The Environmental Dimensions of Emigration from Rural Mexico

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Do not cite.

Preliminary manuscript prepared for presentation at the 2011 meeting of the Population Association of America, Washington DC.

Acknowledgements: Preliminary support for this project provided by the Center for Environment and Population (CEP) through their Summer Fellowship Program. The work has also benefited from the NICHD-funded University of Colorado Population Center (grant R21 HD51146) for research, administrative, and computing support. The content is solely the responsibility of the authors and does not necessarily represent the official views of CEP, NIH, or NICHD.

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Abstract: In many developing countries, natural resource dependency is a day-to-day reality for many rural households. As such, changes in weather and climate patterns hold tremendous potential to impact livelihoods. When livelihood options are constrained due to shifts in environmental conditions, migration becomes a significant, adaptive livelihood strategy reducing household vulnerability. In this project, we offer a preliminary answer to the question: *Is emigration from rural Mexico to the U.S. associated with recent patterns of precipitation, net of other socio-economic factors shaping migration patterns?* Using data from the Mexican Migration Project (MMP), we model U.S. emigration from rural Mexican communities as related to community, household and environmental factors. We find that households subjected to drought conditions are far more likely to send a migrant as compared to those subjected to wet conditions. The results have important implications for policy and programmatic response to current migration pressures emphasizing diversification of rural Mexican livelihoods in the face of contemporary climate change.

The Environmental Dimensions of Emigration from Rural Mexico

Public, policy and academic realms have been paying increasing attention to the potential for environmental change to alter patterns of human migration. Even so, little peer-reviewed scholarship exists on the connection. This project contributes empirically with focus on international migration from rural Mexico, both a setting and social process of considerable policy relevance.

A focus on the potential for environmental "push" factors to shape Mexican migration is especially timely – not only because of contemporary climate change – but also because of heightened attention to trends in U.S. immigration. The United States had 39 million foreign-born residents in 2009 – the highest proportion of foreign born in any nation (Martin and Midgley 2010). Mexico continues to be a leading source of both authorized and unauthorized immigration to the United States (Hoefer, Rytina and Campbell 2007); About 30 percent of U.S. legal immigrants, and half of the unauthorized foreigners, are from Mexico (Martin and Midgley 2006).

Although substantial research has examined the social, economic, and policy drivers of Mexican migration to the U.S. (e.g. Cohen 2004; Durand et al. 1996; Kana'iaupuni 2000; Hernandez-Leon 2008; Lindstrom and Lauster 2001; Massey et al. 1987; Massey, Goldring, and Durand 1994; Massey and Espinosa 1997; Massey et al. 2002; Massey and Riosmena 2010; Riosmena 2009; Rosas 2008), far less is known about the environmental "push" factors related to Mexico-U.S. emigration (Nevins 2007); To our knowledge, the only such published work reveals intriguing state-level associations associations between Mexican outmigration and

declines in crop yields (Feng et al. 2010). We believe the project presented here, at the household-level, is the only effort to-date modeling international outmigration from rural Mexico as related to environmental factors at geographic scales more precise than the state.

Background

This project takes place at the nexus of two literatures: natural resources and rural livelihoods, combined with migration as an adaptive livelihood strategy, particularly among vulnerable households. These literatures are briefly reviewed below, with specific reference to the Mexican setting as available within existing work.

Rural livelihoods, with focus on natural resources: We use the conceptual framework of "Rural Livelihoods" (IFAD 2010) which has been used in a wide variety of analytical endeavors including exploration of health behaviors (Rugalema 2000), food security (Bank 2005) and household diversification strategies (Yaro 2006). The framework classifies various "capital assets" that shape livelihood options, including human capital (e.g., labor), financial capital (e.g., savings), physical capital (e.g., automobiles), social capital (e.g., networks), and natural capital (e.g., wild foods). The relative availability of various assets is shaped by individual and household actions as well as broader socioeconomic-political structures and processes (Bebbington 1999). In turn, availability shapes livelihood strategies which may include human capital use (e.g., labor migration, see Collinson et al. 2006a, 2006b or natural capital use (e.g., making resource-based crafts for market (Pereira, Shackleton and Shackleton 2006)). In general, the livelihoods approach has proven a valuable tool in highlighting the diversity and dynamism of the choices and activities in which rural households engage to meet household needs (Winters et al. 2002).

Focusing on natural capital, in rural regions of the world's less developed nations, proximate natural resources (e.g., land, water, wild foods) are often essential in meeting basic living requirements (e.g. Nunan 2010). As such, environmental change has immediate and direct impacts on the health and well-being of millions of households (Koziell and Saunders 2001).

