Fertility in Petén, Guatemala: the impact of the individual, the household and the context on fertility behavior

Abstract

Abstract This research explores fertility correlates in the Petén, a high fertility region of Guatemala, during the 1998-99 time period. By taking into account land use and labor characteristics at the household and community levels in addition to individual level factors related to diffusion, gender equity, and socio-demographics the research aims to enhance and update the traditional application of the demand framework used to examine fertility. Data from the 1998/99 Demographic and Health Survey containing a unique environmental module was used in concert with 2002 Population and Agricultural census data. This analysis expands the fertility determinants dialogue by including land use variables - rarely examined and directly correlated to individual fertility behavior. A multi-level model using a count variable (total children ever born) as the response where individuals are nested within their geographical location was compared to a negative binomial model as well as a traditional Poisson generalized linear model. The results of the analysis highlight the complex set of individual land use, environmental, and socio-demographic characteristics required to explain the variation in individual fertility behavior at a time when this high fertility population is potentially on the precipice of a long-awaited fertility decline.

Research Question

Recent demographic research has largely been focused on the rapid decline of fertility rates throughout the developed and developing world. The classic theories of the determinants of population change frequently used to model and explore fertility decline and transition in all populations have resulted from substantial empirical research. However, many questions about the mechanisms involved in maintaining high fertility rates or in catalyzing a decline among current high fertility populations remain unanswered. While research inspired by the quick and unanticipated decline in birth rates can provide valuable insight into the demographic transition, it is important that population science maintain a commitment to empirical research of high fertility populations. Besides being the fastest growing populations, high fertility groups also tend to be those who suffer from the most extreme poverty, malnutrishment, and dearth of health care and education. Concomitantly, they tend to live in rural remote regions which are increasingly situated in and around the world's ecological "hot spots" on which they have a considerable impact given that they are nearly all farmers and depend on the forest for felling in order to open agricultural fields and for fuel-wood. Analysis of the correlates of high fertility with attention to modern advances in technology (contraceptive, transportation, communication, etc.) and contemporary concepts of household and community gender equity will update and enhance the applicability and the generalizability of the traditional demographic transition theory and ultimately improve scientific understanding of population change.

The objective of this research project is to explore fertility and reproductive health dynamics within a population with one of the highest total fertility rates (TFR) in the western hemisphere, Guatemala. The particular focus of this paper is to develop a model of fertility in Petén, Guatemala, the Guatemalan sub-population characterized by the highest regional TFR in the country (Instituto Nacional de Estadistica 1999, 2002), by incorporating individual and municipality migration, environmental, and land use characteristics.

figure1 and figure 2 Guatemala 1998/99 Regional TFR map and chart here

Setting

Guatemala's population is roughly equally ethnically divided (50% Indigenous and 50% of Ladino (mixed ancestry) descent) and during the latter half of the 20th century suffered a turbulent civil war characterized by extreme violence directed towards the Indigenous community (Lovell 1999). Furthermore, Guatemala's rates of contraceptive use trail other Central American countries while its fertility rate is one of the highest in the region (Bertrand, de Salazar, Mazariegos, Salanic, Rice & Sow 1999, Bertrand, Seiber & Escudero 2001, De Broe & Hinde 2006). Indeed, in rural areas of Guatemala the TFR exceeds 6 births per woman while in rural regions of the Petén, the region containing the Guatemalan frontier and the focus of this paper, fertility rates are close to 8 births per woman (Grandia & Schwartz 2001), a fertility level that approaches the observed limits for any world region at any time in world history and places Petén within the "belt of high fertility" that defines much of Northern Guatemala and the Highlands (De Broe & Hinde 2006) . Although aggregate Guatemalan fertility rates and lack of contraceptive use, as mentioned earlier, are unusually high for Latin America, the 6% contraception use rate among rural Mayas is extraordinarily low (compared to 50% of ladinos) and may explain some of the differences in fertility outcomes (Bertrand et al. 2001, De Broe & Hinde 2006). Currently, the gap between Indigenous and Ladino fertility is increasing as the Ladino population has begun showing strong signs of fertility decline while the Indigenous population shows limited or no signs of decrease (De Broe & Hinde 2006). The fertility differences between Indigenous and Ladino populations are further impacted by the characteristic differences in fertility behavior between rural and urban communities.

In addition to unusually high fertility, this region is also characterized by severe loss of forest cover (Carr n.d.). In fact, if current deforestation rates continue, over the next 10 years forests will no longer exist in Petén (Carr n.d.). In response to concerns over land use change several national parks protecting the delicate and unique rain forests and Mayan heritage sites, also found in this area, have been developed. Despite the preservation intentions, as land pressures push marginalized farmers out of other areas of the country the 'free' land of the national parks draws these impoverished families and communities ultimately form in protected areas. The increase in the size and number of these illegal communities settling near the boundaries of the

parks (frequently within the park) have begun to impact the forests as agricultural practices intensify to reflect the needs of a growing impoverished population (Carr n.d.). The high rates of deforestation combined with high rates of fertility and in-migration suggest a bleak future may be awaiting Northern Guatemala.

This paper does not focus exclusively on the frontier population. Instead, to determine the factors impacting women throughout this historically marginalized region as well as to develop models capable of comparing fertility correlates across municipalities of the Petén, it explores the population of the entire Petén. This paper will help elucidate the complex relationship of land use and land cover change and fertility by combining traditional approaches to fertility analysis using factors related to ideational change, family planning access, family and community migration experiences, and the usual socioeconomic indicators (age, education, wage earning employment, etc.) with rarely used land use and labor factors(Bertrand et al. 2001, Seiber & Bertrand 2002, Lindstrom & Munoz-Franco 2005). Ultimately, this research will have an important impact on land preservation and public health strategies with the long term goal of improving the lives of individuals and families in Guatemala.

Theories and Tools

Theories of Fertility Decline

Coale (1973) simplified fertility analysis with the development of three "preconditions" of fertility decline (specifically referring to marital fertility); in order for fertility behavior to change or decline fertility decisions must be conscious decisions, contraception or "techniques of fertility reduction" must be accessible (intellectually as well as geographically), and the value of reducing one's fertility must be apparent (Coale 1973, Cleland & Wilson 1987). Changes in factors affecting these preconditions can therefore be attributed to general cultural changes, changes in access to information and technology, and changes to the 'worth' and 'cost' of offspring. According to Cleland and Wilson, the majority of fertility research has been directed towards the third listed precondition of fertility decline; the economics (cost/benefit) of childbirth and childrearing. Approaching fertility decline as an economic benefit to families and individuals

has led the development and wide-spread use of the 'demand theory' of reproduction targeting the economics behind family planning decisions (Cleland & Wilson 1987).

