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**PAPER PRESENTED AT THE
THIRD INTERNATIONAL POPULATION CONFERENCE
OF THE CENTRAL AMERICAN ISTHMUS, 2003**

**Fertility and the Environment in a Natural Resource Dependent Economy:
Evidence from Petén, Guatemala**

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Abstract

This paper examines potential relations between factors related to fertility and the access to and use of natural resources in Petén, Guatemala. The Petén forms the heart of the Selva Maya, the largest lowland humid forest in Mesoamerica. The rapid in-migration of subsistence maize farmers has converted much of the Petén's forests to agricultural fields. Population dynamics have been transformed in that virtually all farm families have arrived since the 1970s and that total fertility rates exceed the national rural mean. Continued migration, exceptionally high fertility, a youthful population, and a large consumer to producer ratio are hypothesized to be related to the dramatic land cover dynamics shaping the landscape of the Petén. An emerging body of literature suggests that environmental factors can affect fertility decision-making and behaviors, especially in natural resource dependent economies like that of the Petén. This paper examines these relationships using data from the 1998/99 Demographic Health Survey in Guatemala. Data on natural resource access and utilization were collected as part of an environment module, in addition to demographic and health information. This dataset, the first ever environmental module of the Demographic Health Survey, provides a unique opportunity to examine possible relationships between fertility and the environment in a tropical agricultural frontier.

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Introduction

Natural resource access and distribution can be critical determinants of demographic processes in rural agricultural settings. In these settings, access to and use of natural resources (hereafter referred to simply as natural resources) including land, livestock, fuelwood, and water are the basis of wealth, living standards, and of social status. The purpose of this paper is to review the theoretical literature on natural resources and fertility and to examine these proposed relationships in a Central American context using data from the Petén, an agricultural frontier in northern Guatemala.

Although evidence for a relationship between natural resources and fertility emerges from many settings around the world, these relationships remain largely unexamined in Central America. Understanding these relationships is important on several different levels. First, while a large literature describes the effects of fertility, migration, and other demographic factors shaping natural resources, potential feedbacks in this system have been largely ignored. The inchoate population and environment literature indicates that these feedbacks exist and can be important but scant empirical evidence has been presented (Geist and Lambdin 2001; Carr Accepted with Revisions). Secondly, as a preponderance of the world economies are natural resource dependent, these resources can play a major role in shaping the world's demographic processes. Finally, natural resources have a great deal of policy leverage and are the focus of many interventions, such as land redistribution and titling schemes. Understanding the demographic implications of such policies could have important consequences for policy makers and major international aid donors, such as the World Bank and the United States Agency for International Development (USAID), both of whom are very active in shaping development schemes in the Petén.

Hypotheses surrounding the use of and access to natural resources and human fertility depend heavily on microeconomic theories of fertility as refined by Easterlin and McCrimmins (Easterlin and McCrimmins 1985). These theories predict that natural resources ultimately affect fertility by changing either the supply of or demand for children. The nature of these relationships is resource dependent and is also shaped by the institutions enabling and constrain the use of the resource.

Land: A complicated construct

Land has long been considered the main driver of social and economic forces in agricultural settings. At the household level, land parcels can be characterized by extent as well as by tenure type. The relationship between the extent of land possessed and fertility is expected to be positive under the land-labor-demand hypothesis put forth by Stokes and Schutjer (1984). This hypothesis postulates that a larger farm size creates a demand for children as labor to put/keep land in production. Positive associations between farm size and family size have been documented in a variety of cultures and settings including Rwanda, Egypt, the Philippines, Iran, Peru and Ecuador (Hiday 1978; Good, Farr et al. 1980; Schutjer, Stokes et al. 1983; Easterlin and McCrimmins 1985; Clay and Johnson 1992; Coomes, Grimard et al. 2001; Carr and Pan 2003; Carr and Pan Accepted with Revisions).

