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Rainfall Patterns and U.S. Migration from Rural Mexico

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In many rural regions of developing countries, natural resource dependency means changes in climate patterns hold tremendous potential to impact livelihoods. When environmentally-based livelihood options are constrained, migration can become an important adaptive strategy. Using data from the Mexican Migration Project, we model U.S. emigration from rural communities as related to community, household and climate factors. The results suggest that households subjected to very recent drought conditions are less likely to send a U.S. migrant, but in communities with drought two years prior and with strong migration histories, emigration is much more likely. In regions lacking such social networks, rainfall deficits actually reduce migration propensities, perhaps reflecting constraints in the ability to engage in migration as a coping strategy. Policy implications emphasize diversification of rural Mexican livelihoods in the face of contemporary climate change.

Variability associated with climate change will most likely increase the frequency and severity of natural disasters such as hurricanes (Trenberth *et al.*, 2007) and more prolonged, lower-intensity events such as droughts (Kundzewicz *et al.*, 2007). Both of these phenomena might alter patterns of human migration (e.g., Gutmann and Field, 2010), an issue that has increasingly garnered attention among the public as well as in policy and academic realms (Hartmann, 2010). Our analytical focus is on Mexico-U.S. migration, one of the largest and longest sustained international flows of people in the world (Massey and Sana, 2003) and the main source of both legal and undocumented migration into the U.S.

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(Passel and Cohn, 2011). Even so, only a handful of peer-reviewed studies exist on potential environmental factors shaping Mexico-U.S. migration.

Most scholars contend that climate change will likely increase mobility within a nation's borders rather than create a wave of international "climate refugees" (e.g., Bardsley and Hugo, 2010; Hartmann, 2010). Yet, the association between climatic variability and migration distance is contingent on factors such as household socioeconomic status (Gray, 2009; Gray and Mueller, 2012a,b). Further, internal or international migrant networks play a key role in determining whether people move within or across national boundaries in response to economic conditions (Lindstrom and Lauster, 2001). In the Mexican setting, a strong association has been identified between migrant networks and migration (Massey and Riosmena, 2010) especially from rural areas (Fussell and Massey, 2004). Likewise, prior migration experience within the household decreases the uncertainty surrounding, and costs associated with subsequent migration, thereby facilitating mobility (e.g., Massey and Espinosa, 1997). As such, we argue migrant networks and prior migration experience will be important mediators on whether migration is used as an adaptation strategy to economic and social vulnerability associated with climatic stress and variability.

To test the association between broad availability of migrant networks, U.S.-bound migration, and environmental stress and variability, we model the association between variation in state-level rainfall and U.S.-bound migration from Mexico's historical sending regions as contrasted with other regions. We use data from 66 rural communities surveyed by the Mexican Migration Project (MMP). Although substantial research has examined the social, economic, and policy drivers of Mexican migration to the U.S. (e.g., Massey *et al.*, 1987; Massey and Espinosa, 1997; Lindstrom and Lauster, 2001; Hamilton and Villarreal, 2011; Angelucci, 2012), less is known about the environmental dimensions of migration streams.

THEORETICAL PERSPECTIVES ON MIGRATION–ENVIRONMENT LINKAGES

A special issue of *Global Environmental Change* (Black *et al.*, 2011a) presented a useful comprehensive conceptual framework and also brought together several empirical contributions to the migration–environment literature. The framework, by Black *et al.* (2011b), "steps back to consider major migration theories" including neoclassical, social capital, and the new economics of labor migration while also integrating environmental factors. Commonly understood migration predictors – such as employment opportunities, family/kin obligations, and political conflict/insecurity – are shown to be indirectly influenced by environmental factors. In addition, spatial and temporal variability in environmental influences are considered because environmental shocks may be cyclical (e.g., seasonal monsoons), short term (e.g., hurricane), or more gradual in their development (e.g., drought).

Also useful within our work is the Sustainable Rural Livelihoods Framework (International Fund for Agricultural Development (IFAD), 2010), which classifies "capital assets" that shape livelihood options, including human (e.g., labor), financial (e.g., savings), physical (e.g., automobiles), social (e.g., support networks), and natural capital (e.g., wild foods and fuels). The relative availability of various assets is further impacted by individual and household actions as well as broader socioeconomic-political structures and processes. In turn, differential capital availability shapes livelihood strategies, which may include how households allocate human capital across space (e.g., labor migration, see Collinson *et al.*, 2006) or how they use natural capital (e.g., resource-based crafts for market, Pereira, Shackleton, and Shackleton, 2006).

Within both the framework by Black *et al.* (2011b) and Sustainable Livelihoods, natural capital holds a prominent position in livelihood and migration decision-making – albeit sometimes acting as an indirect influence. Such centrality is logical because in rural regions of developing nations, proximate natural resources are often essential in meeting basic living requirements and responding to household stress and shocks (e.g., Hunter, Twine, and Patterson, 2007). In rural Mexico, environmental change has immediate and direct impacts on the health and well-being (Koziell and Saunders, 2001) because it shapes vulnerability through impacts on agricultural productivity (Eakin, 2005; Feng, Kruger, and Oppenheimer, 2010; Skoufias and Vinha, 2013).

PREVIOUS EMPIRICAL STUDIES

Livelihood diversification reduces household vulnerability (Ellis, 2000; Skoufias and Vinha, 2013), and migration is a particular adaptation strategy used by households facing environmental strain (Bilsborrow, 1992; De Sherbinin *et al.*, 2008; McLeman and Hunter, 2010; Njock and Westlund, 2010). In this way, changes in proximate natural capital shape household decisions about use of human capital.

There is empirical evidence of this association from rural areas across the globe. Massey, Axinn, and Ghimire (2010) find that environmental factors play a role in migration in Nepal, particularly short-distance moves. Similar results emerge in Burkina Faso (Henry, Schoumaker, and Beauchemin, 2004) where 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. During a severe drought in 1983–1985, Mali, too, experienced an increase in short-term cyclical migration and the migration of women and children (Findley, 1994). Lower natural capital in the form of smaller fish catches also intensified livelihood vulnerability in East Africa, resulting in the migration of fisherfolk (Njock and Westlund, 2010).

Although these results are consistent with the notion that migration increases in times of “environmental scarcity,” others hypothesize that vulnerability can actually constrain migration, particularly costly long-distance moves. In rural Bangladesh, for example, disasters actually reduce mobility through heightened resource constraints (Gray and Mueller, 2012a). Further, crop failure and flooding are more likely to propel migration among women who have less secure access to land in this setting.

Finally, the “environmental capital” hypothesis finds support in other research. In rural Ecuador, for example, land provides capital that can facilitate migration (Gray, 2010). Studies in villages of the Kayes area, Mali, also observed that relatively more advantaged households were willing to invest a sizable amount of resources to send migrants given the prospect of increasing wealth through remittances and thus reinforce their social status (Azam and Gubert, 2006).

As mentioned at the outset, there is little work on how rural Mexican households might respond to natural capital shocks (i.e., climatic variability) using U.S.-bound migration as an adaptation strategy. We draw on three existing studies. Seminal work by Munshi (2003) made use of an earlier version of the MMP sample in rural areas of historical sending regions. The analysis used precipitation patterns as an instrumental variable to predict the size of the international migrant network available to residents of rural sending communities. The focus of that project was the effect of networks on Mexican migrant wages in the U.S., and, indeed, networks exhibit a positive effect on employment and wages (Munshi, 2003). But examination of the rainfall effects shows higher levels of recent precipitation are negatively associated with proportions of recent migrants (1–3 years) in a given migrant network. In other words, periods likely characterized by higher agricultural productivity (with more rainfall) exhibit less emigration. This suggests recent drought, and thereby intensified agricultural vulnerability, may push U.S.-bound migrants.