Changes in culture and ideals as a factor affecting fertility decline is refered to as, 'diffusion of innovations' theory or 'ideation' theory. This approach links the first two of Coale's preconditions and was developed as an explanation of fertility decline among English-speaking populations (Raftery, Lewis & Aghajanian 1995). This decline, particularly notable in European countries with more than one national language, highlighted the similar pace and direction of fertility change amongst English speakers while non-English speakers followed a different transitional pathway. Coale and Watkins (1986), ultimately determined that transition therefore occurred resulting from shared information regarding reproductive health technology as well as cultural and lifestyle ideals rather than driven by changes in socioeconomic factors (Raftery et al. 1995, A. J. Coale 1986). Both the value and the ideations preconditions of Coale and the corresponding theories of fertility decline provide the framework for the analyses and interpretations of this research.

Direct and Indirect Determinants

While the classic theories of decline provide a theoretical framework for analysis, the theories of direct and indirect determinants provide the guidelines for application and interpretation of the general theories. Incorporating direct and indirect determinants into the process of independent variable selection and interpretation of results is influenced by the concept work of Davis and Blake in the 1950s and the subsequent work of John Bongaarts in the 1970s which established a heuristic for researching fertility determinants. According to this approach, direct fertility determinants are defined as a "set of biological and behavioral variables that directly affect reproductive behavior" (Knodel, Chamratrithirong & Debavalya 1987, Davis & Blake 1956, Bongaarts 1978). These factors are largely known as the proximate determinants of fertility. Bongaarts' proximate determinants: marital patterns, induced abortion, postpartum non-susceptibility, and contraception account for the majority of the worldwide variation in fertility (Martine 1996). Simply, fertility decline is predicated upon a change in one or more of

these determinants. This research project approaches fertility determinants using this classic framework by selecting variables and evaluating and interpreting relationships amongst select independent variables and between the variables and the response based on their impact on the proximate determinants. Consequently, the approach to variable selection in this analysis will be based on the effect that each variable will have on one of the proximate determinants of fertility. Additionally, direct measures of these variables will be incorporated into the model where data is available (for example, information on individual contraceptive use or breastfeeding practices).

The individual in context

Incorporating contextual level variables allows the analyst to more accurately model real-world phenomena as women and families are impacted by and impact their surrounding community. Related research exploring the health and lifestyle choices of women and families in Guatemala has begun to incorporate context variables with traditional individual variables (Pebley, Goldman & Rodriguez 1996, Lindstrom & Munoz-Franco 2005). This analysis endeavors to model, as realistically as possible, the factors that impact a woman's fertility decisions. Building on the idea that families may choose to have children based somewhat on the attitudes and motivations of their community regardless of their own standing and background, it is important to incorporate the contextual (in the proposed research context refers specifically to municipality) information as well as the individual level information. Therefore, municipality level variables will be included as a measure of broad social/cultural ideals while individual factors will be used to target individual decision-making.

The following subsections provide broad theoretical categorizations and explanations for the selection and use of each of the independent variables.

Land-Fertility Hypothesis

Easterlin advanced the development of the supply/demand framework for analyzing reproductive decisions when, using a primarily economic perspective, he explored the fertility experience in the fairly homogeneous US 19th century frontier. In this setting he determines

that fertility behavior is influenced initially by "tastes, prices, and income" and is subsequently affected by "infant and child mortality conditions" (i.e., compensatory births to accommodate high mortality and to reach the optimal family size) (Easterlin 1971). His ideas are consistent with Coale's supply/demand precondition. Because of the historical context of his analysis, these ideas lead to the development of a more specific component of the supply/demand framework, the land-fertility hypothesis. The implication of this hypothesis is that as long as children provide labor then the desire for large family size remains intact. The built-in assumption is that fertility is a conscious choice, largely impacted by the need of additional labor in the fields or in the home. He supports this theory with the US frontier example highlighting the fact that the more rural areas with more available land produced more children whereas the urban communities generally produced fewer children. In the few cases where related applications of Easterlin's theories have been explored the results have highlighted complex relationships between fertility and land use trends (Carr, Pan & Bilsborrow 2007, Lee 2001, Lee & Kramer 2002).

Incorporating Easterlin's theory here, household land use characteristics and municipal land characteristics (forested or fallow) will be included in the quantitative analysis to capture the household's perceived labor needs, as a measure of the 'cost/benefit' of a child. I hypothesize that even in the case where a woman does not experience the loss of a child - the experiences of neighbors and friends may motivate a behavioral response. Where more land is available, like unused forest land, families may choose to have more children to work larger areas. Similarly, large amounts of fallow land may also indicate the need for a large labor pool to increase land productivity. Moreover, the percentage of tractors per farm (count of tractors/count of farms) will also be included as a municipal level variable. Tractors clearly reduce the amount of labor required to care for crops and indicate a relatively high socio-economic status. These factors suggest that people living in communities with a higher percentage of tractors would have fewer children. At the individual level, household production, measured as sufficient or insufficient, is hypothesized to be correlated with the number of births. If household production is insufficient then an increase in children should increase the labor available resulting in improved production. Similarly, families where sons provide field labor are anticipated to have more children as the

children are directly involved with family stability and potential longevity. The final individual land use and labor variable in use in this analysis, is cattle ownership. If a family owns cattle, which requires less labor than crops, then the family is hypothesized to be less reliant on labor and therefore have fewer children. As this region of Guatemala contains both developed and frontier lands - two environments were fertility behavior and, in turn, the values of these variables, should be very different, this provides an ideal context within which these theories can be examined.