Alternatively, it has also been proposed that the effects of land tenure can counteract the relationship between farm size and family size. Under this land-security hypothesis, greater security of land tenure creates economic security that lowers the need to invest in large numbers of children (Stokes and Schutjer 1984). More secure farms are also hypothesized to be associated with improvements in living standards and access to health care, as well as greater educational opportunities, all of which have been implicated in aiding fertility transitions. Several studies in the developing world including in the Philippines, Egypt, Ecuador, Iran, India and Mexico, provide evidence for a negative effect of secure land tenure on fertility (Hiday 1978; DeVaney and Sanchez 1979; Good, Farr et al. 1980; Vlassoff and Vlassoff 1980; Schutjer, Stokes et al. 1983; Coomes, Grimard et al. 2001; Carr and Pan 2003).

Easterlin (1976) has proposed that in frontier settings, like the Petén, it is not the actual size of the farm that predicts family size, but the perception of availability of land for one's children. In new frontier areas, he argues, land is abundantly available, and individuals, not perceiving difficulty in settling their children on nearby farms, experience high fertility. As the frontier areas begin to become more settled, however, the frontier hypothesis predicts that fertility will decline in response to the perceived risk of future scarcity. The frontier hypothesis has not been tested at the microlevel using individual perceptions of land availability. At the aggregate level, however, the proportion of settled land has been found to have a negative association with fertility in 19th century Thailand, 19th century United States, and more contemporaneously in Brazil (Easterlin 1976; Merrick 1978; VanLandingham and Hirschman 2001). This study tests this hypothesis in a modern day frontier using individual level data.

Cattle: An alternative economic asset

Cattle are an important part of agricultural systems of many parts of the world, although perhaps no more so than in Latin America. Cattle represent a form of capital that, unlike land, is uncomplicated by tenure security issues (Loker 1993). Cattle are also easy to liquidate and transport and can provide a steady stream of income through the sale of dairy products (Faris 1999). In many parts of Latin America, cattle are also a very visible status symbol that is coveted and maintained even during periods of negative income flow (Heckandon 1983; Jones 1990). Cattle grazing has a relatively low labor requirement and degraded tropical soils will often support pasture, for a short time at least, after traditional swidden agriculture systems have collapsed (Heckandon and McKay 1984).

For all of these reasons, livestock can be thought of as a family asset, like land, that could potentially impact fertility. It could be hypothesized that the possession of cattle is a form of old age security that could ultimately negatively influence fertility by reducing the demand for children as labor or as a form of economic security. However, Perz (2000) asserts that while cattle ownership is the ultimate goal of most Latin American frontier farmers, obtaining the capital needed to purchase the cattle and seed pasture tends to occur later in life. Sufficient capital accumulation only occurs after the farmer has had living children grow to adulthood and provide remittances to parents, enabling those parents to shift to cattle production. Perz therefore predicts that cattle owners will be older and have more adult children. Children, according to this hypothesis, are in demand by parents because they provide labor needed in earlier

agricultural production and remittances in later life that are necessary for the acquisition of cattle, a secure resource with important social status implications.

Fuelwood and Water: Fertility and the commons

Natural resources, such as fuelwood and water, are necessary for every day life and tasks such as cooking and washing. In some places these resources are controlled entirely by the private market, but in rural, agricultural regions they are often collected as an ungoverned commons resource from the surrounding forested areas. Generally speaking, it is often the task of women and children to gather a sufficiency of these resources for daily life. Dasgupta (2000) hypothesizes that as these common property resources become scarce each additional child provides a marginal benefit through his or her labor. As a result, Dasgupta expects that dependency upon the collection of fuelwood and water will result in increased fertility. Indeed, empirical evidence has been found of this positive relationship in cross sectional studies from Pakistan, Nepal, and South Africa (Biddlecom, Axinn et al. 2000; Aggarwal, Netanyahu et al. 2001; Filmer and Pritchett 2002).

Study Setting, Aims, and Rationale

This study examines the relationships between fertility and natural resources in the Petén, Guatemala (see Figure 1). The Petén represents one of the last, vast agricultural frontiers of Central America. Agricultural frontiers are especially interesting cases in which to study natural resource-fertility interactions.