Other research examines Mexican migration at scales coarser than the household. Using data from the 2000 Census and the 2005 Population Count, Feng, Kruger, and Oppenheimer (2010) found a negative association between crop yields (as a proxy of the confluence of climatic shifts and structural conditions) and state-level U.S. migration rates, particularly for the most rural states (Feng and Oppenheimer, 2012). Also using the 2000 Mexican Census, Saldana-Zorrilla and Sandberg (2009) found that local vulnerability to natural disasters was associated with municipal out-migration. Here, dimensions of vulnerability included absence of credit and associated declines in income. Related to this institutional focus, Eakin (2005) argues that migration, as a livelihood adaptation strategy, must be seen as a product of not only climatic forces but also rising production costs, decreasing producer subsidies and obstacles in access to commercial agricultural markets. In this way, institutional changes are key to understanding migration and rural vulnerabilities to climate change (see also Liverman, 1990, 2001).

RURAL MEXICAN CONTEXT: TRENDS AND PATTERNS IN LIVELIHOODS AND MIGRATION

Rural Livelihoods

Rural Mexican livelihoods are particularly vulnerable to weather stress and shocks given the high level of agricultural dependence. Using data from four communities, Wiggins *et al.* (2002) found that 78 percent of households farmed, predominantly maize and beans.[1] Also testifying to the importance of rainfall within rural Mexican agriculture, approximately 82 percent of cultivated land is rainfed (INEGI 2007), thereby highly susceptible to both short- and longer-term weather fluctuations (Conde, Ferrer, and Orozco, 2006; Endfield, 2007). Indeed, Appendini and Liverman (1994) estimate that droughts are responsible for more than 90 percent of all crop losses in

[1]Burstein (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.

Mexico. Off-farm employment and migration appear to stabilize rural livelihoods through diversification and reduced environmental reliance (De Janvry and Sadoulet, 2001) with such diversification also insuring against income risks arising from crop price fluctuations (Stark and Bloom, 1985).

Rural livelihood diversification and institutional failure have become particularly relevant in recent times given economic restructuring and changes in the Mexican political economy disproportionately affecting the countryside. Studies have documented the negative implications of the nation's global economic integration for Mexico's smallholder farmers (Eakin, 2005). After decades of public investment and supportive, protective agricultural policies spurring agricultural growth, liberalization of the agricultural sector and food policy during the Salinas de Gortari administration (1988–1994) brought dramatic and longstanding changes to the countryside. Such changes further concentrated poverty in rural places as agricultural employment diminished considerably and commodity prices declined (e.g., Nevins, 2007). These changes, paired with increases in foreign direct investment and employment in (*maquiladora*) manufacturing helped exacerbate urban–rural and North–South inequality in the country (Polaski, 2004). Such inequalities further stimulated internal and international migration (Lozano-Ascencio, Roberts, and Bean, 1999). Informed by these broader trends, we include both state and year fixed effects in the models presented below to control for space-varying-time-fixed and space-fixed-time-varying unobserved characteristics, respectively.

Key to examination of a potential migration–environment connection within Mexico is *ejidos* – rural communities that collectively possess rights to land and whose resident members (*ejidatarios*) are entitled to work a plot of their own (Wiggins *et al.*, 2002). *Ejidos*, created through land transfers starting in the 1930s, contain approximately 60 percent of the rural population (De Janvry and Sadoulet, 2001). Market liberalization during the 1990s allowed *ejidatarios* to attain individual titles and therefore enable sale of their lands, although very few have sold (Barnes, 2009).

Ejido residents are even more dependent on natural capital than the rural households described by Wiggins *et al.* (2002). In Winters, Davis, and Corral's (2002) examination of a nationally representative sample of Mexican *ejido* households, fully 93.7 percent participated in crop production, while agricultural activities as a whole (crops, livestock, and agricultural employment) comprised over half (55 percent) of total rural *ejido* household income. De Janvry and Sadoulet (2001) further document that agricultural contributions to *ejidatario* household income range from 23 to 67 percent depending on landholding size.

Recent work suggests that contemporary efforts to provide *ejido* households with a certificate of land ownership are associated with an increase in U.S. emigration, inferring that more secure access to such 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 type of land ownership at the household scale.

Yet, other forces clearly shape livelihood strategies. Winters, Davis, and Corral (2002: 141) 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," which may shape access to water resources (e.g., irrigation systems). In this way, environmental change acts in concert with political-economic forces to shape livelihood strategies. As such, we turn now to reviewing the history and political economy of Mexico-U.S. migration.

Mexico-U.S. Migration

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 (Foerster, 1925; Cardoso, 1980). Migration streams plummeted during the Great Depression (Balderrama and Rodríguez, 2006) but emerged again in 1942 due to a bi-national labor accord with Mexico, the Bracero Program (Calavita, 1992). The Bracero Program survived its original purpose of providing emergency farm labor, but was discontinued in 1964 as part of broader civil rights and immigration reform. Despite the end of the program, immigration from Mexico continued, both legally and undocumented, in a somewhat circular fashion (Cornelius, 1992; Massey, Durand, and Malone, 2002). Considerable increases in migration streams occurred in the 1990s and for part of the first decade of the 21st century (Passel and Cohn, 2011; Warren and Warren, 2013) as Mexican emigration increased (Bean *et al.*, 2001) and short-term return migration rates plummeted (Massey, Durand, and Malone, 2002; Riosmena, 2004). Yet, recent estimates suggest that unauthorized immigration to the U.S. has declined substantially since 2008 (Warren and Warren, 2013), that net immigration from Mexico has reached a standstill, and that the Mexican-born population in the U.S. has actually declined in recent years (Passel, Cohn, and Gonzalez-Barrera, 2012). Even so, migration networks remain strong, and it remains to be seen if Mexico-U.S. flows will again rise in better economic times and with climate pressures on agricultural livelihoods in origin communities.

Historically, much of the Mexico-U.S. migration flows have come from rural areas in Central-Western Mexico. The geography of these migration flows was associated with the location of the main railroad lines (Cardoso, 1980) coupled with low population levels in the border region. Through the years, these flows perpetuated and gained strength (Durand, Massey, and Zenteno, 2001; Durand and Massey, 2003). Key to the present analyses, this regional concentration relates to the buildup of strong translocal connections between sending and destination communities (Massey *et al.*, 1987). Social capital in the form of migration networks can decrease costs associated with migration by providing information and assistance that lessen the risks and expenses associated with border-crossing and unemployment upon arrival. In fact, having familial and community-wide connections with migrants in the U.S. is one of the best predictors of U.S.-bound migration from Mexico (Massey and Espinosa, 1997; Phillips and Massey, 2000; Massey and Riosmena, 2010), particularly from rural areas (Massey, Goldring, and Durand, 1994; Fussell and Massey, 2004). Therefore, migrant networks help perpetuate emigration in communities once they reach substantial levels (McKenzie and Rapoport, 2007; Lindstrom and López-Ramírez, 2010).

Although migration networks have traditionally been concentrated in the Central-Western region, a non-trivial portion of migrants has always, and increasingly, come from less traditional sending regions South and East of Mexico City (e.g., Durand and Massey, 2003; Cornelius, 2009). As these areas are disproportionately rural, the particular speed of this social network buildup and diffusion over rural communities in less traditional sending regions may in turn be associated with the deep restructuring of the Mexican countryside over the last two decades (Nevins, 2007; Riosmena and Massey, 2012). For this reason, we conduct our analyses separately on regions with high historical sending rates as compared to other regions without these deeper historical ties.

Additionally, an individual's prior experience is strongly associated with the likelihood of subsequent migration as it is argued that the relevance of migration-specific social capital diminishes as individuals acquire their own migration-specific human capital (Massey and Espinosa, 1997).

In addition to controlling for this prior U.S. experience, we examine if rainfall variability is associated with migration in similar ways according to the prior U.S. migration experience of household members.

