RECONCEPTUALIZING ENVIRONMENTAL MIGRATION: EMPIRICAL FINDINGS FROM DOWNSCALED ESTIMATES OF DROUGHT IN RURAL MEXICO

by

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Reconceptualizing Environmental Migration: Empirical Findings from Downscaled Estimates of Drought in Rural Mexico

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In recent years, the relationship between environmental change and migration has become a timely and popular topic of academic inquiry. However, empirical studies concerned with environment-migration dynamics have consistently demonstrated empirical limitations stemming from coarse scales of analysis, as well as theoretical ones stemming from reductive framings of migration as problematic or undesirable. This study contributes to ongoing research specifically relating drought to patterns of migration from rural Mexico by addressing these issues of scale and conceptual framing. First, it refines the scale at which drought estimates are extrapolated and presumed to be representative of local experience. Second, it critically engages with conventional framings of vulnerability and adaptive capacity, acknowledging the critical social and historical role migration has played throughout Mexican history. Using discrete time hazard analysis, this study identifies a complex relationship between drought and migration. Importantly, it finds that while severe drought seems to encourage migration, increasing intensity and frequency are associated with a decreased likelihood of migration at the household level. These results suggest that drought can actually act to constrain livelihood diversification opportunities, rather than automatically impel population movement, and contribute a significantly greater level of nuance to studies focused on the environmental dynamics of migration.

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CHAPTER 1

FRAMING THE ISSUE

INTRODUCTION

Though Mexican migration has slowed considerably since 2005 (Passel, Cohn, & Gonzalez-Barrera 2012), immigration remains a highly politicized and contested topic of debate. Concern over patterns of Mexican migration to the United States is consistent with a growing political preoccupation with security as well as, in more recent years, potential consequences of anthropogenic climate change (Black et al., 2011). In this context, the relationship between environmental change and migration has become a timely and popular topic of academic inquiry (Faist and Schade, 2013). However, due to its increasingly politicized ramifications, environment-migration scholarship should now be particularly critical of the assumptions underlying many popular framings of migration processes. Conceptions of social vulnerabilities, adaptive capacities, and migration motivations more generally merit careful reflection, particularly as they relate to biophysical, seemingly unhuman, processes of change. Geographers and other social scientists and scholars must take care not to slip into environmentally deterministic frameworks of inquiry.

That being said, exploration into the environmental dynamics of rural livelihoods and Mexico-US migration is important for a number of reasons. First and foremost, numerous studies have identified the enduring centrality of agriculture for many rural Mexican households despite a growing engagement in non-farm employments (Wiggins et al. 2002, Munshi 2003). As the vast majority of these households continue to rely on rain-fed cultivation (approximately 75% in 2008), crop yields are highly responsive to variations rainfall regimes (Eakin 2005; Leiva and

Skees, 2008). Simultaneously, economic restructuring has, since the 1980s, dramatically reduced public investment in the agricultural sector while also exposing farmers to terms of trade (Saldaña-Zorrilla and Sandberg 2009). As a result, the viability of smallholder farming has steadily declined over the last two decades, affecting both the incentives and capacities for households to engage in international migration (Eakin 2005).

This study explores potential links between patterns of drought and migration from rural Mexico to the United States. In doing so, it contributes both empirical findings and critical theoretical reflection to a growing body of literature concerned with what has loosely been termed "environmental migration." While environmental factors have undoubtedly shaped both livelihoods and patterns of human mobility throughout history, forecasts of global climate change have reignited concern over the environment as a central determinant of human wellbeing (McLeman and Smit, 2006; Hulme, 2011). Such forecasts have also fueled policy concerns over issues of security and conflict resulting from mass migrations or direct displacement (Schwartz and Randall 2003; Reuveny, 2007, UN Security Council, 2011). Perhaps in response to this call from policymakers to better understand the potentially destabilizing effects of climate change on global governance, much of the environmental migration research to date has taken as foundational the assumption that extreme weather events directly cause people to move (Tacoli, 2009; Obokata et al., 2014). As a result, this body of literature is characterized by studies identifying environmental push factors, predicting future population flows, or locating hot spots of risk (Faist and Schade, 2013).