People in these regions are often colonists with diverse backgrounds and are usually highly dependent upon natural resources for their economic well-being. Also, Latin American agricultural frontiers in general, and the Petén in particular, are regions of high biodiversity and rapid land use change, and thus the target of many environmental and population policy initiatives. The Petén is currently the focus of development schemes funded by the World Bank, USAID, the Guatemalan national government, as well as a host of nonprofit organizations (Sundberg 1998). These initiatives address both natural resources and, to a lesser extent, fertility. Although some work has been done examining the impacts of land tenure on fertility in Mexico (Devaney and Sanchez 1979), overall, the relationships between natural resources and fertility have been largely unexamined in a Central American context. A better understanding of the demographic impacts of natural resources in the Petén could have immediate policy implications for this region.

The Petén is an area of lowland tropical forest covering 35,000 km², or roughly 40% of the total national land area of Guatemala. Since opening up to immigration in the 1970s the Petén experienced a total population growth rate of more than 2500% to 1990 and the population has continued to climb in the last decade (Schwartz 1990; Grandia, Schwartz et al. 2001). While the Petén was more than 75-80% forested in 1970 (Schwartz 1990), today less than half of the land area is forested (Sever 1999). This deforestation has been attributed to the rapid population growth in the area combined with a swidden agriculture system.

The current total fertility rate (TFR) for the Petén is 6.8 children per woman with a rural TFR of 7.7 children per woman (Grandia, Schwartz, et al. 2001). This is one of the highest rates among the departments of Guatemala and is much higher than the

national TFR of 5.0, and the national rural mean of 6.4 children per woman. Overall contraceptive prevalence in the Petén is 23.5% for any method, which is among the lowest contraceptive prevalence rates in Guatemala (Grandia, Schwartz, et al. 2001). The Petén represents a special case of pretransitional levels of fertility within a transitional country. This kind of lag is often seen in agricultural frontiers, which typically experience higher fertility rates than non-frontier areas. These extremely high rates of fertility together with the dramatic changes in land use and land cover make the Petén an especially interesting place to study population and environment interactions.

Data and Methods

Data for this study comes from the 1998/1999 Encuesta de Salud Materno Infantil, a nationally representative survey conducted by the Guatemalan Instituto Nacional de Estadística and Measure/DHS+, Macro International, with funding from USAID. Individual questionnaires regarding fertility behavior and preferences were administered to all women aged 15-49 in selected households. In addition, in the Petén, a household survey on health, migration, and natural resources was conducted in the same households where individual level fertility data were collected.

These data represent the first environmental information ever collected by the Demographic Health Surveys in any country. This household survey collected background information and migration histories, as well as data on natural resource use. In addition to complete information on land ownership and land use, data were also collected on the use of nonagricultural resources, such as fuelwood and water. Attitudinal questions surrounding the conservation and land use practices were also posed to the head of household answering the questionnaires.

For the purposes of this study, individual level data for the oldest female of reproductive age in a household was linked to the household level environmental data to provide the study sample. The total sample consisted of 894 woman-household matches representing 74 sample clusters. We chose to use the female head of household individual data because this data was matched to household level data that was collected from either the female or male head of household. There is some potential bias in the sample towards older women as a result of restricting the sample to female heads of household. The age of female respondents was summarized for our head of household sample and compared to the overall female sample from the Petén and the comparison is presented in Table 1. In our head of household sample, women ranged from 15 to 49 years of age, just as in the overall sample. The mean age of respondents in the head of household sample was only slightly older than the overall sample at 30.7 versus 28.1 years of age. Other variables used in our analyses are summarized for our head of household sample and presented in Table 2.

Ordinary Least Squares multiple regression was used to examine factors related to the dependent variable of fertility. Number of living children was used as a measure of fertility in the place of children ever born because many of the hypotheses surrounding natural resources and fertility depend upon the use of children as a long term economic investment or as labor. The number of living children better reflects the labor demand and long-term investment of parents than does the number of children ever born.