In rural Mexico specifically, natural capital in the form of land and water are especially central to livelihoods. With a focus on four carefully selected case study communities, Wiggins et al. (2002) detail the diversity of rural Mexicans' livelihoods. In their study, households typically had five sources of income and the great majority of households had access to plots of land. Fully 78% farmed, predominantly maize and beans. Yet, although farming was the most frequent source of income, it contributed in most cases only a relatively small fraction of household incomes (on average, 14 percent). Burnstein (2007) also notes that corn, in particular, continues to be a mainstay of Mexican rural livelihoods, and its production sustains some 15 million of Mexico's 103 million residents. Overall, although farming is not the main activity for smallholders in rural Mexico, it is a central component of the diversification of livelihoods (de Janvry and Sadoulet 2001; Wiggins et al. 2002). In this way, livelihoods are vulnerable to climatic variability that may impact agricultural productivity (Eakin 2005).

Key to examination of natural capital within Mexico is understanding of *ejidos* -- rural communities which collectively possess rights to land and whose resident members (*ejidatarios*) are entitled to work a plot of their own (Wiggins et al. 2002). Ejidos were created through land transfers starting in the 1930s. Though market liberalization reforms during the 1990s allowed ejidatarios to attain private titles of and thus have the capacity to sell their lands, very few have sold (Barnes 2009). Of particular relevance to the present project, it is estimated

that the ejido sector contains approximately 60% of the rural population (de Janvry and Sadoulet 2001). Recent work suggests that contemporary efforts to provide ejido households with a certificate of land ownership are associated with an increase in emigration to the U.S., thereby inferring that more secure access to this form of natural capital provides a foundation from which to engage in the relatively-expensive livelihood diversification strategy of international migration (Valsecchi 2010). As such, our modeling strategy includes land ownership variables both at household and community-levels.

Winters, Davis and Corral (2002) also outline livelihood frameworks in rural Mexico, characterizing the diversity of livelihood activities although the centrality of agriculture and natural capital remains. In Winters et al.'s (2002) examination of a nationally representative sample of Mexican ejido households, fully 93.7% participated in crop production and agricultural activities as a whole (crops, livestock and agricultural employment) made up over half (55%) of total rural household income. Of course, there are distinct livelihood strategies depending on whether rural Mexican households have access to irrigated or rain-fed land.

Yet other forces beyond the household clearly also shape livelihood strategies. Winters and colleagues (2002:141) aptly note that livelihood decision-making "is conditioned on the context in which the household operates – influenced through natural forces, markets, state activity and societal institutions." In this way, environmental change acts in concert with political and economic forces to shape livelihood strategies and, for Mexico's smallholder farmers, recent work has documented the negative implications of the nation's global economic integration (Eakin 2005). After decades of public investment and supportive agricultural policies spurring agricultural growth, neoliberalization of the agricultural sector and food policy during the

Salinas administration, 1988-1994, brought dramatic changes to rural Mexico. Today, Mexican poverty has further concentrated in the countryside, particularly in the South (e.g. Hanson 2003; Nevins 2007; Polaski 2004; Zepeda et al. 2009). Informed by understanding of recent political economic conditions in Mexico, to control for broader, changing macro conditions not captured by our community SES measures, we include both state and year fixed effects in the models presented below.

Rural livelihood vulnerability and adaptation, with focus on migration: Application of the "Rural Livelihoods" framework to Mexican livelihoods and climate is further informed by social science research on "vulnerability" and "adaptation." Vulnerability is defined as "the degree to which a system, subsystem, or a system component is likely to experience harm due to exposure to a hazard either as a perturbation or stress/stressor" (Turner et al. 2003). As explained by Leichenko and O'Brien (2002:2), "within the context of climate studies, conceptualization of vulnerability has mostly focused on marginality, susceptibility, adaptability, fragility, and risk." Using these factors, vulnerability mapping helps identify regions particularly vulnerable to climate shifts (Fussell and Klein 2006; Hahn, Riederer and Foster 2009; Ionescu et al. 2009; Polsky, Neff and Yarnal et al. 2007). High levels of resource dependence contribute to climate vulnerability (Thomas and Twyman 2006) and regions in which residents depend on rain-fed agriculture (such as most of our study sites) are especially vulnerable (Reid and Vogel 2006).

Livelihood diversification is the process by which households reduce vulnerability as they seek to ensure well-being (Ellis 2000). Such *adaptation* may occur in response to climate vulnerability, with adaptation defined as "adjustments to a system in response to actual or

expected climate stimuli, their effects, or their impacts" (Leichenko and O'Brien 2006). In considering vulnerability and adaptive potential, Adger, Paavola and Huq (2006:2) comment "the world's changing climate and our responses to it threaten to exacerbate precisely those trends and pressures that cause present insecurities and that are likely to lead to increased insecurity in the future. The old, young, poor, and those dependent on climate-sensitive resources, including all of the world's farmers and fishers, are at greatest risk."

Migration is a particular adaptation strategy used by households in the face of environmental strain (Bilsborrow 1992; McLeman and Hunter 2010; McLeman and Smit 2005; Njock and Westlund 2010; Nunan 2010). Much of the existing empirical research on migration, livelihoods and shifts in natural capital focuses on land availability and/or land use decisions, and is situated in Asia, and Central/South America (e.g., Ayuwat 1993; Snegstrom 2009). Results suggest when faced with a lack of livelihood options, often due to cumulative processes of environmental degradation (Zweifler, Gold and Thomas 1994), households may strategically diversify with some household members migrating to seek opportunity elsewhere (Bilsborrow 2002; Snegstrom 2009; McLeman and Hunter 2010). In this way, changes in proximate natural capital shape household decisions about use of human capital.