Ideation

Applying concepts form the theories of diffusion and social networks to fertility behavior is growing in popularity and may provide key evidence of fertility transitions. In fertility and social science research theories of diffusion are used to explain the movement of ideas (Kohler, Behrman & Watkins 2001). Social learning and social influence are highlighted as the two "defining features" of diffusion (Lindstrom & Munoz-Franco 2005, Kohler et al. 2001, Montgomery & Casterline 1996). Social learning is the process of obtaining information about new technologies and their affects from friends, family or community members either resulting from direct interactions or from information passed over mass-media (Kohler et al. 2001, Lindstrom & Munoz-Franco 2005). Social influence reflects the idea that values can be transferred because of an individual's membership within a group and that personal preferences (i.e., contraceptive use and family size) may be influenced by group preferences (Kohler et al. 2001, Lindstrom & Munoz-Franco 2005). In Montgomery and Casterline's research they identify increased awareness and knowledge of consequences, as well as pressure to conform as three different effects of diffusion on fertility behaviors. In the case of rural Guatemala diffusion will most likely occur differently than in urban communities, and differently in rural indigenous versus Ladino communities, since diverse community interactions are more limited and mass media influences may be less present. Diffusion, in general, however, has been shown to increase contraceptive knowledge in a variety of settings where variations in contraceptive use have more or less impact on individual behavior depending on the density of the social networks

(Montgomery & Casterline 1996, Entwisle, Rindfuss, Guilkey, Chamratrithirong, Curran & Sawangdee 1996, Kohler et al. 2001). Identifying the characteristics of the diffusion of information in the rural and urban settings is an important component in understanding the effects of structural variation on fertility behavior. Additionally, understanding the process of diffusion of knowledge in a community facilitates effective and possibly community customized family planning policy (Kohler et al. 2001).

Incorporating ideas from diffusion theory in the Guatemalan setting is particularly important because of the tendency of Indigenous populations to be suspicious of the motives of "outsiders" who provide family planning information (Santiso-Galvez & Bertrand 2004, Seiber & Bertrand 2002, Bertrand et al. 2001). Clearly, in the case of Indigenous populations, information gained from individuals linked by strong social ties may be vitally important in an individual's understanding of family planning technology. In terms of variable selection and evaluating community characteristics, the theory of diffusion and its relationship to fertility change and transition indicates the importance of developing a solid understanding of the movements of ideas throughout the community and the neighboring communities and further developing an understanding of this process as it relates to development and population density. If individuals live in an urban environment or have lived in an urban environment at some point, they are expected to have fewer children as their exposure to family planning technologies should be greater than individuals who have lived only in rural settings. Similarly, use (also a direct determinant) and knowledge of contraception, approval of family planning and family planning discussions with others is theorized to reflect an acceptance of family planning, perhaps gained from shared ideas and experiences, and is assumed to result in smaller numbers of children. (Although contraceptive use may only be relied on once family size has exceeded "ideal" family size and therefore may be associated with a higher number of children). Television ownership may also enable exposure to smaller family-size ideals and more affluent lifestyles. Lindstrom and Munoz-Franco (2005) have shown that families and communities with out-migrants to urban or international locations have higher contraceptive use suggesting that information and values from these outside communities is seeping into relatively geographically

isolated communities - reflecting this theory, the municipality proportion of domestic outmigrants is incorporated. The proportion of women aware of modern methods of contraception will also be included as a municipality level variable. The intended use of this variable is to account for the general contraceptive knowledge among women, perhaps a context where a large proportion of women are aware of modern contraceptive methods will permit increased use and access to contraception.

Gender equity: The assumption inherent in the theories of cost/benefit is that once fertility begins to 'cost' more than it 'benefits' the behavior will change to re-establish the household quantity-quality equilibrium. In developing world households where men frequently maintain decision making power regarding reproductive health and family planning decisions it is often not possible for women to change their behavior based on the 'cost' of another child. Furthermore, reproductive health research has indicated that men's higher fertility preferences, resulting from lower cost and greater benefit relative to women, will result in higher rates of fertility particularly in those households where gender inequality is particularly acute (Fapohunda & Todaro 1988, Dodoo & Seal 1994, Boserup 1981, Dodoo 2001). Generally, however, as institutional gender equity increases then fertility decreases (women have increased access to higher education and wage earning employment) (Torr & Short 2004). Incorporating household and municipality gender dynamics in reproductive health and fertility research within the developing world context will enable close examination of gender dynamics in the home and in the community and the resulting impact of these dynamics on reproductive health and fertility. Partner approval of family planning, discussion of family planning amongst the couple, role as an income earner and a gender equity variable will be included. The gender equity variable assigns one of three values to each woman, a 0 indicating that the relationship is *equal* a 1 for either a difference in age of more than 5 years, or for a difference in education (based on the three broad individual categories - no education, primary education or secondary/beyond secondary), or a 2 if both of those differences are present. Similarly, the percent of women who have completed high school at the municipal level will also be included as this serves as potential measure of the opportunities and freedom available to women where an increase in high

school educated women can provide an increase in social equity - regardless of an individual's personal academic background.

Socio-demographic

Socio-demographic variables are factors that frequently serve as 'controls' in fertility analysis. This research project will also incorporate these variables as both individual and contextual level controls.

Age will be used to control for exposure to childbearing with the expectation that as women age the number of children they have increases. Similarly, union status (currently involved in a partnership or single) will be included also to serve as an exposure control variable. Religion, particularly Catholicism and traditional Mayan beliefs have been identified as potential macro-level causes of high fertility (Santiso-Galvez & Bertrand 2004). While the openly anti-contraception stance of the Catholic church has been hypothesized as a potential block to family planning advancement in the country, Mayan beliefs have been hypothesized to impact fertility desires as the Mayan "cosmovision" discourages attempts to interfere with a "destined" birth (Santiso-Galvez & Bertrand 2004). In this analysis, therefore, I would anticipate that women who identify with a religion other than traditional Mayan or Catholic will have fewer children.

A consistently important factor in the economic theory of fertility decline is the role of education. As education becomes more of a social norm more children therefore attend school and cannot contribute as "labor" to the family and their cost increases while their benefit decreases. The role of education can also represent a change in the community's values as well as those of the family or individual. In fact, in an analysis of fertility decline in Iran, the role of education was examined from two different perspectives; the role of maternal education and the current acceptance and accessibility of education for children (Raftery et al. 1995). The point was to determine if maternal education levels, which may impact contraceptive knowledge and gender equity, had a different impact than current trends in education of children. Either way, increasing education (for either the parent, child or overall community) can ultimately impact the number of births. In this analysis both the education level of the woman and the partner

will be included in the modeling.