Many maternal and household variables are known to be correlated with fertility and have been controlled for in this model. Variables for maternal age, education, and ethnicity were included in the model. Household level variables included in the model were rural residence, residence floor material, and having electricity. Maternal age is a particularly important variable to consider since both fertility and accumulation of land and cattle tend to increase with age. Previous studies of natural resource use and fertility have been criticized for failing to control for this confounding variable (Cain 1985). Education is known to have a negative impact on fertility, often by increasing awareness and effective use of contraception as well as delaying marriage (Singh, Casterline et al. 1985; Singh 1994; Caldwell 2001). Living standards have also been widely examined in regards to fertility and have been found to have both negative and positive impacts on fertility. While improved living standards are associated with greater wealth and the ability to afford a larger number of children, they also tend to accompany a better ability to invest in health care and education for children. In short, parents with higher living standards are more likely to invest in the quality rather than quantity of children (Caldwell 1976; Easterlin and McCrimmins 1985; Caldwell 2001).

Natural resource variables included in the model were farm size and tenure security, ownership of cattle, time to collect water in minutes, and collecting fuelwood. Bivariate relationships between the natural resource variables and fertility are presented in Table 3.

Results

The variables used in our model have been summarized in Table 2. Overall, missing data is a problem, with the exception of the perception of land availability for children and the time to collect water in minutes, both of which variables have complete data. Missing data for both variables are due to skip patterns in the questionnaire. Landless families were not asked about their perception of land availability for children and families relying on piped water systems and rainwater were not asked about time to collect water. These variables have been coded as missing in these instances and no attempt was made to impute these values.

The sample is largely rural and Ladino with a mean female head of household aged 30. Family size ranges from 0 to 14 with a mean of 4 living children. Tenure security is low and the average farm size is 271.8 manzanas. About one third of households rely on collected fuelwood from nearby forests and the average time to collect water is 13 minutes. Roughly one third of households have electricity, and, while there is large variability in flooring materials, homes typically have a floor of mud bricks or wooden planks.

The results of the fertility model are shown in Table 3. Maternal variables showed highly significant relationships with the number of living children. As expected, the number of living children significantly increases with maternal age ($p < 0.000$) and decreases with maternal education ($p < 0.001$). Improved living standards, specifically floor materials and electricity ($p = 0.02$), were negatively associated with fertility, although the association of floor materials with number of living children was not significant at the 5% level. Rural residence has a positive, but not quite significant ($p = 0.077$) at the 10% level, relationship with number of living children, while ethnicity is not shown to have significant association with fertility.

Land variables have a mixed association with family size. Neither farm size nor tenure security were found to have an independently significant effect on the number of living children in a family ($p > 0.05$). However, the perception of land availability was significantly associated with fertility ($p = 0.045$). Those perceiving land as available for their children had significantly fewer children than those who perceived land to be scarce.

The ownership of cattle was strongly and positively associated with the number of living children ($p = 0.002$), however the common property resource variables, including gathering fuelwood from the forest and the time in minutes to collect water were not significantly associated with family size.

The multivariate model did not change the significance or direction of any of the bivariate relationships for natural resources and fertility with the exception of security of land tenure. The bivariate association between security of land tenure and fertility is positive and significant ($p = 0.03$). In the multivariate model, security of land tenure has a negative but nonsignificant effect on fertility ($p = 0.75$).

Discussion

Land

Overall we failed to find a significant relationship between farm size or security of land tenure and family size in the Petén. It is possible that these types of relationships could be missing within the context of the Petén due to the weak tenure systems and skewed land distributions that characterize the country of Guatemala and much of Central America as a whole (Southgate 1992; Clark 1996). In Guatemala, 96% of farm units are characterized as subsistence or below subsistence and represent only 20% of the country's agricultural land. Twenty-six percent of rural families are characterized as landless. In our own sample, 28% of households reported themselves to be landless. (Tanaka and Wittman 2003) Furthermore, cadastral records show that land registry totals are more than twice the land area of Guatemala and yet at least half of all landholdings are currently unregistered. (Tanaka and Wittman 2003) This ambiguity of tenure could weaken the effect that farm size and land tenure might have on fertility in the Petén.