Four additional studies deserve mention. A recent one, undertaken in Nepal, provides evidence that environmental factors play a role in migration, particularly short-distance moves. (Massey, Axinn and Ghimire 2010). Another, undertaken in Ethiopia, evaluates historical experience gained from drought-induced migration, finding that families with more survival strategies tended to resist distress-migration longer (Meze-Hausken 2000:382). In Burkina Faso, Henry and colleagues (Henry, Schoumaker and Beauchemin 2004) demonstrate that residents

of drier regions are more likely to engage in both temporary and permanent migrations to other rural areas, as compared to residents of high-precipitation regions. Findley (1994) explored the migratory implications of Mali drought and found that the severe drought of 1983-1985 was associated with a dramatic increase in migration of women and children, and also an increase in short-term cyclical migration.

With the above work as a foundation, a spate of new research has recently emerged on the migration-environment association. Overwhelmingly, the recent additions provide evidence of lack of, and variability in, natural capital acting as a "push factor" in outmigration, in concert with other influences. As an example, bringing the livelihoods framework to rural migration-environment issues in China, Qin (2010) finds that rural out-migration is a strategy that lowers dependence on natural capital, specifically agriculture and other proximate natural resources used for subsistence. Lower natural capital in the form of smaller fish catches intensifies livelihood vulnerability in East Africa, resulting in the migration of fisherfolk (Njock and Westlund 2010; Nunan 2010).

Bringing our attention to Mexico, Eakin (2005) argues that understanding farmers' range of livelihood choices, and limits to their adaptive capacity, is important in understanding rural vulnerabilities to climate change. Indeed, environmental trends clearly shape household coping capacity since agricultural yields are impacted by climate factors (Luers et al. 2003). Related, research has shown that off-farm employment and migration appear to stabilize household livelihoods through diversification and reduced environmental reliance (De Janvry and Sadoulet 2001; Wiggins et al. 2002). Such livelihood diversification is also important to insure against income risks arising from crop price fluctuations (Massey et al. 1993; Stark and Bloom 1985).

Migration as livelihood diversification in Mexico, particularly in light of environmental change, is also suggested by recently published work by Saldaña-Zorrilla and Sandberg (2009) as well as by Feng et al (2010). Using data from the 2,443 municipalities of Mexico, Saldaña-Zorrilla and Sandberg's econometric analyses reveal higher emigration rates from Mexican municipalities more frequently affected by natural disasters and with relatively higher impoverishment levels. Operating at the state-level, Feng et al. (2010) also identify an environmental "push" with intriguing state-level associations between declines in crop yields and U.S.-bound migration.

Overall, existing science in several arenas -- natural resources, livelihoods, vulnerability and migration as adaptation -- forms an important foundation for bringing examination of migration-environment associations to rural Mexico. Such is especially the case given the important social, economic and political aspects of Mexican migration to the U.S., as reviewed next.

Mexico migration patterns and processes: Mexican migration to the U.S. has a long history. Sustained, massive movement of labor migrants dates back to recruitment efforts by U.S. employers in the early 20th Century (Gamio 1930; Foerster 1925; Cardoso 1980). Migration streams plummeted during the Great Depression (Balderrama and Rodriguez 2006; Hoffman 1924) but emerged again due to a bi-national labor accord with Mexico, the Bracero Program, initiated in 1942 (Calavita 1992). While the Bracero Program was discontinued in 1964 as part of broader civil rights and immigration reform, immigration from Mexico continued, both legally and undocumented, in a somewhat circular fashion (Massey et al. 2002). Considerable increases in migration streams occurred in the 1990s and for most of the first decade of the 21st

Century (Martin and Midgley 2010; Passel and Cohn 2009) as emigration from Mexico increased (Bean et al. 2001; Hill and Wong 2005) and return migration rates plummeted (Massey et al. 2002; Riosmena 2004).

Historically, much of the Mexico-U.S. migration flows has come from rural areas in Central-Western Mexico (Durand et al. 2001; Durand and Massey 2003). However, since the 1980s, emigration to the U.S. from less traditional sending regions in rural South-Central and Southeastern Mexico has increased considerably (especially in the last 15 years, see Durand and Massey 2003) helping fuel the recent surge out of rural areas and, in particular, of less traditional sending communities in Southern Mexico (Riosmena and Massey *forthcoming*; Riosmena and Zenteno 2010).

Rural Mexicans have, of course, also migrated to cities within Mexico (Garza 2003; Lozano-Ascencio et al. 1999) and some changes in these processes are also of importance to the present project. Rural-urban flows, once mainly destined for Mexico City, Guadalajara, and Monterrey, have been increasingly directed toward border cities since the 1980s (Lozano-Ascencio et al. 1999). Migration to northern cities is fueled, in large part, by employment opportunities in export-processing (*maquiladora*) firms. Still, internal migrants are also more likely to ultimately emigrate to the U.S. as compared to longer-term (non-migrant) northern residents (Fussell 2004; Lozano-Ascencio et al. 1999). This pattern suggests at least part of the internal migrant flow from rural areas may eventually yield U.S-bound migration.