As Guatemala's population is divided by ethnicity and language and reports a large percentage of the Indigenous population living in rural areas, I anticipate that the application of the proximate determinants will require different variable specification, ultimately highlighting the different development, economic, and fertility pathways present in the diverse population. The gap in living standards and contraceptive use between these populations indicates that there may well be different factors resulting in specific reproductive health outcomes. Related research examining health and fertility outcomes within Guatemala has highlighted the necessity of exploring the ethnic differences in determinants and correlates of these outcomes (Seiber & Bertrand 2002, Pebley, Goldman & Robles 2005, Lindstrom 2003, Lindstrom & Munoz-Franco 2005, De Broe & Hinde 2006). Therefore, percent of the municipality population identified as Indigenous may also prove to be a significant contextual level variable as health service availability may be limited in locations with a large Indigenous population (Pebley et al. 1996).

In related research socio-economic status at both the individual and community level has been linked to fertility outcomes and health service use (Pebley et al. 1996). In fact, even adjusting for socio-economic status at the individual level, a community's socio-economic status as measured by community sewer system status, remained significant. The number of households with indoor plumbing is included as a measure of municipal level wealth, indoor plumbing status at the household level will also be included to measure household economic status. Individual wealth within the context of a relatively wealth municipality may have a different impact than when a household is wealthy in a poorer context.

Data

The Demographic and Health Survey (DHS) data collected in 1998/99, by the Guatemalan Instituto Nacional de Estadistica and Measure/DHS+, Macro international, will be used. The DHS is the largest ongoing survey in the world and is the primary source of data on population, health, and socio-economic indicators for developing world nations. The 1998/99 DHS is unique in that it is the first to incorporate an environmental survey module, thus allowing for analyses

that explicitly link health and fertility outcomes to natural resource and environmental factors; this is key in a frontier context in which the population is overwhelmingly comprised of subsistence farm families. The DHS data is invaluable for conducting research of this type among this high fertility and dynamic population. Not only do the DHS results provide extensive information regarding individual and family health and cultural norms, the large sample size provides a fantastic overview of large-scale trends and ultimately enables region-wide generalizability of the results. Moreover, the 1998/99 survey represents the first large-scale data collection of reproductive health information of inhabitants of the Petén region. Previously, this extremely impoverished population was excluded from surveys and was therefore un-represented in policy decisions based on large-scale analyses. The Agriculture and Population census data, compiled in 2002, will also be used. This census data will be used to provide contextual level information to the quantitative analysis.

Methods

To explore fertility in Guatemala and the specific factors affecting fertility in urban and rural Guatemala at micro level, analysis will be conducted using traditional generalized linear modeling techniques where the response variable is assumed to follow a Poisson distribution. Results from this model will also be compared with results from the negative binomial and multi-level (random and fixed effects) regression. The application of analysis methods that take into account an individual's characteristics as well as those of her household and community represents an innovative technique of incorporating place and location into demographic analyses.

Generalized linear mixed models are applied to this data to examine fertility correlates in the Peten region of Guatemala. Generalized linear models build on the standard regression technique in two different ways. First, the non-normal nature of the dependent variable (total children ever born) requires the use of a link function and therefore transforms a linear regression approach to a generalized linear approach. In the context of total children ever born, the count of births is discrete and therefore violates the assumption of continuity contained within

the application of the normal distribution (McCullagh & Nelder 1989). Alternatively, the Poisson distribution is commonly applied to variables that represent counts of events. To develop a regression model in the case where the dependent variable is assumed to follow a Poisson distribution, a log link is frequently used. Equation 1 shows the linear combination of explanatory variables and estimated coefficients on the response, η. Since we are using the Poisson distribution to model the response then we introduce a link function, $g(\mu) = \eta$ where μ is equal to the expected value of the response and, consistent with common application, $\eta = log(\mu)$ (McCullagh & Nelder 1989).

$$\eta = \beta_0 + \beta_1 x_1 + ... + \beta_j x_j \tag{1}$$

However, the assumption of equal mean and variance built into the Poisson distribution can make the use of the distribution questionable. In response to the limitations of the Poisson distribution, the negative-binomial distribution may be an appropriate distribution. The negative-binomial distribution is a more flexible distribution allowing the variance term to vary with each independent observation. In fact, the construction of the negative binomial distribution follows as a hierarchical or two-level distribution where the variable follows a Poisson distribution but the variance term for each observation follows a gamma distribution. For rate λ, the mean and variance of the distribution, $\mathrm{E}\lambda = \mu$ (equal to the expected value of the response) while the $var(\lambda) = \mu/\theta$ (Faraway 2006). Assuming that the dependent variable follows the negative-binomial distribution allows the variance term to vary over individuals and removes the restriction of equality of the mean and variance. In this paper both distributions, the Poisson and negative-binomial, will be used for modeling the phenomena of interest and will be briefly compared and evaluated to determine the best modeling scheme.

The second characteristic of the generalized linear mixed model approach, which differentiates this approach from classical regression, is the incorporation of random effects. Ultimately, the analysis will use a combination of fixed and random factors to explore fertility (the use of both types of factors results in the so called 'mixed model'). In this case, the data contains

information about individuals as well as information characterizing an individual's current or past location or residence. The analytic strategy incorporates the fact that individuals who live in the same community are more alike than their counterparts of a different community (and so on up to higher geographic levels) but approaches these geographic regions as a sample from a larger population of geographic regions. This approach makes it possible for the analyst to "estimate the pattern of variation in the underlying population" of geographic areas within Guatemala then "attempt to explain the pattern in terms of general characteristics of the [geographic area] by incorporating further variables into the model" (Goldstein 2003). Here, each individual respondent is nested within the municipality and the municipality serves as the random effect.

Nesting individuals allows for the adjustment of the model to accommodate the fact that members of a municipality are more alike when compared to individuals from different areas. Without incorporating this into the model, the observations cannot be regarded as independent and the resulting standard errors, and, in some cases, point estimates can be incorrect (Rodriguez & Goldman 2001). Additionally, land use and demographic characteristics of the municipality are included in the analysis and are allowed to vary over the clusters and municipalities (in effect this evaluates the interactions between these higher level variables and the geographic nesting levels) (Goldstein 2003)

The variables used for the analysis are listed in Table 1. They were selected based on their impact on fertility as outlined in the 'Theories and Tools' section. They are further categorized into socio- demographic, ideation and land use and labor variables.

Figure 3 here - explanatory variables

Results

The results of the model, using each of the modeling strategies are virtually identical, this was perhaps foreshadowed by the lack of over (or under) dispersion in the initial poisson single level model. Since the initial generalized model is not over-dispersed the application of methods usually used to adjust for dispersion issues, resulting from the limitations of modeling

the response variable as poisson distributed, may not be necessary. Ultimately, however, the significant variables in the single level model, which utilized the simplest and most traditional analysis scheme, remain the same for each of the models despite the increasing statistical complexity required to fit these models. Moreover, the Akaike Information Criterion (AIC) measure suggests that the poisson GLM fits the data better than the negative binomial model. For the purpose of interpretation the results from the traditional poisson GLM will be the focus.