DATA

We use data from the Mexican Migration Project, a bi-national research initiative based at Princeton University and the University of Guadalajara. Since 1987, the MMP has annually selected between 4 and 6 Mexican communities and interviews a random sample of approximately 200 households in each community. Given the focus on rural livelihoods, our sample is restricted to non-urban communities, defined traditionally in Mexico as those with less than 2,500 inhabitants. As we include state-level rainfall data and to insure representation and variation in state-level variables over time, only states in which more than one community has been surveyed are included (see Appendix 1). This also allows for inclusion of state fixed effects in our regression specification (see Munshi, 2003). With this restriction, our working sample includes 23,686 households in 66 communities located in 12 states surveyed from the year of 1987 to 2005.

As migration has consistently varied by region within Mexico, and given the strength of Mexican migration's association with existing migrant networks, we disaggregated the data into two key categories. Communities located in the "historical region" represent central-western states that have historically contributed most of the emigrant flow (Durand and Massey, 2003). In our data, 74 percent of households are located within this region, namely in the states of Zacatecas, Guanajuato, Jalisco, Michoacán, San Luis Potosí, Aguascalientes, and Colima. The remainder set of communities comprises "all other regions" located in the states of Chihuahua in the border region; Puebla, Guerrero, and Oaxaca in the central region; and Veracruz in the southeast (for a full regional classification, see Durand and Massey, 2003).

The MMP questionnaire collects basic socio-demographic and retrospective migration questions about all members of the household at the time of 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 people listed in the household roster. Our dependent variable reflects emigration to the U.S. by any individual age 15+ in the household roster within 3 years prior to the survey (that is, during the survey year and 2 years prior). U.S.-bound migration is a relatively common phenomenon among the MMP respondents, with approximately 21 percent of households sending a migrant to the U.S. during the 3-year window. As expected, there are large differences between the emigration rates from historical and other sending communities in our sample: whereas 25 percent of households in the historical region sent a migrant to the United States in the 3-year window of observation, only 11 percent of households in other regions did so (see Table 1).[2]

Central to this project are variables reflecting the availability of natural capital as shaped by variability in rainfall. Rainfall measurements are commonly used to reflect the consumption impacts of weather shocks (e.g., Dercon and Krishnan 2000; Skoufias *et al.* 2011). Our main predictor variables represent deviations from long-term average rainfall at the state level. We follow the lead of a large body of climate science and use a 30-year mean as "climate normal" for assessment of variability (National Climatic Data Center (NCDC), 2011). We define "drought" years as those in which the state-level rainfall measurement was one standard deviation below the 30-year mean, while "severe drought" years represent two standard deviations below the 30-year mean. Inversely, we define "wet" or "severe wet" years as those with rainfall one or two standard deviations above the 30-year mean, respectively.

There is substantial variation in precipitation regimes in our total sample, with an overall mean of 18 percent of households subjected to drought during the survey year. In addition, 32 percent of our sample had a drought the year prior to the survey, while a similar level (30 percent) experienced drought 2 years prior. As would be anticipated, severe droughts are far less frequent with only 6 percent of households experiencing them during the survey year, 7 percent the year prior, and 6 percent 2 years prior.

Fewer sample households experienced relatively high levels of rainfall, although "wet" locations are more consistently wet across time. For example, 18 percent of households experienced a wet year during their survey year, 13 percent the year prior, and 10 percent 2 years prior. Similar levels characterize "severe wetness" with 11 percent of households experiencing rainfall at least two standard deviations above the 30-year normal during their survey year, 11 percent in the year prior, and 10 percent 2 years prior.

[2]The MMP data pose some limitations including, as an origin-only survey, the departure of entire households is not measured. Still, in this way, the data underrepresent rural outmigration, thereby potentially underestimating environmental correlates.

TABLE 1
MEANS (AND STANDARD DEVIATIONS) OF DEPENDENT VARIABLE AND COVARIATES IN THE ANALYSIS

	All communities Mean (SD)	Historical Region Mean (SD)	All Other Regions Mean (SD)
Outcome of interest			
Proportion households sending a migrant	0.206 (0.404)	0.245 (0.430)	0.106 (0.308)
State-level climatic variability (natural capital shifts)			
Current year a drought year	0.179 (0.384)	0.207 (0.405)	0.100 (0.300)
Current year is a Severe drought year	0.058 (0.235)	0.016 (0.127)	0.181 (0.385)
Last year a drought year	0.316 (0.465)	0.384 (0.486)	0.120 (0.325)
Last year was a severe drought year	0.067 (0.251)	0.032 (0.176)	0.170 (0.375)
Two years ago was a drought year	0.301 (0.459)	0.384 (0.486)	0.062 (0.242)
Two years ago was a Severe drought year	0.058 (0.234)	0.033 (0.180)	0.130 (0.336)
Current year a wet year	0.175 (0.380)	0.145 (0.352)	0.261 (0.439)
Current year is a severe wet year	0.110 (0.313)	0.125 (0.331)	0.067 (0.250)
Last year was a wet year	0.132 (0.338)	0.136 (0.343)	0.120 (0.325)
Last year was a severe wet year	0.105 (0.306)	0.079 (0.269)	0.181 (0.385)
Two years ago was a wet year	0.098 (0.298)	0.111 (0.314)	0.062 (0.242)
Two years ago was a severe wet year	0.100 (0.300)	0.035 (0.183)	0.287 (0.452)
Household's human capital			
No. of household members	4.9 (2.4)	5.0 (2.5)	4.6 (2.1)
Proportion of household in labor force	0.397 (0.234)	0.397 (0.236)	0.394 (0.225)
Proportion of household that is daughters	0.234 (0.195)	0.240 (0.196)	0.215 (0.192)
Household head is employed	0.855 (0.352)	0.851 (0.356)	0.864 (0.343)
Age of household head	47.675 (15.632)	47.473 (15.889)	47.998 (14.903)
Schooling years, household head	5.0 (4.4)	4.9 (4.4)	5.6 (4.3)
Age of spouse (if applicable)	35.3 (20.0)	35.2 (19.9)	35.7 (20.1)
Schooling years, spouse (if applicable)	4.2 (3.9)	4.1 (3.9)	4.5 (4.0)
Household's financial and physical capital			
Household engaged in farming	0.263 (0.440)	0.215 (0.411)	0.316 (0.465)
Household owns a business	0.221 (0.415)	0.215 (0.411)	0.231 (0.422)
Household has both a farm and business	0.062 (0.241)	0.048 (0.215)	0.093 (0.291)
Primary property is in community/*ejido* land	0.157 (0.364)	0.135 (0.342)	0.217 (0.412)
Amenities in HH (out of 11)	7.489 (2.386)	7.608 (2.343)	7.152 (2.496)
Percent of Sample with more than Median Amenitie	0.545 (0.498)	0.556 (0.497)	0.512 (0.499)
Household's migration-specific social capital			
Percent HH head has been to US	0.351 (0.5)	0.402 (0.490)	0.203 (0.403)
Percent spouse has been to US	0.061 (0.240)	0.1 (0.3)	0.0 (0.2)
Municipal-level socioeconomic levels, community-level migration-specific social capital			
Female labor force participation	0.131 (0.053)	0.131 (0.045)	0.133 (0.070)
Female labor force in manufacturing	0.206 (0.151)	0.196 (0.151)	0.234 (0.149)
Male labor force in agriculture	0.500 (0.190)	0.465 (0.155)	0.585 (0.240)
Community Migration Prevelance Prevalence in 1980	0.185 (0.152)	0.237 (0.144)	0.049 (0.050)
Community Migration Prevalence Lagged 1 year	0.246 (0.137)	0.286 (0.132)	0.129 (0.072)
Sample Size	23,686	17,613	6,073

With regard to the categorization by historical sending regions, the clearest distinctions relate to drought. Households in regions with stronger histories of sending migrants to the U.S. are more likely to have been subject to drought during the 3-year window compared with those in other sending regions (20–10 percent, respectively). On the other hand, households in non-historical regions were more likely to have experienced severe drought as compared to historical region households (20 percent compared with 2 percent, respectively, for year of survey). No clear patterns emerge with regard to wetness by region.