As briefly noted above, explanations for the transformation in the geography of rural Mexican migration are associated with the deep economic restructuring of, and shocks to, the Mexican political economy (Fernandez-Kelly and Massey 2007; Lustig 1990; Massey et al. 2002;

Nevins 2007). These shocks have disproportionately affected livelihoods in rural areas and in the South in particular. For instance, consider the results of a study of the Mexican economy since the enactment of NAFTA. Zepeda et al. (2009) point out that the manufacturing sector has gained in terms of exports, productivity increases, and, to a lesser extent, job growth. Still, primary sector employment has suffered the most losses (for similar views, see Hanson 2003; Polaski 2004). Of course, especially important for the research outlined here, many rural regions of Mexico remain dependent on agriculture for subsistence and/or as a component of a broader livelihood strategy (De Janvry and Sadoulet 2001).

As noted, recently published research by Saldaña-Zorilla and Sandberg (2009) and Feng et al. (2010) suggest intriguing municipal- and state-level associations between outmigration from rural Mexico and environmental "push" factors (namely natural disasters and declining crop yields, respectively). Yet, municipal- and state-level analyses do not allow for adequate control of the myriad household-level factors shaping migration decision-making (e.g. Hondagneu-Sotelo 1994; Lindstrom 1996; Massey, Goldring, and Durand 1994; Massey and Espinosa 1997; Stark and Bloom 1985). Therefore, what remains missing from the research on Mexican migration is a more precise examination of the potential for environmental factors to be included in the suite of migration drivers. The work presented here operates at finer scales, most notably the household and community levels given the relevance of the former as a decision unit (Massey et al. 1993) and of the latter in terms of socioeconomic and network processes associated with migration decisions (Massey and Espinosa 1997; Massey, Goldring and Durand 1994). Making use of the "Rural Livelihoods" framework, we include "natural capital" among the more typical predictors of migration – human, financial, physical, and social

capitals. Given the public and policy attention to both climate change and Mexican migration, bringing the environment explicitly into household-level analyses of migration in this setting is far overdue. Here, we investigate the question: *Is emigration from rural Mexico associated with recent patterns of precipitation, net of other socio-economic and political factors shaping emigration patterns?*

Data

We use data from the Mexican Migration Project (MMP), a bi-national research initiative based at Princeton University (USA) and the University of Guadalajara (MX). Every year since 1987, the MMP selects between 4 and 6 Mexican communities and interviews a random sample of approximately 200 households. The MMP questionnaire collects basic socio-demographic and retrospective migration questions about all members of the household at the time of the survey. Data are also collected on all children of the household head regardless of their place of residence. Among these questions, respondents report the dates and duration (if applicable) of the first and last U.S. trip for all members of the household. Our dependent variable reflects emigration to the U.S. by an adult household member (age 15+) within the year prior to the survey. For the purposes of the present project, our analytical focus is on international migration, although we intend to expand upon the work presented here with additional migration streams. On emigration, as would be anticipated from contemporary trends, outmigration from the sampled rural households is a common phenomenon with approximately 21% sending a migrant to the US during the three years prior to the year of observation.

At the household level, we include measures reflecting access to the variety of capitals outlined in the Rural Livelihoods framework and central to household strategies. These include human capital (e.g., household size and composition, educational levels), financial capital (e.g., business ownership), physical capital (e.g. land and livestock ownership, possessions[i]), and social capital (e.g., head's prior trip to the US). As to sample characteristics for these livelihood variables, human capital measured at the household level shows that household heads have approximately 5 years of education and 86% are employed at the time of the survey. Overall, 40% of household members are considered to be in the labor force. On average, 26% of households engage in farming, 22% own a business and approximately 6% have both a farm as well as business. Of those who own land, approximately 16% have their primary holding in either communal or ejido land. As noted prior, households whose primary landholding is ejido territory are more constrained in livelihood options due to incomplete property rights which lessens their financial and capital assets as well as decreases the households ability to access formal credit markets relative to households with private property.

Central to this project is inclusion of variables reflecting the availability of natural capital as shaped by recent rainfall levels and variability. Specifically, our predictor variables of central interest represent rainfall patterns within the 3 year window prior to household observation. We followed the lead of much climate science in calculating a state's "average annual rainfall" as over a historic 30-year period, in our case 1960-1990. A year in which rainfall is one standard deviation below the state's historic average is classified as a drought year. Inversely, a rainy year is one in which current rainfall is one standard deviation above the state's historical average. Importantly, we find substantial variation in precipitation regimes with approximately

23% of our sample subjected to a drought in their survey year. In addition 13% of our sample had a drought the year prior to the survey while 3.6% had a drought in both years. Approximately 28% of our sample experienced a rainy year in their survey year, while 23% had a rainy year the year prior to the survey and 7% had a rainy year in both years.