Figure 4 here - muni level values

Fifteen women were excluded from the analysis as they were determined *infecund* (a classification by DHS as infecund/menopausal combined with a total birth count of 0 characterized this small portion of the population). Also, in the case where more than one woman was sampled from a household only the partner of the head of household (or the head of household herself) were used. As the household sample used for the environmental module was self-weighted restricting the sample to only one response per household maintained the self-weighting structure for the analysis.

Figure 3 presents the variables used as contextual variables as they are aggregate measures of individual behavior. A quick look at these values and the results shows that, despite the obvious variability, differing socio-economic, demographic and development contexts do not significantly impact individual fertility behavior in the presence of individual demographic, diffusion, gender equity and labor variables. Moreover, the 2nd level geographic variable (nesting individuals within their municipality) was not necessary to explain the variation in the response, and any inclusion of individual random effects did not improve the model fit enough to justify the inclusion of this complicated modeling strategy. Therefore, the final model results as a generalized linear model with a log link to accommodate the count nature of the response variable. The dispersion parameter is almost 1 indicating that the mean/variance requirements of the Poisson model are very nearly met. The deviance improvement over the null model is about 56% . Figure 4 presents the significant variables and the model coefficients. Significance was determined using the chi-squared tests where deviance values of the models were compared

upon explanatory variable inclusion.

Figure 5 here - regression results

The demographic variables found in the final model, highlight the continued applicability and significance of the traditional ideas of fertility determinants while suggesting that the interplay between socio-economics and ideation can also significantly impact fertility behavior. Keeping in mind that the use of Poisson regression requires that a unit increase in the independent variable (or moving from the reference category of a categorical variable) results in an impact on the *log* of the expected number of children born (holding all other variables constant), maternal age is positively correlated with fertility where an increase by a year increases the log of expected fertility by .0468. Maternal education and partner education are both negatively correlated with fertility. The differences between the lowest category of education and completion of primary or secondary school are larger than those for the partner. Women who have completed secondary school are expected to have 66.6% as many children as women who have no schooling, whereas the same comparison for men yields a percentage value of 73.5. To illustrate: if, for example, a woman with no education is expected to have 3 children then a woman with a secondary education (assuming all other factors are equal) is expected to have 2.00 (or 3*.666). Similarly, if the only difference is partner education level then the expected number of children would be 2.21. Ethnicity is also included amongst the significant socio-demographic variables. In this case, Ladino women are expected to have a log fertility count of .092 less than their Indigenous counterparts.

Among the socio-demographic variables, the significance of maternal age points to the extended exposure to childbearing naturally found among older women as they have been reproducing for a longer period of time than the younger cohorts, and they have, therefore, experienced more births. The significance of age however, can also indicate an ideational cohort effect or a change in the ideals and values of the younger women (perhaps favoring families with fewer children). In this analysis it is not possible to tease out the impact of ideation or exposure for this particular variable - and therefore it is important to keep the complex nature of the variable in mind when reviewing the results. A bivariate analysis of age and the

response variable suggested the potential for a curvilinear relationship (an indication that as age increased the number of children began to plateau), however the inclusion of a higher order age term resulted in multi-collinearity (between age and the squared age term) which made the model somewhat unstable and therefore the higher order term was excluded.

In the analysis of the fertility transition in Iran the study authors argue that maternal education (as opposed to contemporary trends in education of offspring which impacts the cost/benefit of children) serves to increase intellectual accessibility to contraceptive technology or may directly impact exposure (to childbearing) by causing a delay in marriage and/or first birth (Raftery et al. 1995). The effect of education is assumed to impact Guatemalan women in the same way, through ideational or exposure change. In this case women who have had primary or no education do not have significantly different fertility outcomes - only those women who have a secondary school education are expected to have statistically fewer births than women who have had no education. The large coefficient highlights the huge impact that secondary education completion will have on individual level fertility.

The role of paternal education impacts intellectual accessibility to contraceptive technology as well as the 'earning-potential' or socio-economic level of the household. However, because the gender equity variable which incorporated educational differences between the partners was not significant, the paternal education variable seems more likely to serve as a measure of socio-economics in the household. Furthermore, while the employment variable (partner employment) was not significant in the model, it's correlation of .51 with men's education level suggests that the education variable serves as a proxy for socio-economic level.

Ethnicity also plays a significant role. The significance of ethnicity further suggests the importance of ideational factors, perhaps particularly related to language or culture. In light of the other variables in the model, the significance of ethnicity illustrates that among the most impoverished and under-educated women, Indigenous women are still anticipated to have more children. Television ownership suggests the importance and intertwined nature of ideation and socio-economic level on fertility outcomes. In this case, the prediction that families will have fewer children in the case that the household possesses a television could result from either the

increase in socio-economic status that permits for spending on a television or the exposure to gender, family and, possibly, family planning values that reflect the ideas of more developed areas of the country or of Latin America. The direction of the relationship between the response variable and the approval of family planning variable may initially seem surprising as approval of family planning is correlated to higher numbers of births. Our assumption is that the causal arrow is pointed away from high fertility towards approval of family planning. In other words, as family size increases, an increased need of contraception develops. It is significant to note that partner's approval of family planning was not significant, suggesting that the female partner makes the family planning decisions.

The significance of the land use/labor variables which are rarely applied to fertility studies highlights the complex nature of individual and household decisions to reproduce. Already the model points to a complex interaction of ideational and socio-economic measures related to fertility outcomes, the significance of land use and labor variables in addition to the existing variables in the model continues to support the idea that fertility is affected by a variety of inter-related factors. Cattle ownership has been hypothesized to have a negative effect on fertility as families invest resources in cattle as a safety in case of future needs (rather than investing in offspring). Also, as cattle are less labor intensive than food crops, fewer children are necessary to aid in farm work. In this case, however, cattle ownership is positively correlated with fertility. The reasons behind this relationship are not immediately clear. Perhaps cattle ownership measures a different aspect of socio-economic level in this semi-frontier context or perhaps cattle ownership inspires families to greater reproductive levels as the family has confidence of being able to meet the increased economic needs of a larger family. The need for farm labor and the possibility that children may serve as a status symbol, particularly amongst frontier and low-socioeconomic communities, does complicate this seemingly straight-forward negative relationship between socio-economic status and fertility (Carr et al. 2007). Perhaps, in this context higher economic levels lead to larger families. The final variable within this grouping incorporates a direct measure of the economic benefit of children to the family. When sons serve as labor the family is expected to have more children. This relationship could develop

as a response to the increased food needs of a large family as farming requires more labor. It could also suggest that when children belong to a household where they can provide labor larger family size goals exist as children are seen to advance the production and economic capabilities of the farm/household.