At the household level, included variables reflect access to human capital (e.g., household composition, percent female, life cycle stages, and educational levels), financial capital (e.g., business ownership), physical capital (e.g., land and livestock ownership, possessions), and social capital (e.g., trips to U.S. *prior* to the 3-year measurement window, perhaps a measure of both migration-specific social and human capital). On human capital, the average household has almost five members with only 5 percent of households having no children. A large portion of households, 42 percent, have both young and teenage children, and on average, 40 percent of household members are in the labor force (reflecting the presence of older children). On average, 23 percent of the family members are daughters, which is controlled for as female family members are less prone to migrate (Cerrutti and Massey, 2001). Eighty-six percent of household heads are employed; heads have on average 5 years of formal schooling. Differences in human capital across regions are minimal, with households located out of the historical region being smaller (4.6 vs. 5.0 members) and having heads with slightly higher levels of schooling (4.5 vs. 4.1 years).

On financial and physical capital, about 25 percent of households are engaged in farming, with percentages slightly higher in non-historical sending regions compared with historical sending regions (32 percent vs. 22 percent, respectively). This relates to the higher levels of *ejido* land as well, with 22 percent of households in the historical region having *ejido* land as their primary property, compared with only 14 percent in all other regions. On the other hand, business ownership occurs at the same level across regions (22 percent vs. 23 percent in the historical vs. other regions), as does ownership of a variety of physical capital ("amenities") with the overall sample noting 7.5 of 11 classified possessions.

On social capital, 35 percent of surveyed households have a head with prior U.S. migration experience. However, this average is composed of a higher rate of migration in the historical regions with approximately 40 percent of household heads with prior US migration experience and only 20 percent of households in non-historical regions with experience.

Fewer spouses have made the journey – overall only 6 percent and virtually none within the non-historical regions (see footnote 2).

The various capitals represented by the household-level data are supplemented with information collected by the MMP at the community and municipal scales that reflect access to livelihood diversification options. For instance, prior work has shown that migration is associated with local economic conditions that are particularly indicative of opportunities for remunerated work for women (Kana'iaupuni, 2000; Riosmena, 2009). As such, we use female labor force participation rates and the proportion of the female labor force in manufacturing. We also measure the municipality's dependence on agriculture in terms of the proportion of males in the labor force devoted to these activities. Finally, we include the previous year's community-level migration prevalence to control for varying levels of community-level social capital, the strength of broader migrant networks (see Fussell and Massey, 2004; Lindstrom and López-Ramírez, 2010).

Lending credence to our disaggregation by regions characterized by different migration histories, 24 percent of individuals aged 15 and over in historical sending regions had been to the United States in 1980, compared with about 5 percent in less traditional sending communities. Further, communities located outside the historical regions have higher dependence on agriculture (male participate rate 59 percent vs. 47 percent). And although the regions have nearly identical rates of female labor force participation, non-historical sending regions have slightly higher levels of female labor participation in manufacturing specifically (23 percent vs. 20 percent).

METHODS

We first simply graph aggregated migration and precipitation trends across time, by state. Importantly, we present migration trends only after 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 U.S. We also present separate graphs for historical and non-historical migration-sending regions. Rainfall trends are calculated as the percentage of rain in the most recent year in comparison with maximum of the sample timeframe. Similarly, migration prevalence represents the number of adults reported in the MMP, retrospectively, as having left in each year and the trend line is formed by calculating the percentage of migration prevalence in the current year in comparison with the maximum within the overall sample timeframe.

As noted, the MMP is a repeated cross-sectional survey that includes retrospective questions. To undertake multivariate analyses, we use information from the retrospective questions to generate a pseudo-panel across a 3-year window for each household. We then estimate event history models predicting the probability of migration within a household during that 3-year period. We model migration at the household level because, in this context, such livelihood strategies represent household decision processes (e.g., Hondagneu-Sotelo, 1994). We use a three-year recall window to: 1) minimize potential memory biases (Auriat, 1991; Smith and Thomas, 2003); 2) increase representativeness by avoiding going too far back in time, when the experience of people emigrating is lost; and 3) maximize available covariates for modeling purposes as many of the community and household characteristics are measured only in the survey year (e.g., our household amenity index; as such, we assume they remained stable during the 3-year window). Static measurements such as these clearly limit our ability to use retrospective information too far back due to obvious temporal mismatch.

Our outcome of interest is a time-dependent event, which has a probability of occurrence derived from a censored distribution because the potential migration "window" ends at the point of data collection. As such, we employ discrete-time event survival analysis techniques and, following Allison (1982), fit a logistic regression model on a set of pseudo-observations, in this case household-years of exposure before the first household member's emigration (if one) during the 3-year window (see also Singer and Willett, 2003). To control for changing economic conditions, we use both state and year fixed effects. Finally, because data from each MMP community come from a random sample, pooling communities in any analysis implies the clustering of households within communities. We estimate robust standard errors accordingly.

Tables 2 and 3 present three models run separately for historical and other sending regions, respectively. For each region, we model the probability that a household member initiates a U.S. trip as a function of:

1. indicators of state-level rainfall at least one deviation below or above the 30-year average for the survey year, 1 year prior and 2 years prior,
2. indicators of state-level rainfall either one standard deviation below or two standard deviations below the 30-year average for the survey year, 1 year prior and 2 years prior. As compared to the measurement outlined in #1, distinguishing two standard deviations represents more severe drought or wet conditions;

3. interactions between household head prior international migration experience and the one and two standard deviation rainfall measures. These models test the relevance of migration-specific social capital as a facilitator of environmentally associated international migration (Massey *et al.*, 1990).[3]

All models include the comprehensive suite of community- and household-level control variables described before as well as state and year fixed effects.

RESULTS

First, Figures 1 and 2 present trend lines for sampled Mexican communities in regions with strong historical migration streams and those without. The figures hint at a negative association between rainfall patterns and emigration. For example, in historical regions (Figure 1), the relatively dry year of 1989 was associated with relatively high levels of outmigration from study communities although these increases could be due to other factors, such as family reunification in the aftermath of IRCA. Still, migration declined following increases in rain during the early 1990s, with a consistent decline after a peak rainfall year in 1994 despite the fact that Mexico then underwent one of its most severe economic crises in recent memory; Relative migration again increases during a period of low rainfall around the year 2000.

Historical Sending Regions

Table 2 presents results of the first set of discrete-time event history models focused on historical sending regions. Many of the standard migration predictors behave similarly across models. For example, human capital variables suggest households with more educated heads are less likely to send an international migrant, perhaps as they face more favorable local diversification opportunities. Spouse's education and household's business

[3]In addition, we estimated the models with interactions between household primary dependence on natural resource-based occupations and the measure of drought/wet at least one standard deviation below the long-term average. Due to data restrictions, this interaction cannot be estimated with consideration of separate measures of "severe" drought/wet conditions and, as such, we have included these as an Appendix.