The frontier hypothesis of Easterlin maintains that greater land availability is associated with greater levels of fertility. At the surface, this seems to hold for the Petén at the aggregate level. Half of the department's land is still forested, far more than other parts of Guatemala, and fertility rates are also higher in the Petén than in other parts of Guatemala (Schwartz 1990; Sever 1999; Grandia, Schwartz, et al. 2001). However, at the microlevel we do not find that those who perceive land as available have the highest fertility.

Instead we find the opposite: those who perceive land as available have fewer living children. This apparent discrepancy could be attributed to differences in the abundance of uncleared land and the actual availability of land. Although land seems to be available on the Petenero frontier, much of that land is in national parks and protected areas or consolidated by large absentee landowners. As noted above, we found that 28% of Petenero families are landless, a proportion comparable to the national rate. Therefore individuals may perceive their own land holding the only land that is available

for their children to settle in the future. Farmers with smaller families could be more likely to believe that their current landholdings will support their children's future demand for land and consequently to report land as available for children. This result implies that the direction of causality may flow from fertility to perceived land availability rather than in the opposite, hypothesized direction. This could also potentially be an indication that the Petén is moving out of a truly frontier settlement pattern where land is abundant relative to the demand. A better understanding of the factors considered by households when judging future land availability is necessary to fully interpret this result.

There are other factors to consider, however, besides land availability when considering the characteristically high fertility of modern agricultural frontiers. The Petén, like other Latin American frontiers, is low in infrastructure. As a result, access to health care and education is limited (Grandia, Schwartz et al. 2001). These factors can translate into high infant mortality and subsequent "insurance births" as well as high levels of unwanted fertility due to a lack of available contraception (Caldwell 1976; Caldwell 2001). Furthermore, off farm employment opportunities, especially for women are constrained in a frontier setting, promoting early marriage and childbearing (Singh, Casterline et al. 1985; Singh 1994; Caldwell 2001).

Cattle

We found a very strong positive relationship between cattle ownership and the number of living children. This result supports the hypothesis that a greater number of children provide larger economic benefits to parents as they age by contributing to early agricultural efforts and/or partaking in off-farm employment. These benefits allow parents to accrue the necessary capital to invest in cattle. Although this hypothesis is a relatively recent development (Perz 2000), our result indicates that it should be more closely studied in the Petén. Again, the direction of causality is important. It seems as though having high fertility results in the accumulation of cattle, rather than the acquisition of cattle leading to an increased demand for children.

Common Property Resources

Despite the recent growth in evidence from Asia and Africa to support the theory that dependence upon common property resources, especially fuelwood and water are associated with higher fertility, we found no relationship between the two variables and the number of living children in a household. One possibility that could account for such a relationship is that these resources are not scarce enough to have created a marginal benefit for additional children in the Petén; a small number of children can easily collect the necessary resources. A second possibility is that, in the Petén, children are not as vital to the collection of these resources as they are in other settings, such as Nepal and Pakistan. Follow up research is necessary to fully understand the relationships between fertility demand and use of common property resources.

Study limitations and Future Research

This study provides a first look at natural resource-fertility interactions in a Central American context. These data suggest that natural resources are associated with fertility in such a setting. As has been suggested above, there are factors unique to

the Petén and Central America, such as the cultural role of cattle and the skewed land distribution, could help explain these relationships and should be studied in greater detail.

These results serve as a springboard for future research in this area, as findings of this study, while suggestive, cannot be considered definitive. The data are cross-sectional and therefore cannot determine direction of causality. There are also many factors unmeasured in this study, such as certain components of socioeconomic status, for example, whose inclusion in future studies may prove to be important in explaining fertility-environment relationships in the Petén. Furthermore, although the overall female head of household sample is fairly large (n=894) missing data diminishes the power of the model by reducing the sample to 404 complete observations. In addition to these concerns, this study and past studies have focused on family size as a measure of fertility. It is important to keep in mind, however, that fertility is a product of past circumstances, which may or may not be reflected in current perceptions and characteristics. This consideration may be especially important in a region like the Petén that experiences such heavy migration from different areas of the country. For these reasons, more complete and longitudinal data recording changes in access to and use of natural resources as well as changes in fertility are necessary to make more definitive statements about the relationships that are suggested by multivariate cross-sectional analyses.