The household and individuallevel data were supplemented with information collected by the MMP at the community and municipal levels. These data include information reflecting households' access to livelihood diversification options, such as manufacturing facilities, in addition to information on larger scale social capital, such as community-level migration prevalence (indicating strength of broader migrant networks). Indeed, this form of social capital is well developed in most communities, particularly for men; Male migration prevalence tends to be between 25-50% while female migration prevalence of most communities is between 0 – 25% (see also Massey, Goldring, and Durand 1994; Fussell and Massey 2004).

(Table 1, Descriptive Statistics, about here)

Given the focus on rural livelihoods, our sample is restricted to non-urban communities. Our analyses make use of data from 24,132 households, with a total of 117,040 persons, in 66 non-urban communities located in 12 states surveyed from the year of 1987 to 2005. Given that we include state-level rainfall data, only states in which more than one community has been surveyed are included in our sample (see Appendix A). This restriction was necessary in order to ensure representation and variation in state level variables over time and enables us to utilize state fixed effects in our regression specification.

Methods

We first simply graph aggregated migration and precipitation trends across time, by state, to descriptively examine their association. Importantly, we present migration trends only after the high levels of migration motivated by the 1986 Immigration and Reform Control Act (IRCA), which provided amnesty to approximately 2.3 million seasonal and undocumented Mexican workers in the US. For these bivariate associations, communities were classified according to the majority percentage of the state's climate distribution provided by the 2003 study by, INEGI, National Institute of Statistics, Geography, and Informatics. Overall categories include: warm dry, warm humid, mild dry, mild humid and cold (INEGI Anuarios Estadisticos de los Estados, 2004). Within these categories, rainfall trends were calculated as recent deviation from the longer-term historic mean. Migration prevalence represents the number of adults reported, retrospectively as leaving in each year.

We then develop event history multivariate models and, given that migration is rooted in household decision processes (e.g. Hondagneu-Sotelo 1994; Stark and Bloom 1985), we model emigration decisions at this scale. Specifically, we model the likelihood that at least one household member emigrates to the U.S. in the three years prior to the survey as a function of community level, household-level and environmental factors. We opted for a three-year recall window for three reasons: 1) to minimize potential memory biases (Auriat 1991; Belli 1998; Smith and Thomas 2003); 2) to increase the representativeness of the analyses by avoiding going too far back in time, when the experience of people emigrating out of the community is lost; and 3) to maximize the number of covariates available for modeling purposes. Clearly, timing represents a key challenge in working with the MMP data. The MMP is a repeated cross-

sectional survey that includes retrospective questions. We made use of information from the retrospective questions to generate a pseudo-panel across time for each household. Even so, many of the community and household characteristics are measured only at the time of the survey. These static measurements, therefore, limit our ability to utilize retrospective information too far back in time due to the obvious temporal mismatch. To balance data needs with data availability, we use a 3-year migration window, including migration events only if they occurred within the 3-years prior to survey observation. We further worked to minimize measurement error by converting community level measures to categorical dummy variables.

As our outcome of interest is a time-dependent event, which has a probability of occurrence derived from a censored distribution, we employ discrete-time event survival analysis techniques. Following Allison (1982; see also Singer and Willett 2003), we do this by fitting a logistic regression modeling the likelihood of U.S. migration while considering the exposure to the risk of emigration of each unit of analysis. To do so, we estimate the model on a set of pseudo-observations, in this case household-years of exposure before household member's emigration. To control for the changing economic conditions in Mexico we employ both state and year fixed effects and to address the fact that household decisions may be correlated at a community level, we cluster our standard errors accordingly.

Results

First, Figures 1-3 present trend lines for sampled Mexican communities grouped by environmental region. As noted above, the regions are mild dry, mild humid, and warm humid, as classified within the MMP and based on the 2003 study by INEGI, National Institute of Statistics and Geography, which provides climate zone categorization for each state in Mexico.

The figures clearly hint at an association between rainfall patterns and emigration. For example, in mild dry regions (Figure 1), the relatively wet year of 1994 was associated with relatively low levels of outmigration from study communities while migration increased following the 1999 rainfall deficit. In warm humid regions (Figure 2), we see consistently high levels of precipitation accompanied by a steady decline in emigration. Finally, in mild humid regions (Figure 3), both emigration and rainfall have recently been experiencing upward trends, but looking carefully, we see a fairly consistent negative correlation with low precipitation years characterized by relatively high emigration (see 1988, 1994), and vice versa (see 1990, 1991, and 1995).

(Figures 1-3 about here)

The findings from our logit model shed additional light and are, for the most part, consistent with many of the studies mentioned in the background section. Human capital variables suggest households with more educated heads are less likely to send an international migrant, perhaps related to enhanced local opportunities to diversify livelihoods. Household composition is also associated with emigration, with consistently positive coefficients suggesting larger households are more likely to send migrants as might be anticipated. Such is not the case, however, in households with relatively more daughters, which are less likely to send an international migrant to the US. On financial capital, employment of head and business ownership dampen emigration probabilities, again likely due to existing diversification strategies. Assets and land ownership tends to increase household emigration probability while social capital gained through prior migration does indeed enhance the likelihood of emigration.