TABLE 2
DISCRETE TIME LOGIT PREDICTING THE LIKELIHOOD OF HOUSEHOLD SENDING A MIGRANT IN HISTORICAL REGIONS

	(I) β (SE)	(II) β (SE)	(III) β (SE)
Community level capital			
Female Labor Force Participation in 1900 between 10 and 20%	−0.32+ (0.18)	−0.29+ (0.17)	−0.28 (0.17)
Female labor force participation in 1990 above 20%	−0.01 (0.25)	0.01 (0.23)	0.03 (0.22)
Female Labor force in manufacturing is over 50%	0.82*** (0.23)	0.69*** (0.21)	0.69*** (0.21)
Male labor force participation in Agriculture is over 50%	0.42*** (0.13)	0.40** (0.12)	0.40*** (0.12)
Household's human capital			
% of HH members in labor force	0.65*** (0.14)	0.64*** (0.14)	0.64*** (0.14)
HH Head is employed	−0.19 (0.13)	−0.18 (0.13)	−0.18 (0.13)
Life Cycle — young children only	1.25*** (0.19)	1.26*** (0.19)	1.26*** (0.19)
Life Cycle — young and teenage children	1.64*** (0.21)	1.65*** (0.21)	1.64*** (0.21)
Life Cycle teenage children only	0.65* (0.32)	0.63+ (0.32)	0.63+ (0.32)
Life Cycle — all children are adults	1.51*** (0.25)	1.53*** (0.25)	1.53*** (0.24)
HH head education	−0.06*** (0.01)	−0.06*** (0.01)	−0.06*** (0.01)
HH head age	−0.01* (0.00)	−0.01** (0.00)	−0.01** (0.00)
Spouses education	−0.05*** (0.01)	−0.05*** (0.01)	−0.05*** (0.01)
Spouses age	−0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)
% daughters in family	−0.61*** (0.17)	−0.62*** (0.17)	−0.63*** (0.17)
Household's financial and physical capital			
Primary land is community or Ejido	0.39** (0.14)	0.39** (0.14)	0.39** (0.14)
High Amenity HH	0.08 (0.14)	0.07 (0.14)	0.07 (0.14)
Percent of ammenitites HH has out of 11	1.05*** (0.28)	1.06*** (0.29)	1.07*** (0.29)
Number of types of livestock	0.12*** (0.03)	0.13*** (0.03)	0.13*** (0.03)
HH owns a business	−0.39*** (0.09)	−0.39*** (0.09)	−0.39*** (0.09)
HH Engages in farming	−0.16+ (0.09)	−0.17+ (0.09)	−0.17+ (0.10)
Household's migration-specific social capital			
HHH has been to US prior to 3--year survey period	0.47*** (0.09)	0.47*** (0.09)	0.54*** (0.10)
Total number of US trips made by HHH prior to 3--year survey period	0.16*** (0.02)	0.16*** (0.02)	0.16*** (0.02)
Spouse has been to US prior to 3--year survey period	0.30+ (0.18)	0.29 (0.18)	0.29 (0.18)
Migration Prevalence in Community (lagged 1 year)	0.02*** (0.00)	0.01** (0.00)	0.01*** (0.00)
State-level climatic variability (natural capital shifts)			
Current year = any drought	0.34* (0.14)		
Last year = any drought	0.56*** (0.13)		
Two years ago = any drought	0.20 (0.19)		
Current year = any wet	−0.30* (0.14)		
Last year = any wet	−0.29+ (0.17)		
Two years ago = any wet	−0.17 (0.23)		
Current year = drought		0.19 (0.18)	0.28 (0.18)
Current year = Severe drought		−2.88*** (0.81)	−2.72** (0.84)
Last year = drought		0.42* (0.20)	0.40+ (0.22)

TABLE 2 (CONTINUED)
DISCRETE TIME LOGIT PREDICTING THE LIKELIHOOD OF HOUSEHOLD SENDING A MIGRANT IN HISTORICAL REGIONS

	(I) β (SE)	(II) β (SE)	(III) β (SE)
Last year- = severe drought		−2.36** (0.73)	−2.28** (0.78)
Two years ago = drought		−0.08 (0.23)	−0.04 (0.23)
Two years ago = severe drought		2.73*** (0.55)	2.48*** (0.63)
Current year = wet		0.09 (0.18)	0.17 (0.20)
Current year = severe wet		−0.56** (0.19)	−0.63** (0.21)
Last year = wet		0.38 (0.28)	0.42 (0.30)
Last year = -severe wet		−0.56*** (0.13)	−0.69*** (0.15)
Two years ago = wet		0.37 (0.27)	0.40 (0.27)
Two years ago = -severe wet		−1.17*** (0.22)	−1.38*** (0.21)
HH head has been to US & drought year			−0.18 (0.12)
HH head has been to US & severe drought year			−11.44*** (1.31)
HH head has been to US & drought last year			0.00 (0.10)
HH head has been to US & severe drought last year			−11.28*** (1.36)
HH head has been to US & drought 2 years ago			−0.11 (0.09)
HH head has been to US & severe -drought 2 years ago			11.86*** (1.39)
HH head has been to US & wet year			−0.15 (0.14)
HH head has been to US & -severe wet year			0.13 (0.15)
HH head has been to US & wet last year			−0.06 (0.17)
HH head has been to US & severe wet last year			0.20 (0.16)
HH head has been to US & wet 2 years ago			
HH head has been to US & severe wet 2 years ago			0.45* (0.23)
Intercept	−3.77*** (0.85)	−3.75*** (0.79)	−3.83*** (0.79)
Observations	17,613	17,465	17,465

Notes: All regressions include state and year fixed effects. Standard errors are clustered at the community level.
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, +$p < 0.10$.

ownership are associated with lower emigration probabilities, again likely due to existing diversification strategies (Massey and Espinosa, 1997; Riosmena, 2009).

Ejido or communal land ownership is associated with a higher probability of migration (as posited by Valsecchi, 2010), suggesting migration may be a more important livelihood diversification strategy under these land tenure systems. Likewise, human and social capital gained by the household head through prior migration is indeed associated with a higher

TABLE 3

DISCRETE TIME LOGIT PREDICTING THE LIKELIHOOD OF HOUSEHOLD SENDING A MIGRANT IN NON-HISTORICAL REGIONS

	(I) β (SE)	(II) β (SE)	(III) β (SE)
Community level capital			
Female Labor Force Participation in 1900 between 10 -and 20%	0.40 (0.30)	0.40 (0.30)	0.40 (0.30)
Female Labor Force Participation in 1990 above 20%	−2.09*** (0.51)	−2.09*** (0.51)	−2.09*** (0.50)
Female Labor force in manufacturing is over 50%	−1.41** (0.49)	−1.41** (0.49)	−1.38** (0.51)
Male labor force participation in Agriculture is over 50%	−1.09*** (0.20)	−1.09*** (0.20)	−1.09*** (0.20)
Household's human capital			
% of HH members in labor force	0.35 (0.39)	0.35 (0.39)	0.33 (0.38)
HH Head is employed	−0.58* (0.24)	−0.58* (0.24)	−0.60* (0.24)
Life Cycle — young children only	2.11** (0.80)	2.11** (0.80)	2.13** (0.79)
Life Cycle — young and teenage children	2.55** (0.78)	2.55** (0.78)	2.56*** (0.77)
Life Cycle — teenage children only	1.47 (0.92)	1.47 (0.92)	1.50 (0.93)
Life Cycle -—all children are adults	1.70* (0.74)	1.70* (0.74)	1.71* (0.74)
HH head education	−0.06*** (0.02)	−0.06*** (0.02)	−0.06*** (0.02)
HH head age	−0.02** (0.01)	−0.02** (0.01)	−0.02** (0.01)
Spouses' education	−0.06* (0.03)	−0.06* (0.03)	−0.07* (0.03)
Spouses' age	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
% daughters in family	−0.62 (0.43)	−0.62 (0.43)	−0.62 (0.43)
Household's financial and physical capital			
Primary land is community or Ejido	0.29 (0.25)	0.29 (0.25)	0.28 (0.25)
High Amenity HH	0.30 (0.23)	0.30 (0.23)	0.32 (0.24)
Percent of ammenitites HH has out of 11	1.27* (0.60)	1.27* (0.60)	1.27* (0.61)
Number of types of livestock	−0.08 (0.11)	−0.08 (0.11)	−0.08 (0.11)
HH owns a business	−0.12 (0.18)	−0.12 (0.18)	−0.10 (0.18)
HH Engages in farming	0.08 (0.19)	0.08 (0.19)	0.09 (0.19)
Household's migration-specific social capital			
HHH has been to US prior to 3- year survey period	−0.94* (0.47)	−0.94* (0.47)	−0.89 (0.57)
Total number of US trips made by HHH prior to 3--year survey period	0.72** (0.24)	0.72** (0.24)	0.71** (0.25)
Spouse has been to US prior to 3--year survey period	0.75* (0.34)	0.75* (0.34)	0.77* (0.33)
Migration Prevalence in Community (lagged 1 year)	0.10*** (0.03)	0.10*** (0.03)	0.10*** (0.03)
State-level climatic variability (natural capital shifts)			
Current year = any drought	−3.38*** (0.22)		
Last year = any drought	−0.37+ (0.22)		
Two years ago = any drought	0.18 (0.47)		
Current year = any wet	0.24 (0.35)		
Last year = any wet	1.08** (0.35)		
Two years ago = any wet	0.63* (0.29)		
Current year = drought		−1.94*** (0.38)	−1.62*** (0.35)
Current year = Severe drought		−0.51*** (0.06)	−0.52*** (0.13)
Last year — drought		−0.49 (0.47)	−0.72+ (0.40)