Finally, it is important to consider community context and migration history in future examinations of fertility patterns in the Petén. Some macro-level factors that bear examination have been noted above, such as the land tenure and land distribution patterns in the Petén. Migration histories can also influence social networks and personal ideals surrounding resource use and fertility. Heavy migration is an important feature in the Petén, and it is difficult to entangle what part of the relationships found in this study may be due to differing conditions in the area of origin of Peténero settlers. Cultural patterns regarding child labor in the Petén should also be closely examined. It is possible that multi-level models and qualitative methods could be helpful in better understanding the relationships between natural resource use and access and fertility. We are not currently aware of any study that has utilized qualitative methods to address these relationships.

Conclusion

Natural resource use and access can have implications for demographic change and are often the target of policy change, such as efforts to redistribute or title land. Our study finds that natural resources, especially cattle ownership and the perception of land availability for children, are associated with fertility differences in the Petén, a biodiverse region that is currently the focus of many population and environment policy and development schemes. Understanding the full nature of these relationships necessitates the use of longitudinal studies, multilevel models, and an understanding of the cultural context that could be provided by qualitative research. Future research should address these weaknesses in the current literature, as well as test the proposed mechanisms driving these relationships.

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Figure 1. Map of Guatemala showing the Petén



Table 1. Summary of respondents' age in female head of household sample and overall Petén sample for individual surveys

Sample	Mean	Min	Max
Female Heads of Household	30.7	15	49
All Surveyed Females	28.1	15	49

Table 2. Summary of variables

Variable	N	Number missing	Mean	Min	Max
Number of living children	894	0	4.04	0	14
Maternal age	894	0	30.70	15	49
Maternal education 0-none 1-primary 2-secondary 3- >secondary	894	0	0.72	0	3
Maternal ethnicity 0-qu'echi 1-ladino	894	0	0.73	0	1
Rural 0-urban 1-rural	894	0	0.79	0	1
Floor material 11-earth floor 12-mud bricks 21-wood planks 31-polished wood 32-cement bricks 33-tile 34-cement	891	3	17.96	11	34
Electricity 0-no electricity 1-electricity	892	2	0.35	0	1
Land available for children 0- Land is not available 1-Land is available	601	293	0.78	0	1
Farm size (manzanas)	840	54	271.79	0	9998
Security of land tenure 0-least secure 1-less secure 2-secure 3-most secure	841	53	1.07	0	3
Cattle 0-does not own cattle 1-owns cattle	841	53	0.15	0	1
Collects fuelwood 0-has not collected fuelwood in past year 1-has collected fuelwood in past year	840	54	0.31	0	1
Time to collect water (min)	539	355	13.02	0	200

Table 3. Multiple regression model estimates of the effect of maternal, household, and natural resource factors on the number of living children reported by women

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Maternal Factors							
Age							0.22**
Years of Education							-0.73**
Ethnicity							0.21
Household Factors							
Floor materials							-0.02
Electricity							-0.82*
Rural residence							0.90
Natural Resource Factors							
Perceive land availability for children	-0.81**						-0.49*
Farm size		<0.00					<0.00
Security of land tenure			0.21*				-0.03
Owning cattle				1.03**			0.83**
Time to collect water (in minutes)					<0.00		<0.00
Collect fuelwood from forest						0.36	0.22
Constant	4.94**	4.01**	3.85**	3.89**	4.24**	3.94**	-2.28**
n	601	840	842	841	539	840	404
Adjusted R²	0.01	<0.001	0.004	0.01	<0.001	0.002	0.60

*p<0.05

**p<0.01