Key to our analyses is inclusion of natural capital measures and the models yield intriguing findings. Net of the incorporated human, physical, financial and social capital variables, environmental factors retain statistically significant predictive ability with regard to emigration. Consider drought. Net of the other included household and community-level characteristics, households experiencing a drought in the year under consideration have 29% higher odds of sending an international migrant to the U.S. than a household not experiencing a drought.[1] While, if the household experienced a rainfall deficit the year prior, odds are 39% greater of international migration. Yet, the association is even more substantial when considering a longer-term rainfall deficit. Households experiencing a 2-year drought are over three times as likely as other households to send an international migrant to the U.S.

As might be anticipated based on the drought results, higher than average rainfall is then associated with lesser emigration probabilities. Households with rainfall abundance in the year under examination, relative to historic averages, have 30% lower odds of sending an international migrant and 40% lower odds if higher levels of rainfall characterized the year prior. On the other hand, the estimate of the association between emigration probabilities and higher than average rainfall over both years did not reach statistical significance.

Of course, it is logical to assume rainfall is most likely to impact households with resource-dependent livelihood strategies. As such, we also estimate emigration as a function of rainfall interacted with indicators for households who engage in farming, work in agriculture or own livestock. Here, somewhat counterintuitive results emerge. Two year rainfall deficits actually decrease the odds of farming households sending an international migrant by 35% as compared

[1] The percentage increase in odds is observed using a base of an odds ratio of 1.

to non-farm households at a 10% significance level. Similarly, the odds of international migration decline for households where the household head is working in agriculture, with 40% lower odds of sending an international migrant compared to the effect of a two year drought on households with a non-agricultural head. It is likely that these patterns hint at income constraints. International migration is a costly endeavor and perhaps unavailable to agricultural-dependent household in times of particular livelihood stress.

Discussion & Conclusion

Human migration is a complex social process contingent on origin- and destination-based factors of which climate variability may be an important one. As suggested by prior work in contexts as varied as Mali, Ethiopia and Burkina Faso, the research presented here finds an association between rainfall patterns and emigration from rural Mexico to the U.S., with dry years generally acting as a migrant "push" and wet years inhibiting emigration.

In rural Mexico, as in rural regions across the world's less developed nations, environmental change has direct impacts on health and well-being of residents since natural resources are often central to income generation activities and/or essential in meeting basic living requirements (Koziell and Saunders 2001). Given this resource dependence, changes in weather and climate patterns hold tremendous potential to impact livelihoods and, in the face of a decline in livelihood options, migration becomes a significant adaptive livelihood strategy (e.g. Adger 2006; McLeman and Smit 2006).

Current climate models for Latin America project mean warming from 1 to 6°C, and a net increase in the number of people experiencing water stress within the region (IPCC 2007). Specific to Mexico's most valuable agricultural export, coffee, Gay et al. (2006) project climate

change may yield a 34% reduction in production in Veracruz, potentially making coffee no longer an economically viable livelihood strategy (see also Nevins 2007; Zepeda et al. 2009). Clearly environmental change holds important potential to impact rural Mexicans' livelihood strategies, and thereby influence migration patterns. Indeed, our results find a prominent association between emigration from rural Mexico and recent patterns of precipitation, net of other socio-economic and political factors shaping migration patterns.

The preliminary work outlined here presents many directions for future research through expansion of both social and environmental dimensions. On the social dimensions, we aim to disaggregate migration streams both by destination (to examine internal and international migration), while also exploring different migration outcomes for Mexican men and women. On the environmental dimension, we aim to integrate additional aspects of environmental change including temperature fluctuations and shifts in vegetation coverage. Of course, we could also explore the "pull" of desirable natural attributes; Within the U.S., a state-level association exists between climate and migration with desirable weather attributes (warmer temperatures, less humidity) associated with positive net migration (Poston et al. 2009). In Ghana, regions with greater access to natural capital experience higher levels of in-migration (Van der Gesest, Vrieling and Dietz 2010).

The public, policy and academic realms have recently paid increasing attention to the potential for environmental change to alter patterns of human migration. Social, political, economic and environmental pressures converge in rural Mexico regions where the present study suggests reduction of proximate natural capital may enhance the likelihood of households tapping into migration's livelihood potential. Certainly such evidence suggests that

the environmental dimensions of livelihood strategies, including emigration, deserve additional, focused research attention.