Finally, the fact that nearly all of the municipal level variables were not statistically significant suggests that individual and household characteristics have a stronger impact on individual behavior. The exception to this however, is found with the variable, number of tractors per farm. This municipal average significantly impacts the expected number of children we anticipate a woman to have. Women who live in municipalities with more tractors per farm are expected to have more children than their counterparts who live in municipalities having, on average, fewer tractors per farm. Municipalities with higher tractor ownership also have a lower percentage of forest of owned land as well as show higher rates of deforestation (Carr, Grace, Davis & Davenport n.d.). Similar to cattle ownership, perhaps the impact of wealth, even as a municipality level variable, is increased confidence in the ability of the household to support more children. The presence of large and wealthy farms could also indicate a community need for labor - promising economic opportunities for children as they age. Additionally, the use of machinery and the high rates of deforestation in the areas with the most machinery suggest that the land is being reshaped and is able to produce more and more efficiently which also may inspire confidence in the ability of the community to support the needs of a growing population.

figure 6 here - muni map with fallow

Discussion

The variables were initially selected based on their ability to operationalize economic and ideational theories of fertility decline. Similarly, an additional category of variables was created to reflect the specific land use and labor challenges faced by impoverished families in a largely rural region. While the land use/labor grouping could exist as a subfield within the economic factors, the uniqueness of the variables in fertility analyses mandate special consideration of the results. The discussion of the results is limited by the cross-sectional nature of the data making

it impossible to determine the causal factors of fertility change (possible in a longitudinal data setting), however, these results can indeed be used to begin to disentangle the impact on fertility of economic, ideation and land-use variables as well as begin to make hypotheses regarding their interaction.

Consistent with fertility literature, increasing women's education can significantly decrease the number of children born. As education continues to become more available and with technology that facilitates the accessibility of remote learning stations, men's and women's education can expand and fertility in this area should continue to decline. As explained previously, the importance of men's education highlights the significance of the socio-economic level of the household. While expanding men's education is anticipated to continue to reduce fertility an increase in economic opportunities should also reduce fertility. The significance of the ethnicity variable indicates that the fertility path may be different for Indigenous families and Ladino families - perhaps reflecting the Maya cosmovision or, as Bertrand Salazar suggest, lingering apprehension that family planning is a technique used to monitor and control the Indigenous population. Bertrand Salazar and De Broe Hinde have emphasized the significant differences between fertility behavior based on ethnicity - these results confirm that the difference is more complex than access or socio-economic. Clearly significant factors that distinguish and characterize the Indigenous population remain to be found. In order for Petén to meet the needs of its changing and ethnically diverse population augmenting the focus and commitment to the Indigenous population is vital.

The lack of significance attributed to the contraceptive use/knowledge variables in combination with the negative relationship between contraceptive approval and fertility suggests that women decide to accept (use) contraception when family size goals are met or exceeded and that knowledge of contraception is not an inhibiting factor. This finding is consistent with related work showing that distance to the nearest family planning clinic is not a deterrent or motivator of contraceptive use (Bertrand et al. 1999) but that contraceptives are used and obtained when the woman determines that they are necessary.

Finally, the implementation of land use and labor variables provides a unique opportunity

to examine factors that are not frequently included in fertility analyses but that are potentially important determinants of childbearing behavior. This research introduces variables that have not been used in fertility analyses and explores the link between land use, socio-economic development, and reproductive health. While results are not consistent with our initial hypothesis, the simple significance of these unusual variables underscores the importance of the link between population and the human shaped environment. A classic theory supporting the economic value of children is that when children serve as labor then families will have more children. In this case, that theory is supported by the presence and positive correlation between the sons-as-labor variable and the number of children. Further building on the idea of children as an economic benefit is the hypothesis that when families invest in cattle they need less labor and have also invested in their future, as cattle serve as an asset that can be sold if necessary. However, families in Petén have more children when they own cattle! An increase in children given the presence of cattle is not consistent with our traditional theories of the economic benefit of children. In Petén cattle provide the security and serve as a measure of wealth that actually encourages a larger family size. We theorize that this additional financial security provided by cattle ownership assuages concerns of not being able to support a larger family and consequently results in larger families.

Similarly inconsistent with our understanding of wealth is the significance of the number of tractors per farm. This municipality variable should measure municipality-level wealthy - an area with higher tractor ownership is more wealthy than a corresponding area with fewer tractors per farm. Again, building the cost/benefit theories, a wealthier community should create an environment that encourages fewer children. However, the variable is positively correlated with the response! Perhaps there are a few large, wealthy land holders who own tractors and are surrounded by poorer, lower educated families who provide labor to the larger farms. These poor families therefore have larger numbers of children who can contribute additional economic support to the families through their own labor. Families may respond to the presence of wealthy farms by increasing their contribution to the future labor pool as there is a promise of employment, on the large farm, for their children.

Conclusion

Fertility rates in the Petén are unusually high and the social and political turmoil that has characterized Guatemala's recent past have limited demographic analysis of this high fertility population. This analysis combined and applied diverse theories to three rich and detailed data sources to develop an understanding of fertility behavior in this underrepresented region of the world. The outstanding resources available through the unique DHS data set provide important details regarding the complexity of household and individual reproductive decision making. Petén is in the midst of huge demographic and land cover and use changes, developing a plan and providing guidance to the communities and individuals of this dynamic region will only serve to ensure sustainable development capable of meeting the health and resource needs of the population.