This study stands with a small but growing number of empirical studies that intentionally complicate conventional framings of environmental migration. Indeed, predictions of global climate change almost universally predict an increase in the prevalence of extreme weather

events, ranging from natural disasters such as flooding, to slow-onset processes like drought (IPCC 2007, 2014, Trenberth, 2011). However, in most cases, the consequences of such climatic shifts for migration decisions are unlikely to manifest in the wholesale displacement of populations (De Hann, Brock, and Coulibaly, 2002). This should be especially obvious in light of the relative risk and expense involved in international movement, which puts it out of reach to the poorest of the poor (Massey, Goldring, and Durand, 1994; Castles, 2002; Black et al., 2011). Rather, migratory responses to environmental change will likely demonstrate particular configurations of other social, political, historical, and economic factors acting simultaneously and on different scales (Gray and Mueller, 2012, Obokata et al., 2014). This study thus seeks to reexamine the environment-migration relationship in a highly contextualized manner, with special consideration for both spatial and social variation. It also employs a new method for relating drought estimates to household experience at a more granular scale than previous studies.

The interplay of various historical, social, and economic forces in shaping migration patterns is especially evident in the spatial characteristics of Mexican migration to the United States. For example, the existence of established migrant networks has historically facilitated migration from particular regions, namely, from the west central parts of the country (Fussell and Massey, 2004; Massey, 2011; Massey et al., 2010). Because such network ties effectively decrease the cost of migration and establish the process as somewhat of a cultural norm, they likely increase the feasibility of migration as an adaptive strategy to cope with drought (Massey, Goldring, and Durand, 1994). Thus, if drought acts as an environmental push factor, we might still expect to see spatial variations in the timing and likelihood of migration between regions with strong network and cultural ties and those without. Similarly, if drought in fact constrains a

household's ability to send a migrant, as Hunter, Murray, and Riosmena (2013) as well as Gray and Mueller (2010) discuss, we might expect even greater migration declines in non-traditional sending areas where the cost is unmitigated by the presence of strong network ties.

Of course, the complexity of environment-migration dynamics in Mexico extends beyond regional differentiation, as localized experiences of social and economic factors shape household-level livelihood strategies and constraints. Accurately quantifying these factors, however, relies on rigorous theoretical reflection. For example, as Watts (1983) argued decades ago, oft-employed indicators of rural development are, in many cases, inept for understanding vulnerability or adaptive capacity in the face of environmental change. The process of separating biophysical crises from the social systems that produce differential vulnerability is, in and of itself, overly reductive.

In this light, and in following Liverman (1990) and Eakin's (2005) work in Mexico in particular, this study critically explores the interplay of drought and conventional indicators of development and vulnerability in shaping livelihood options. For example, market integration and access to modernized agricultural methods, such as mechanization and fertilizers or pesticides, are not necessarily expected to increase a household's adaptive capacity. In fact, as Eakin (2005) demonstrates, reliance on commercialized agricultural markets, year-round production, and capital-intensive agricultural inputs may actually increase the challenges posed by drought. To more accurately evaluate varying experiences of vulnerability and adaptive capacity, I thus pay particular attention to the level at which households engage in different forms of agriculture in combination with other livelihood strategies.

Finally, this study addresses the challenge of estimating local experiences of environmental change. As McLeman (2013) notes, reliable environmental data is often hard to

come by at the scales necessary to accurately connect environmental change with local experience, which is likely why so many empirical accounts of environmental influences on migration rely on state-level data. This study attempts to overcome that gap by including a new measure of drought, interpolated at a localized level. By interpolating drought spatially, rather than relying on the state-aggregated measures used in all prior work on "environmental migration" from Mexico (Munshi, 2003; Feng et al., 2010; Nawrotzki et al., 2012; Hunter et al., 2013), I aim to both increase the accuracy of empirical accounts of environmental migration as well as bring attention to the importance of scalar considerations with the field more broadly.

In sum, this study analyzes potential links between drought and migration by modeling mobility as a function of intersecting social, historical, and environmental factors. To model this relationship, I use demographic data collected from more than 5,000 households in 39 communities throughout Mexico along with estimates of drought interpolated at the local-level rather than the state scale. Multivariate discrete time hazard analysis then identifies relationships between a suite of livelihoods indicators and varying experiences of drought. Results from this study invite interesting comparisons with similar work in the region. Specifically, in refining the scale of drought estimates, a nonlinear relationship between drought intensity and migration emerges. While severe drought appears to encourage household migration, extreme drought exhibits a constraining effect, as does the recurrence of less severe drought.