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Figure 1

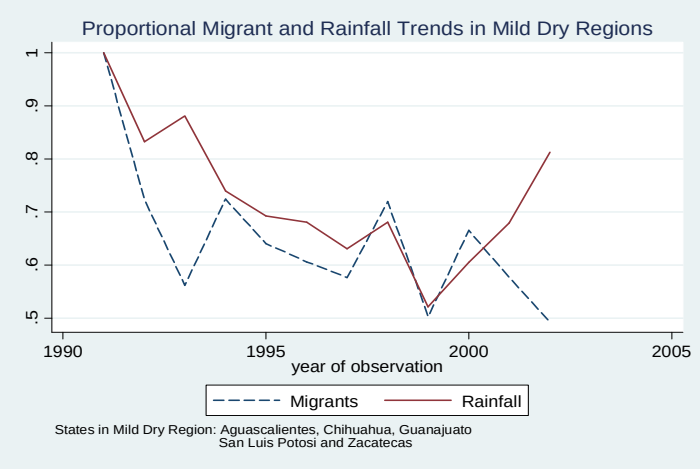

Figure 2

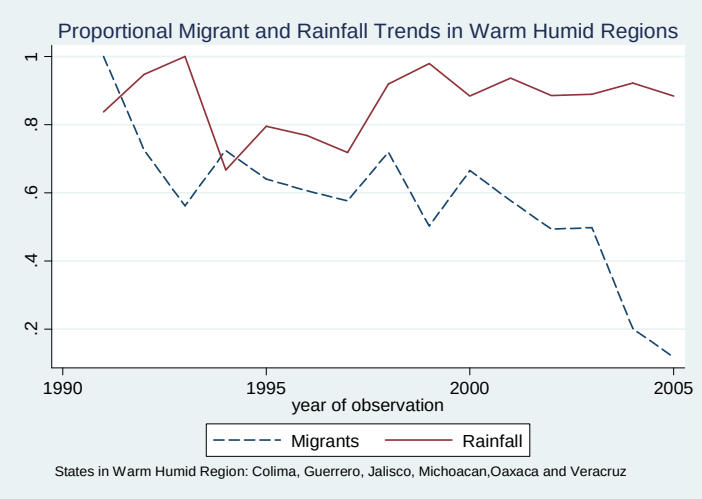

Figure 3

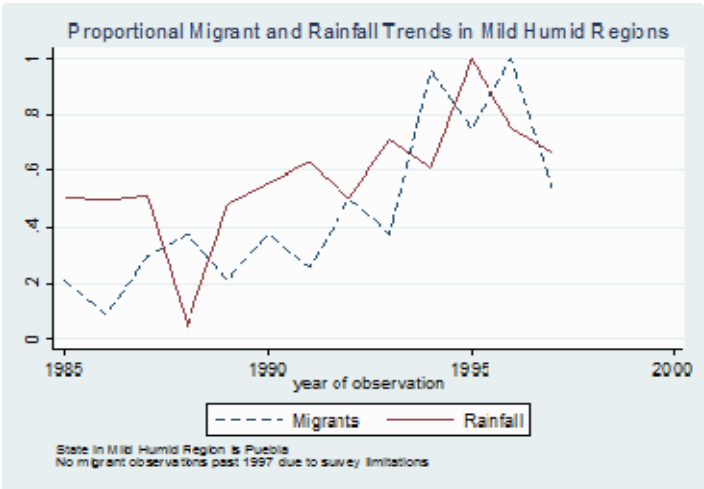

Table 1: Means and Standard Deviations of Community and Household Covariates

Variable	% / Mean	Std. Dev
Community-Level Characteristics		
Female Labor Force Participation between 0 - 10%	26.70%	0.442
Female Labor Force participation between 10 -20%	60.70%	0.488
Female Labor Force participation between 20 -30%	12.60%	0.332
Proportion of Females in Manufacturing over 50%	8.00%	0.271
Male Agricultural work Participation over 50%	48.70%	0.500
Female Migration Prevalence in 1990 between 0- 25%	86.50%	0.342
Female Migration Prevalence in 1990 between 25- 50%	13.50%	0.342
Male Migration Prevalence in 1990 between 25- 50%	62.80%	0.483
Male Migration Prevalence in 1990 between 50- 75%	22.70%	0.419
Male Migration Prevalence in 1990 between 75- 100%	1.00%	0.099
Household Charcteristics		
Dependent Variable: Household sends a migrant	20.60%	0.404
Human Capital		
Household size	4.85	2.369
Percentage of HH in Labor Force	39.70%	0.234
Household head employed	85.50%	0.352
Household head education	5.00	4.355
Financial Capital		
Household has business	22.10%	0.415
Social Capital		
Household head number of trips to US	1.53	3.847
Physcial Capital		
Primary property is either community or ejido land	15.70%	0.364
Natural Capital		
Current Year is a Drought Year	23.30%	0.423
Current Year is Rainy Year	27.90%	0.449
Last Year was a Drought Year	13.10%	0.338
Last Year was a Rainy Year	22.60%	0.418
Two Drought Years have Occurred in Row	3.60%	0.186
Two Rainy Years have Occurred in a Row	6.80%	0.251
Reliance on Natural Capital		
Household engaged in farming	26.30%	0.440
Household has both farm and business	6.20%	0.241
Household owns livestock	28.00%	0.450
Household head works in agriculture	34.50%	0.476

Table 2: Discrete Time logit Predicting the Likelihood of a Household Sending a Migrant