Figure 1: 1998/99 Guatemalan Regional Total Fertility Rates

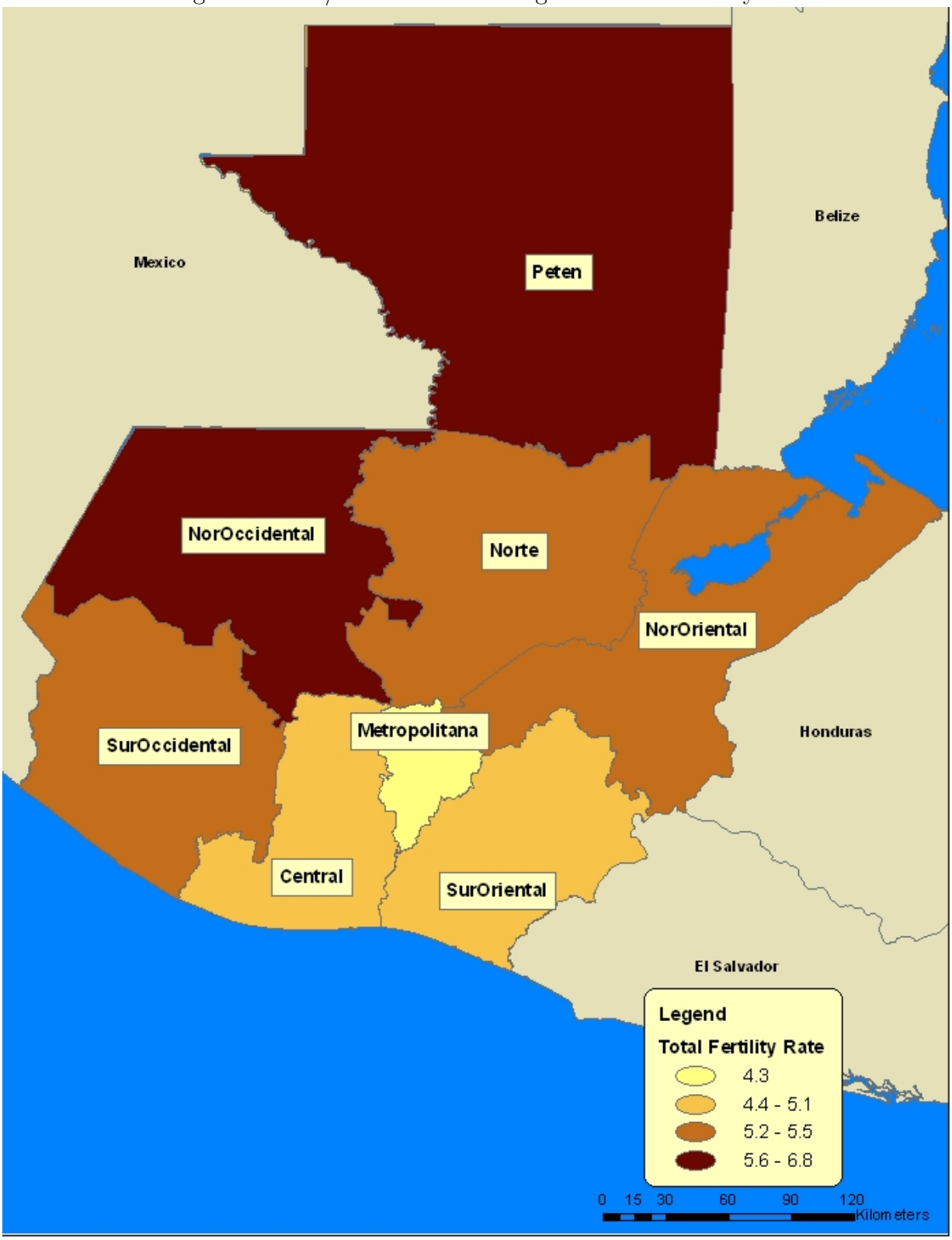


Figure 2: 1998/99 Guatemalan Regional Total Fertility Rates

Metropolitan	4.3
North	5.5
Northeast	5.4
Southeast	5.1
Central	5
Southwest	5.3
Northeast	6.2
Peten	**6.8**

Sources: Guatemalan Demographic and Health Survey 1998-99

Figure 3: Explanatory Variables

Category	**Individual**	Expected
Socio-Demographic	Age	+
	Education	-
	Partner Education	-
	Indigenous	+
	Religion (Mayan or Catholic)	+
	Union Status	+ (in union)
	Indoor Plumbing	-
Ideation	Television Ownership (yes)	-
(including gender equity)	Urban (yes)	-
	Urban Living Experience (yes)	-
	Discussed Family Planning With Others (yes)	-
	Contraceptive Use (yes)	-/+
	Contraceptive Knowledge (yes)	-
	Approves of Family Planning	-
	Partner Approves of Family Planning	-
	Discussed Family Planning with Partner	-
	Earns Money for Work	-
	Gender Equity	-
Land Use and Labor	Production Sufficient (yes)	-
	Cattle Ownership (yes)	-
	Sons in Fields (yes)	+
Municipality Level	Proportion Indigenous	+
	Percent Women Completed Secondary School	-
	Percent Rural	+
	Percent with Indoor Plumbing	-
	Number of Tractors per Farm	-
	Percent of Land in Fallow	+
	Percent Forested Land	+
	Out-migration (domestic)	-/+
	Women Aware of Modern Contraception	-

Figure 4: Municipality Level Variables

Municipality	Flores	San Jose	San Benito
Women Completed High Schl.	26.53%	16.67%	30.25%
Indigenous	12.74%	51.37%	10.96%
High School Educated	27.16%	18.69%	30.99%
Urban	52.18%	31.61%	82.84%
Plumbing	90.24%	85.27%	95.40%
Number of Tractors per Farm	0.032	0.106	0.004
Women aware of Modern Cont.	97.51%	81.36%	74.60%
Domestic Outmigration	13.81%	19.54%	6.24%
Percent Owned Land in Forest	25.80%	28.66%	7.16%
Percent Owned Land in Fallow	19.54%	58.95%	42.10%

Municipality	Santa Ana	Dolores	San Luis
Women Completed High Schl.	8.43%	8.25%	5.81%
Indigenous	13.52%	14.80%	60.47%
High School Educated	9.26%	8.59%	6.73%
Urban	42.56%	24.74%	11.74%
Plumbing	66.75%	64.55%	56.57%
Number of Tractors per Farm	0.017	0.033	0.001
Women aware of Modern Cont.	96.30%	94.92%	49.50%
Domestic Outmigration	7.17%	10.52%	10.96%
Percent Owned Land in Forest	17.90%	15.71%	16.30%
Percent Owned Land in Fallow	43.35%	19.37%	47.59%

