ecosystems (World Resources Institute) and we consider an agricultural frontier to be the area of interface (border) between human agricultural development and the forest frontier edge. In these types of environments, particularly in the Amazon rainforest, labor is scarce, land is abundant, social services are limited both due to access and to the lack of physical presence, and there are few economic opportunities for women outside the home with cultural norms that put considerable pressure on women to pursue child-rearing as their primary activity. Views of frontier (or rural) areas are that families tend to exist in a peasant (familial-based) economy in which economic production (i.e., agricultural) is governed by separate demographic laws than traditional environments that are primarily based in a capitalistic society. Familial modes of production are typically focused toward subsistence agriculture and dependent upon relationships among nearby relatives. In this type of setting, higher fertility is advantageous as it allows families to increase production to attain more dominance in the limited economy. This has been described by several researchers as the land-labor demand hypothesis (Caldwell 1978; Caldwell and Caldwell 1987; Carr et al. 2006) which hypothesizes that in cases of abundant land but limited infrastructure, capital and labor, economic returns to land are relatively low relative to labor, thus resulting in high desired family size. This concept is closely related a core population-environment hypothesis articulating the relationship between household demographics, farm size, and land tenure (Doveri 2000), which can be explicitly described as "(1) when access to land increases, fertility tends to rise; and, conversely, (2) land ownership suppresses fertility" (Carr et al. 2006). Seminal research in this area includes Hawley's 1952 study showing an increase in fertility from 4.8 to 7.0 as land plot size increased from 1 to over 4 hectares (Hawley 1955). Other studies have shown similar relationships in Bangladesh, Philippines, India, Mexico, Brazil, Egypt, Thailand, and Ecuador (Merrick 1978; Schutjer et al. 1983; Cain 1984; Stokes et al. 1984; Stokes et al. 1986; Carr et al. 2006).

Although these studies provide strong support for the land-labor hypothesis, not all studies have found significant correlations (e.g., (Tuladhar et al. 1982) and there are several key shortcomings in the available research: first, almost all the studies to date examining land use and fertility have been conducted in rural areas, but not in frontier environments; second, many of these studies have been cross-sectional in their approach, which limits inference regarding causation; third, many land-fertility studies have been conducted in areas with high population density (mostly due to land scarcity); and finally, there is clear evidence that agricultural frontiers are characterized by high (in- and out-) migration yet most of the literature to date focuses on rural-to-urban migration effects on fertility or the effect of international migration on fertility levels of those left behind (Gorwaney et al. 1991; Fennelly et al. 1992; Lerman and Goldscheider 1992; Lee and Pol 1993; Burke 1995; Zeng 1996).

In addition to the challenge of disentangling proximate and distal factors associated with fertility along a frontier is the impact of fertility decisions themselves on land use trajectories. The hypotheses described above generally evolves into an empirical approach that either models the impact of land use change on fertility differentials or the reverse, without the recognition that there is a cyclic or dynamic relationships between the two. Fertility, migration and population size in general are recognized as important factors in land use change literature (Bilsborrow 1987; McCracken et al. 1999; Perz 2001; Geist and Lambin 2002; Bilsborrow et al. 2004; Carr 2004; Entwisle and Stern 2005; Vanwey et al. 2007); however, scant research exists that looks at the dynamic relationship that exists between elements of population growth and land use.

An obvious exception to the critiques above is the paper by Carr et al (2006) that uses a subset of the data analyzed in this paper. Carr et al examined female heads of households who responded to surveys administered in both 1990 and 1999, thus limiting the inference since we did not take into account all WCBA (see data methods for more details). The present study will more accurately assess the relationship between fertility and land use by reconstructing birth histories for **all** WCBA, examining determinants of childbirth, and identifying components of population momentum (fertility and migration) related to changes in land use over time and space.

METHODS – DATA COLLECTION

Data for this study are derived from longitudinal household surveys conducted in the northern Ecuadorian Amazon in 1990 and 1999. Details of the surveys and sample selection have been described in previous studies (Pichón 1997; Bilsborrow et al. 2004; Pan and Bilsborrow 2005). Briefly, a 2-stage sample was drawn in 1990: stage one resulted in 61 randomly selected settlement sectors and stage two resulted in random selection of government-defined agricultural plots, or *fincas*. *Fincas* generally ranged in size from 40-60 hectares and in 1990 were occupied primarily by one family - i.e., approximately 450 *fincas* were selected from which 405 *fincas* had agricultural activity and 418 families were occupying these plots. By 1999, unexpected rapid subdivision of *fincas* to relatives and incoming migrants resulted in 934 plots on 395 *fincas* (10 *fincas* were not revisited due to safety concerns along the Colombian border). Surveys were administered to all household farms on the *fincas* as well as to new types of household plots referred to as *solares*, which were urban units with landholdings under 0.5 hectares in which the family was primarily involved in labor away from the household. There were 823 farm households and 111 *solares*. Another complexity of the 1999 household survey administration was multiple family housing: we obtained data from 767 of the 823 farm plots, which were owned by 703 families. Thus, several households owned more than one plot that was located away from the *finca* in which they lived (usually an adjacent *finca*). In addition, not every family had a separate household – these 703 family-owned farms occupied 652 households, indicating that several families lived under the same roof and shared food (almost always a relative, usually a son or daughter). This complicated survey administration and data analysis – i.e., land use data (administered to each head of the household who owns a plot) needed to be merged with the household demographic survey data (administered to one spouse per household). More simply, if a *finca* has 4 subdivisions (family owned-plots) and one household, there will be four land use surveys administered (to each of the heads of each plot) but just one household survey (administered to the spouse of the primary head, usually the original migrant or father) in which all families have their data recorded. In regard to fertility data, numbers of children ever born, children surviving, family code, marital status, age, and education were all recorded. However, data on contraceptive use are only relevant to the female who responds to the survey; thus this information can only be used as a proxy for access to contraceptives.