	1		2		3	
	β	SE	β	SE	β	SE
ommunity-Level Characteristics						
Proportion of Females in Manufacturing is over 50%	0.666***	(0.204)	0.671***	(0.204)	0.673***	(0.204)
Male Agricultural Work Participation is over 50%	0.454**	(0.177)	0.449**	(0.175)	0.445**	(0.175)
Male Migration Prevalence in 1990 was between 25- 50%	0.571***	(0.159)	0.565***	(0.159)	0.558***	(0.160)
ousehold Characteristics						
Human Capital						
Head of House Education	-0.0616***	(0.0107)	-0.0599***	(0.0107)	-0.0603***	(0.0107)
Age of Head of Household	-0.0133***	(0.00393)	-0.0134***	(0.0039)	-0.0135***	(0.00393)
Spouse's Education	-0.0498***	(0.0118)	-0.0495***	(0.0118)	-0.0491***	(0.0119)
Lifecycle - Young Children	1.327***	(0.194)	1.333***	(0.194)	1.332***	(0.194)
Lifecycle - Young and Teenage Children	1.702***	(0.200)	1.710***	(0.202)	1.710***	(0.202)
Lifecycle - Teenage Children Only	0.694**	(0.310)	0.706**	(0.311)	0.709**	(0.311)
Lifecycle - Adult Children	1.474***	(0.222)	1.482***	(0.224)	1.485***	(0.224)
Percentage of Daughters to Household Members	-0.637***	(0.158)	-0.639***	(0.159)	-0.640***	(0.159)
Financial Capital						
The Household has a Business	-0.320***	(0.0834)	-0.304***	(0.0792)	-0.304***	(0.0793)
Percentage of the Household that is in the Labor Force	0.574***	(0.128)	0.574***	(0.128)	0.577***	(0.128)
Household Head is employed	-0.225*	(0.116)	-0.264**	(0.117)	-0.262**	(0.117)
Physical Capital						
Primary Property is either Community or Ejido Land	0.365***	(0.126)	0.361***	(0.126)	0.366***	(0.127)
Percentage of Amenities owned by Household (out of 11)	1.338***	(0.252)	1.353***	(0.251)	1.358***	(0.252)
Number of livestock owned by HH	0.115***	(0.0310)	0.117**	(0.0459)	0.115**	(0.0461)
Social Capital						
Household Head- Number of Trips to the US	0.205***	(0.0167)	0.205***	(0.0169)	0.205***	(0.0169)
Natural Capital						
Current Year is a Drought Year	0.254**	(0.128)	0.253**	(0.128)	0.254**	(0.128)
Current Year is a Rainy Year	-0.361***	(0.139)	-0.363***	(0.139)	-0.363***	(0.139)
Last Year was a Drought Year	0.329**	(0.148)	0.330**	(0.148)	0.332**	(0.148)
Last Year was a Rainy Year	-0.500***	(0.133)	-0.502***	(0.132)	-0.502***	(0.132)
A drought has Occurred Two Years in a Row	1.228***	(0.464)	1.224***	(0.463)	1.385***	(0.472)
A Rainy year has Occurred Two Years in a Row	0.329	(0.235)	0.335	(0.235)	0.336	(0.234)
Reliance on Natural Capital						
Household is Engaged in Farming	-0.0986	-0.0913	-0.116	(0.0924)	-0.113	(0.0930)
Household Owns Livestock			-0.0228	(0.114)	-0.0283	(0.115)
Household head works in Agriculture			0.0876	(0.111)	0.106	(0.112)
Interaction Farm & Two Year Drought					-0.444**	(0.204)
Interaction Owns Livestock & Two year Drought					0.237	(0.545)
Interaction HH Head Works in Ag & Two Year Drought					-0.501**	(0.250)
Intercept	-3.956***	(0.826)	-3.939***	(0.815)	-3.938***	(0.813)
State Fixed Effects	Yes		Yes		Yes	
Year Fixed Effects	Yes		Yes		Yes	
Community Female Labor Force Participation Controls	Yes		Yes		Yes	
Community Female Migration Prevalence in 1990 Quartile Cor	Yes		Yes		Yes	
Community Male Migration Prevalence in 1990 Quartile Contr	Yes		Yes		Yes	
Spouse's Education and Number of US trips Controls	Yes		Yes		Yes	
Observations	24,132		24,132		24,132	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

**All results given in log odds*

Appendix A1)

States, Communitites and HH observations in Sample

State	Communitites	HH Observations	Percent of Sample
Aguascalientes	2	650	2.69
Colima	3	1,027	4.26
Chihuahua	3	1,266	5.25
Guanajuato	12	4,181	17.33
Guerrero	3	977	4.05
Jalisco	11	3,613	14.97
Michoacan	6	2,369	9.82
Oaxaca	4	1,704	7.06
Puebla	2	549	2.27
San Luis Potosi	9	3,176	13.16
Veracruz	6	2,023	8.38
Zacatecas	5	2,597	10.76
Total	66	24,132	100

[i] The MMP includes measures of 11 amenities/possessions within study households: running water, electricity, sewage, a stove, a refrigerator, a washing machine, a sewing machine, a radio, a television, a stereo and a telephone.