Municipality	San Andres	La Libertad	San Francisco
Women Completed High Schl.	9.11%	6.18%	15.58%
Indigenous	15.14%	21.11%	28.45%
High School Educated	9.70%	6.77%	16.64%
Urban	28.28%	10.58%	39.08%
Plumbing	58.69%	70.17%	80.07%
Number of Tractors per Farm	0.01	0.103	0.007
Women aware of Modern Cont.	92.31%	85.81%	72.22%
Domestic Outmigration	5.38%	6.90%	9.60%
Percent Owned Land in Forest	31.98%	22.56%	15.67%
Percent Owned Land in Fallow	38.83%	47.38%	41.14%

Municipality	Sayaxche	Melchor de Mencos	Poptun
Women Completed High Schl.	6.05%	15.01%	18.60%
Indigenous	62.91%	3.13%	35.90%
High School Educated	6.91%	15.42%	19.35%
Urban	13.17%	54.57%	40.50%
Plumbing	58.68%	86.52%	70.84%
Number of Tractors per Farm	0.025	0.023	0.007
Women aware of Modern Cont.	64.55%	97.78%	66.20%
Domestic Outmigration	6.23%	5.00%	6.38%
Percent Owned Land in Forest	20.54%	27.34%	29.12%
Percent Owned Land in Fallow	42.95%	32.40%	33.48%

Sources: Guatemalan Agricultural Census - 2002 and Guatemalan Population Census - 2002

Figure 5: Regression Results

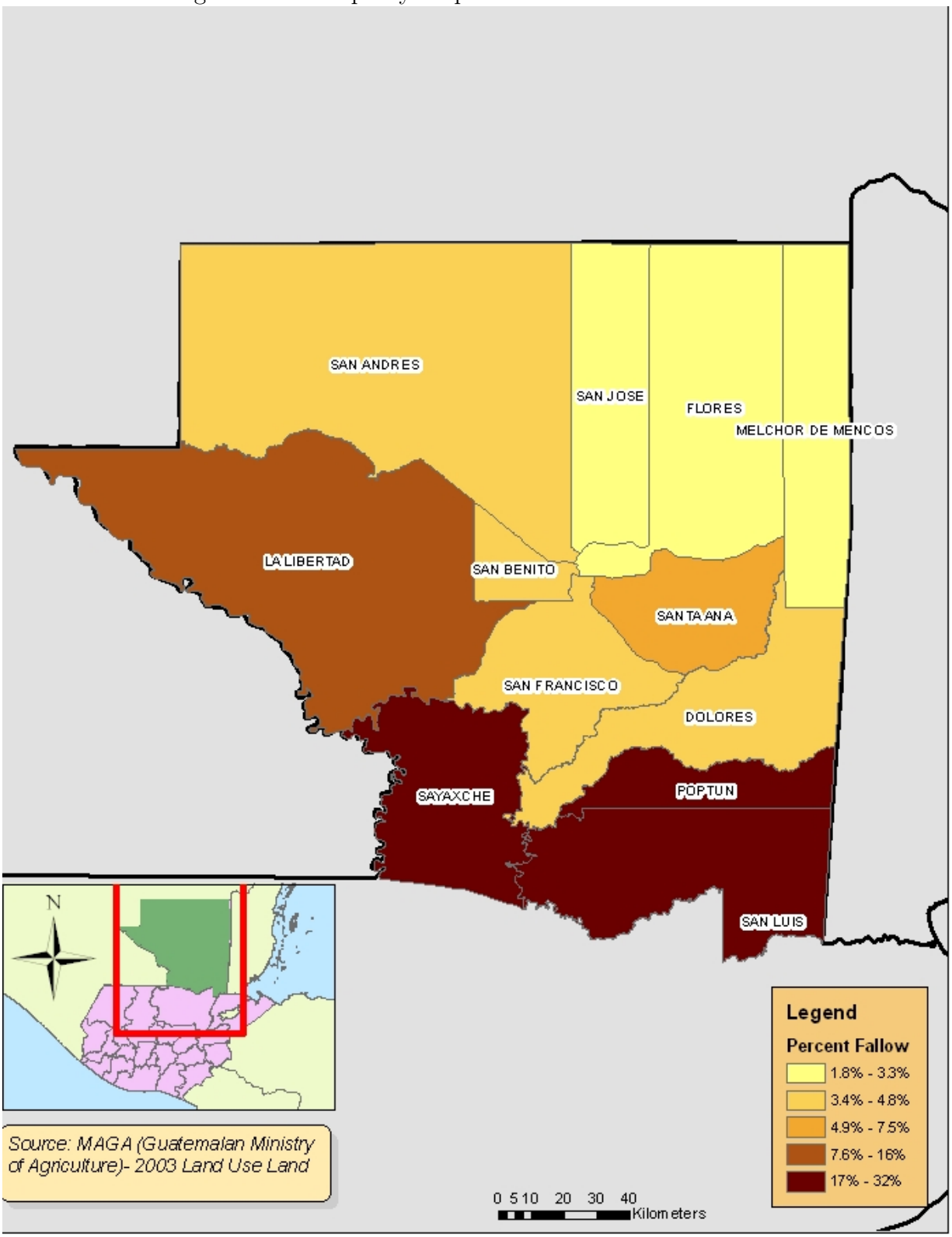
	Variable	Estimate (Poisson)	Estimate (Neg. Bin.)	Estimate (Multi-Level)
Socio-demographic	Age	0.0468***	0.0468***	0.0468***
	Education Level 1	-0.0719	-0.0719	-0.0719
	2	-0.4068 *	-0.4068 *	-0.4068 *
	Partner Education Level 1	-0.0131	-0.0131	-0.0131
	2	-0.3073*	-0.3073*	-0.3073*
	Ethnicity (Indigenous)	-0.0923.	-0.0923.	-0.0923.
Ideation	Television Ownership (no)	-0.1779*	-0.1779*	-0.1779*
	Approves of Family Planning (no)	0.1106*	0.1106*	0.1106*
Land Use/Labor	Cattle Ownership (yes)	-0.1535**	-0.1535**	-0.1535**
	Sons Work in Fields (yes)	-0.1403**	-0.1403**	-0.1403**
Municipality	Number of Tractors per Farm	1.3175*	1.3175*	1.3175*

Residual Deviance		459.36	459.32
Degrees of Freedom		450	450
AIC		1954.8	1956.8

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Reference category in parantheses

Figure 6: Municipality Map of Percent Fallow of Owned Land



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