TABLE 3 (CONTINUED)
DISCRETE TIME LOGIT PREDICTING THE LIKELIHOOD OF HOUSEHOLD SENDING A MIGRANT IN NON-HISTORICAL REGIONS

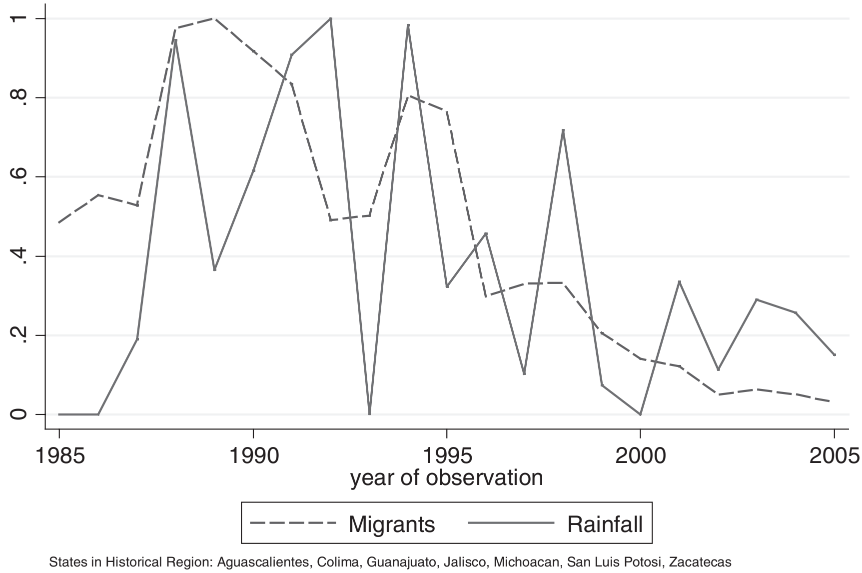
	(I) β (SE)	(II) β (SE)	(III) β (SE)
Last year — severe drought		−0.51*** (0.06)	−0.52*** (0.13)
Two years ago = drought		−1.84*** (0.55)	−1.86*** (0.46)
Two years ago = severe drought		0.41 (0.36)	0.10 (0.35)
Current year = wet		−1.04*** (0.26)	−1.11*** (0.22)
Current year = severe wet		0.24 (0.35)	0.27 (0.33)
Last year = wet			
Last year = -severe wet		−0.20 (0.27)	−0.24 (0.22)
Two years ago = wet			
Two years ago = -severe wet		−0.91 (0.64)	−0.86 (0.66)
HH head has been to US & drought year			−0.56 (0.34)
HH head has been to US & -severe drought year			0.04 (0.32)
HH head has been to US & drought last year			0.05 (0.29)
HH head has been to US & severe drought last year			0.61* (0.26)
HH head has been to US & drought 2 years ago			−0.61 (0.42)
HH head has been to US & severe drought 2 years ago			0.51 (0.39)
HH head has been to US & wet year			−0.24 (0.21)
HH head has been to US & -severe wet year			−0.12 (0.40)
HH head has been to US & wet last year			
HH head has been to US & severe wet last year			−0.42+ (0.24)
HH head has been to US & wet 2 years ago			
HH head has been to US & severe wet 2 years ago			0.16 (0.31)
Intercept			
Observations	6,073	6,073	6,073

Notes: All regressions include state and year fixed effects. Standard errors are clustered at the community level.
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, +$p < 0.10$.

likelihood of emigration. Additionally, a higher index of household amenities is associated with a higher likelihood of international migration. This association may be from higher income households being able to afford migration or from the fact that previous migration trips have facilitated savings and amenities for the household.

Our key analytical focus is the inclusion of rainfall variability yields findings mostly in line with the "environmental scarcity" hypothesis while suggesting intriguing differences according to the degree of rainfall variability. In Model I of Table 2, drought during the household-year under analysis (defined as >1 SD below the long-term precipitation mean) is

Figure I. Proportional Migrant and Rainfall Trends in Historical Regions

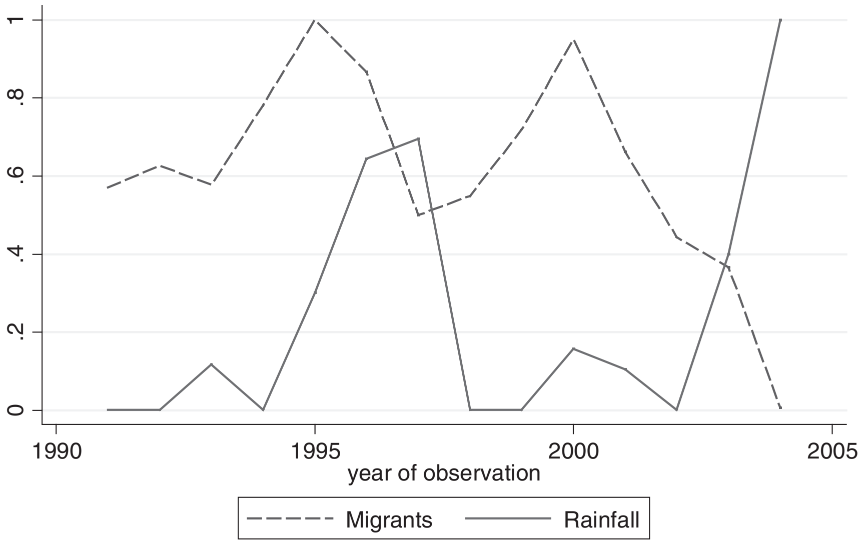


associated with $100 \cdot [\exp\{0.34\} - 1] = 40\%$ higher odds of U.S. emigration among historical region households. Further, a drought in the year prior is associated with $100 \cdot [\exp\{0.56\} - 1] = 75$ percent higher odds of U.S. migration. On the other hand, a current wet year is associated with 35 percent lower odds of international migration. A high rainfall year during the year prior to survey also exhibits a negative impact on the likelihood of emigration out of household located in the historical region.

Yet, disaggregating the rainfall measures into indicators of "severe" drought or wetness – at least 2 SD above/below long-term mean – sheds light on the important effect of more extreme conditions. Indeed, it is these more extreme conditions that appear to primarily drive the rainfall effects. Although a lesser drought in the year prior to survey retains the positive "push" for emigration, the more severe drought measures in the year of the survey, and the prior year, exhibit dampening effects on emigration probabilities. In other words, households in regions with recent severe rainfall shortages are less likely to have sent a migrant to the U.S. Yet, with the severe drought in the more distant past – 2 years ago – the "push" of rainfall deficit is again exhibited through a positive coefficient.

As to rainfall excess, none of the measures reflecting rainfall 1 SD above the long-term mean achieve statistical significance. On the other

Figure II. **Proportional Migrant and Rainfall Trends in Non-Historical Regions**



States in Non-Historical Region: Chihuahua, Guerrero, Oaxaca, Puebla and Veracruz

hand, all three measures for "severe" wetness exhibit an association with emigration – in each case, the survey year, prior year, and 2 years prior, all lessen the likelihood of emigration. The largest such effect is exhibited by households experiencing a particularly wet year 2 years prior to the survey, reducing the odds of emigration by 69 percent.

The interactions in Table 2, Model III, allow for examination of differential rainfall effects on households according to the household head's prior migration experience. Again, we find statistically significant associations only with the measures of severe conditions, notably rainfall deficit. In households where the head has prior migration experience, the effect of severe drought in the survey year and year prior is strongly negative – a lessening of the likelihood of emigration. Yet, a severe drought 2 years prior acts as an emigration "push."