As stated above, past analyses (Carr et al 2006) restricted longitudinal analysis to the primary female head to which the survey was administered in both 1990 and 1999, thus we utilized a sub-sample of women of child-bearing age (WCBA) who provided longitudinal data. In this paper we analyze fertility determinants for all WCBA by reconstructing 10-year (maximum) birth histories from each survey. In other words, for each WCBA during the 1990-1999 interval (reported age 15-59 in the 1999 survey), we construct annual birth histories during the time a WCBA lived in the Amazon by examining the number of children born to that woman, the ages of the children living with her, and the reported number of child deaths and migrations. In the household roster, whenever a child is born and living with his/her mother they are coded as a separate family in the household roster. If a child migrated or died after birth prior to the 1999 survey, they are listed in the migration or mortality rosters. Thus, we can theoretically re-construct annual childbirths each year for each WCBA. Birth histories will be reconstructed from 1990 to 1999 using the 1999 survey data and from 1980 to 1990 using the 1990 survey data. For the 1990 year we will individually examine each woman reporting a birth during that year based on both surveys.

METHODS – STATISTICAL MODELS

Data will be constructed such that each row of data consists of a WCBA in year *t*, living in household *i*, *finca j*, sector *k*, and linked to community *c*. Thus, we develop a multilevel logit regression to model the odds of childbirth during a specific year, household, *finca*, sector and community. Random effects will adjust for clustering by household, *finca*, and sector / community. We suspect the latter random effect (sector / community) to be inseparable: i.e., we view sector effects as capturing spatial correlation among WCBA living in the same area, while community effects capture aspects of neighborhood structure and function. The difficulty in estimating these two random effects is that most settlement sectors are associated with just one community. Previous research on land use has indicated that for these data it suffices to model the sector and community effects as the same and non-spatially (Pan et al. 2007). Other predictors to be included into the model as fixed effects will include: variables describing individual characteristics of the WCBA (age, education, marital status, parity, labor participation), household characteristics (dependency ratio, income, contraceptive use/access of the primary female household head, landholdings, population density, adult males or labor demand), temporal factors (year, presidential terms or other relevant time intervals), and spatial factors (distance to health centers, distance to roads, road access). All variables will be derived from the most recent forward survey – i.e., data pertaining to childbirths from 1980-1990 will be obtained from the 1990 survey, while data pertaining to childbirths from 1990-1999 will be obtained from the 1999 survey. Variables that will change over time include: age, parity, dependency ratio, landholdings, population density, adult males, and temporal factors. Other variables will be static as we cannot assign changes to the other variables. This is a limiting but necessary approach.

For this paper, land use models will focus on deforestation, but may be extended to multivariate land use outcomes depending on the progress of the paper prior to the PAA Annual Meeting. Prior land use models will use a multilevel framework approach and define parameters as used elsewhere (Pan et al. 2007). However, one primary exception is implemented – i.e., explicitly model the number of childbirths in five-year intervals (1980-84, 1985-89, 1990-94, 1995-99) to determine deforestation rates from 1990 to 1999. In other words, we will add 8 variables (4 fertility and 4 migration) to determine the relationship between population growth velocity (or cohort population effects) on deforestation.

Results

Preliminary results do not yet exist, but this research was motivated by two observations in our past interpretations of data. First, fertility rates were reported to have dropped from 8.0 births per woman in 1990 to 5.0 in 1999. However, as stated earlier, these indirect estimation methods were based only on women who responded to the female questionnaire and not all the WCBA in the sample. A reanalysis of the data shows that 1990 TFR ranges from 6.95 to 7.91 while 1999 TFR ranges from 5.77 to 6.81 depending on the interpolation method and types of weights employed. Table 1 summarizes the analysis of fertility data.

Based on this finding, we hypothesize that (1) Factors influencing birth over time do not change (i.e., factors identified prior to 1990 will also be important between 1990-1999) and (2) that population growth due to fertility contributes to a higher proportion of forest cover change than previously believed and is equal to the importance of in- / out-migration. Specifically, regarding (1) we hypothesize the labor demand (total landholdings cleared for agricultural use) on the farm drives fertility decisions across all age ranges, while younger women are more likely to have children overall, consistent with proximate determinant literature. Regarding (2) we specifically hypothesize that children born during earlier time periods will have the greatest impact on deforestation, while more recent childbirths will affect change trajectories. Less.

Table 1. Total Fertility Rates by Year, Indirect Estimation Method, and Weighting

	2nd-degree polynomial, Coale & Trussell			Interpolation Equation, Coale & Trussell		
	Unweighted Adjustment (20-24, 25-29, 30-34)	Weighted Adjustment (20-24, 25-29, 30-34)	Weighted Adjustment (20-24, 25-29)	Unweighted Adjustment (20-24, 25-29, 30-34)	Weighted Adjustment (20-24, 25-29, 30-34)	Weighted Adjustment (20-24, 25-29)
1999	5.77	5.74	5.80	6.62	6.64	6.81
1990	7.12	7.08	6.95	7.32	7.51	7.41