Non-Historical Sending Regions

Substantially different associations emerge, however, for less traditional sending areas as shown in Table 3. Within these regions, drought in the current/prior year is associated with a *decrease* in the likelihood of

U.S.-bound migration. Specifically, drought in the concurrent year reduced the odds of U.S.-bound emigration by a substantial 97 percent. A drought the year prior was associated with a more modest reduction of 31 percent in international migration odds. The opposite emerges for wet years in which a year with rainfall in excess of 1 SD above the long-term mean is associated with increased odds of U.S.-bound migration, while a wet year 2 years prior also enhances emigration's potential.

Again, disaggregating "severe" rainfall variation adds nuance, shifting the story predominantly for households experiencing rainfall excess. In Table 3, Model II, drought measures (both 1 and 2 SD) continue to exhibit negative associations with emigration – suggesting scarcity dampens migration. Yet, a relatively wet year during the survey year also dampens emigration, while the lagged and extreme measures of excess rainfall do not achieve statistical significance.

On the interactions between rainfall variables and household head's prior migration experience (Table 3, Model III), we find only one statistically significant association – a drought last year increases the likelihood of emigration but to virtually the same extent as the main effect suggests a reduction. As such, the negative effect of drought on households in general does not occur within households with prior head emigration experience. That said, the negative effect associated with rainfall excess does, indeed, occur for household with prior head emigration experience.

DISCUSSION AND CONCLUSIONS

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, Nepal, and Burkina Faso on internal movement (e.g., Findley, 1994; Meze-Hausken, 2000; Henry, Schoumaker, and Beauchemin, 2004), the results presented here reveal intriguing associations between rainfall patterns and U.S.-bound migration from rural Mexican households. Specifically, the results yield four key narratives. First, although droughts may increase the overall (medium-run) likelihood of U.S.-bound migration in households in the historical region, migration may not be a likely *immediate* response to drought but rather one requiring some time for households to mobilize financial and social capital. Severe drought seems to constrain migration in the very short run (i.e., the same year the drought occurs), perhaps acting as a livelihood shock. However, *roughly* 2 years after severe rainfall deficits take place, emigration probabilities rise considerably. While 2 years could seem like a long lag to link drought and migration, we lack information on the exact timing of migration during a year; as such, it is possible that migration takes place early enough in the second calendar year after a bad harvest (for maize, for instance, taking place well into the Fall; see Smeal and Zhang, 1994) that the lag could represent a difference of slightly more than one full harvest season.

Second, in the historical region, excess rainfall appears to keep migrants home. This suggests that years of greater potential for productivity require less livelihood migration – more natural capital negating the need to tap into social capital. Altogether, these results suggest households are particularly prone to tap into migrant networks – social capital – in the face of declining natural capital due to rainfall shortage and in line with a long tradition of work demonstrating the ways in which social capital decreases the costs associated with international migration (Massey and Riosmena, 2010), particularly from rural areas (Fussell and Massey, 2004).

Third, in non-historical regions, which lack stronger migrant networks, rainfall deficits may actually constrain emigration more generally and not only in the very short term as in the historical region. In these places, emigration may entail greater costs and risks due to lower existing social capital associated with migrant networks. In this case, rainfall shortages may lessen livelihood security and options, thereby reducing the potential for an additional risky household investment in international migration. However, as households outside of the historical region where the head has U.S. migration experience prior to the retrospective window do not experience the negative effects of drought on migration, individual experience and migration-specific familial social capital do seem to enable movement by loosening the type of constraints that keep people in place during a drought.

Lastly, and also consistent with the idea that lower crop yields and crop failure may constrain the migration of households in non-historical regions, we find that rainfall excess actually spurs migration. This association aligns with that of the "environmental capital" hypothesis as illustrated, for example, in rural Ecuador, where (productive) land provides capital that can facilitate migration (Gray, 2010). In rural Mexico, this association appears particularly strong in regions lacking existing social networks, perhaps as particularly good rainfall (and thus, crop yields) ease budget constraints that do not allow individuals living in places with less established migrant networks to otherwise emigrate.

Although our estimates of the effect of rainfall controlling for the community prevalence ratio should be net of differences across communities in the size of migrant networks (and, in theory, of network size between regions), note that we still find large differences in both emigration probabilities and the effect of networks on migration between the historical and other regions in an all-region "global" model (results not shown but available upon request). In this sense, the prevalence ratio, generally regarded as a measure of broader migrant networks available to people in a community, may not necessarily measure all long-term U.S.-bound movement due to differences in attrition prior to the survey date (e.g., due to the combined effects of mortality and more permanent internal and international outmigration) between people with and without prior U.S. experience (see Massey, Goldring, and Durand, 1994: 1507–1508). In addition, the actual effectiveness of networks (e.g., the social capital carried in them) could vary systematically between regions. Part of this effectiveness during times of environmental stress in particular could be related to spatial heterogeneity in the livelihood and adaptation strategy portfolio available to households. As our research only included indicators of *current* physical and financial capital (and not of past or potential entitlements), future research should consider if broader measures of adaptive capacity may explain inter-regional/spatial differences in the association between climatic variability and migration.

Current climate models for Latin America project mean warming from 1 to 6°C and a net increase in persons experiencing water stress (IPCC, 2007). Specific to Mexico's most valuable agricultural export, coffee, Gay *et al.* (2006) project climate change may yield a 34 percent reduction in production in Veracruz, potentially making coffee no longer an economically viable livelihood strategy (see also Nevins, 2007). Clearly, environmental change holds important potential to impact rural Mexicans' livelihood strategies (Conde, Ferrer, and Orozco, 2006; Endfield, 2007), including U.S. migration (e.g., Feng, Kruger, and Oppenheimer, 2010). Even so, the results of our study also warn against interpretations of the potential rise of climate-induced, U.S.-bound migration that do not consider not only the availability of other livelihood and adaptation strategies, but also differences in the buildup of migration-specific social capital. For instance, coffee production is mostly concentrated in Southeastern Mexico (Nevins, 2007), which is not a region with a long history of migration (though it is indeed growing in tradition; see Rosas, 2008). As such, the aforementioned reductions in yield may or may not increase U.S. migration substantially, but could in fact be associated with a net reduction in international migrants.

While we do not claim that the future will look like the past reflected in our analyses, we do argue that the future development of the association between climate change (in terms of climate variability) and migration will likely be *highly* contingent on the development of migrant networks along with labor demand in different sectors in the United States, which help shape the amounts and forms of social capital carried by network nodes and distributed over networks. As such, the evolution of migration trends will likely be instrumental in shaping whether people use U.S. migration as an adaptation strategy in response to economic and social vulnerability driven by climate stress, and how these associations may vary across the Mexican territory in the future. As such, estimates of future ("climate-induced") migrants should explicitly allow for the buildup of migrant networks (for instance, see Massey and Zenteno, 1999), while understanding how standard network measures such as the prevalence ratio may have different meanings across places (e.g., Fussell and Massey, 2004).

Research should also aim to understand whether migration associated with climate variability is more likely to be used as a *temporary* adaptation strategy as compared with migration stemming from other motivations. This knowledge has different implications regarding life and development in sending areas and thus for agricultural and social policy. Further, it can hold different implications in terms of immigration and agrarian policy in destinations. Yet, to get at this nuance requires more precise research approaches.

On future research, to disentangle distinctions between climate-related and other migration, information on motivations is required as well as detailed migration histories (i.e., dates, destinations, return intentions). These data may best be collected through qualitative approaches such as in-depth interviews or ethnographies within migrant-sending communities. Indeed, data collection in origin communities would aid in understanding migration's implications for those left behind. Further, both quantitative and qualitative data revealing the gender dimensions of environmentally related migration would allow insight as to the potential for environmental change to differentially shape the migration of men and women. Finally, a comparison of destination choices (e.g., internal and international migration) would shed light on particular household livelihood strategies. On the environmental dimension, integration of additional aspects of environmental change and vulnerability including potential for disaster impacts and the influence of temperature fluctuations and shifts in vegetation coverage would represent logical extensions.

Regardless, the work presented here offers important insight on an important and real factor influencing migration decisions, environmental factors of particular relevance to resource-dependent rural communities. We argue such factors are too often ignored in demographic scholarship. Indeed, the public and policy realms are paying increasing attention to the potential for environmental change to alter patterns of human migration, and academic research along these lines is increasingly emerging (see Adamo and Izazola, 2010). With regard to Mexico, the barrage of political pressure in the U.S. to deal with immigration might benefit from shifting focus to origin areas where social, political, economic, and environmental pressures converge to shape household decision-making. In rural regions with well-established U.S. migrant networks, the present study suggests drought may enhance the likelihood of households tapping into migration's livelihood potential. The work also suggests important constraints to migration as a coping strategy in the face of environmental pressures may be felt by households lacking migration-related social networks. Certainly, such evidence suggests the environmental dimensions of livelihood strategies, including emigration, deserve additional, focused research attention.

APPENDIX

TABLE A1
PERCENTAGE AND STANDARD DEVIATIONS OF CLIMATE COVARIATES

	Entire Sample		Historical Region		Non—Historical Region	
Variable	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
Warm Humid	48.54	0.500	39.79	0.490	70.11	0.458
Mild Humid	2.27	0.149	0.00	0.000	9.04	0.287
Mild Dry	49.19	0.500	60.21	0.489	20.85	0.406

States in Sample in Historical Region

	Observations	% sample
Aguascalientes	650	3.69
Colima	1027	5.38
Guanajuato	4181	23.74
Jalisco	3613	20.51
Michoacan	2369	13.45
San Luis Potosi	3176	18.03
Zacatecas	2597	14.74

TABLE A2
REGRESSIONS OF PRIMARY DEPENDENCY INTERACTIONS FOR HISTORICAL & NON-HISTORICAL REGIONS

	Historical Regions		Non-Historical Regions	
	(I) β (SE)	(II) β (SE)	(I) β (SE)	(II) β (SE)
Community level capital				
Female Labor Force Participation in 1900 between 10 and 20%	−0.37+ (0.19)	−0.38* (0.19)	0.42 (0.31)	0.44 (0.31)
Female Labor Force Participation in 1990 above 20%	−0.09 (0.25)	−0.09 (0.24)	−2.06*** (0.49)	−2.14*** (0.49)
Female Labor force in manufacturing is over 50%	0.82*** (0.24)	0.83*** (0.24)	−1.44** (0.48)	−1.32** (0.50)
Male labor force participation in Agriculture is over 50%	0.38** (0.13)	0.37** (0.13)	−1.05*** (0.18)	−1.16*** (0.15)
Household's human capital				
% of HH members in labor force	0.64*** (0.14)	0.64*** (0.14)	0.32 (0.39)	0.33 (0.39)
HH Head is employed	−0.18 (0.13)	−0.18 (0.13)	−0.55* (0.24)	−0.56* (0.24)
Life Cycle — young children only	1.30*** (0.20)	1.29*** (0.20)	2.10** (0.79)	2.12** (0.81)
Life Cycle — young and teenage children	1.68*** (0.21)	1.68*** (0.21)	2.54*** (0.76)	2.57** (0.78)
Life Cycle — teenage children only	0.74* (0.30)	0.74* (0.30)	1.46 (0.91)	1.48 (0.93)
Life Cycle — all children are adults	1.52*** (0.24)	1.52*** (0.24)	1.67* (0.74)	1.71* (0.75)
HH head education	−0.06*** (0.01)	−0.06*** (0.01)	−0.07*** (0.02)	−0.06*** (0.02)
HH head age	−0.01* (0.00)	−0.01* (0.00)	−0.02** (0.01)	−0.02** (0.01)

TABLE A2 (CONTINUED)
REGRESSIONS OF PRIMARY DEPENDENCY INTERACTIONS FOR HISTORICAL & NON-HISTORICAL REGIONS

	Historical Regions		Non-Historical Regions	
	(I) β (SE)	(II) β (SE)	(I) β (SE)	(II) β (SE)
Spouses education	−0.06*** (0.01)	−0.06*** (0.01)	−0.07* (0.03)	−0.07* (0.03)
Spouses age	−0.00 (0.00)	−0.00 (0.00)	0.01 (0.00)	0.00 (0.00)
% daughters in family	−0.62*** (0.18)	−0.63*** (0.18)	−0.63 (0.43)	−0.65 (0.43)
Household’s financial and physical capital				
Primary land is community or Ejido	0.38** (0.12)	0.37** (0.12)	0.34 (0.22)	0.32 (0.23)
High Amenity HH	0.09 (0.14)	0.09 (0.14)	0.33 (0.23)	0.32 (0.23)
Percent of ammenitites HH has out of 11	1.01*** (0.28)	1.01*** (0.28)	1.13^{+} (0.63)	1.14^{+} (0.64)
HH owns a business	−0.38*** (0.09)	−0.38*** (0.09)	−0.14 (0.18)	−0.14 (0.17)
HHH works in agriculture, HH owns Livestock or HH engages in farming	0.07 (0.10)	0.22^{+} (0.13)	−0.15 (0.15)	-0.44^{+} (0.25)
Household’s migration-specific social capital				
HHH has been to US prior to 3--year survey period	0.45*** (0.08)	0.45*** (0.08)	-0.88^{+} (0.49)	-0.86^{+} (0.50)
Total number of US trips made by HHH prior to 3--year survey period	0.16*** (0.02)	0.16*** (0.02)	0.70** (0.25)	0.71** (0.24)
Spouse has been to US prior to 3--year survey period	0.29 (0.18)	0.29 (0.18)	0.70* (0.33)	0.68* (0.34)
Migration Prevalence in Community (lagged 1 year)	0.02*** (0.00)	0.02*** (0.00)	0.10*** (0.03)	0.10*** (0.03)
Migration Prevalence in Community (lagged 1 year)				

TABLE A2 (CONTINUED)
REGRESSIONS OF PRIMARY DEPENDENCY INTERACTIONS FOR HISTORICAL & NON-HISTORICAL REGIONS

	Historical Regions		Non-Historical Regions	
	(I) β (SE)	(II) β (SE)	(I) β (SE)	(II) β (SE)
Current year = any drought	0.37* (0.14)	0.50** (0.15)	−3.21*** (0.21)	−3.20*** (0.26)
Last year = Any drought	0.57*** (0.13)	0.64*** (0.15)	−0.43⁺ (0.22)	−0.36⁺ (0.21)
Two years ago = Any drought	0.20 (0.19)	0.21 (0.20)	0.24 (0.47)	−0.06 (0.45)
Current year = wet year	−0.29⁺ (0.15)	−0.22 (0.15)	0.26 (0.35)	−0.06 (0.45)
Last year = wet year	−0.29 (0.18)	−0.32⁺ (0.19)	1.09** (0.35)	0.75 (0.48)
Two years ago = wet year	−0.16 (0.23)	−0.11 (0.23)	0.64* (0.29)	0.63 (0.39)
HH has primary dependency & drought year		−0.22⁺ (0.13)		−0.00 (0.29)
HH has primary dependency & drought last year		−0.13 (0.10)		−0.11 (0.13)
HH has primary dependency & drought 2 years ago		−0.01 (0.14)		0.36 (0.31)
HH has primary dependency & wet year		−0.13 (0.11)		0.39 (0.37)
HH has primary dependency & wet last year		0.06 (0.13)		0.42 (0.33)
HH has primary dependency & wet 2 years ago		−0.11 (0.13)		0.03 (0.42)
Intercept	−3.71*** (0.85)	−3.73*** (0.85)	−5.05*** (1.30)	−4.70*** (1.30)
Observations	17,811	17,811	6,097	6,079

Notes: All regressions include state and year fixed effects. Standard errors are clustered at the community level.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $+p < 0.10$.

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