The findings in this study add significant nuance to previous understandings of drought-related Mexico-US migration. They also contribute to an important theoretical discussion related to common framings of both migration and climate change. Given the long-acknowledged challenges of international migration, this study reflects on the consistent preoccupation within the literature on climate-*induced* migration rather than, for example, climate-*constrained*

mobility. In turn, it considers the ways in which popular approaches to climate-migration research have served to reproduce normative assumptions about both the process of migration itself as well as the political economic conditions that surround it.

THEORETICAL FRAMINGS

This study draws from a synthesis of theoretical framings. Namely, it incorporates critical conceptions of social vulnerability into a sustainable livelihoods framework that also draws heavily from classical migration theories. The logic behind this approach stems first from the need within environmental migration scholarship to further explore the socio-political dynamics of vulnerability, particularly, in the case of Mexico, as they relate to policies of economic liberalization and changes in agricultural systems. Critical conceptions of vulnerability can then allow for a more dynamic understanding of rural livelihoods and the ways in which certain household characteristics might constrain or enable livelihood diversification in situations of environmental stress. Finally, following Hunter et al. (2013), this study draws from a suggestion posited in 2011 by Black et al. to "step back" and reposition environmental drivers within theories of migration. Exploring environmental factors alongside processes such as cumulative causation and risk diversification, long-theorized within migration literature, creates a framework capable of incorporating multiple and simultaneous drivers of migration. The following is a brief introduction to these three framings and the ways in which they intersect to inform this study.

Vulnerability

Early studies of climate change impacts often viewed vulnerability as simply the result of either unfortunate geography or poor resource management (for example, Ehrlich, 1968; Myers, 1993,

2002). Such studies often concerned themselves with identifying environmental "push" factors, quantifying future population flows, and locating hot spots of risk. Often, as Perch-Nielson et al. (2006) note, much of this early research was limited to "common sense" postulations rather than empirical demonstration. Dramatic, broad-sweeping, conclusions regarding the role of environmental factors in inducing migration or producing displacement often resulted (Pigeut 2010; Glibert & McLeman, 2010). While such findings have since proved inaccurate, their influence on public debate and policy endures (Faist & Schade, 2013).

The most notable of such studies is probably Myers's (2002) prediction that environmental change could lead to the displacement of 200 million individuals by the year 2050. The result of this forecast, which essentially layered estimates of population growth on top of estimates of sea level rise, drought, and agricultural yield "plateaus" (Myers, 2002: 611) was, as Hartman (2010) notes, the naturalization of inequality in scientific terms. While most frequently cited in academic circles to exemplify the perils of reductive methodologies, the study has experienced enduring influence within popular media (see, for example, Zelman, 2011) and thus demonstrates the importance of more reflective conceptions of vulnerability (Hulme, 2010; Faist & Schade, 2013).

Of course, many scholars have acknowledged the centrality of social relations of power in the production of vulnerability (Liverman, 1990, 1999; O'Brien et al., 2004; Adger 2006). In the context of environmental change, research emphasizing the social aspects of vulnerability often refers to the "double exposure" of certain populations to both biophysical stresses along with social and political marginalization (O'Brien et al., 2004). One of the main contributions of this framework has been its emphasis on the often contradictory consequences of development, particularly in the form of economic liberalization and technological advancement.

In her early work examining vulnerability in the context of climate change in Mexico, for example, Liverman (1990) offers a typology of vulnerabilities that includes not only environmental factors but demographic, land tenure, and technological conditions as well. Here, she points to the potential for a growing dependence on seeds, fertilizers, and other inputs associated with intensive agriculture to actually exacerbate vulnerability to environmental fluctuations. Recent scholarship regarding migration and the environment in Mexico has likewise expanded notions of vulnerability to include trade-related hazards associated with NAFTA. Such studies place particular emphasis on vulnerabilities resulting from changes such as declining terms of trade, privatization and land tenure reform, as well as differential access to credit (Eakin, 2005; Saldaña-Zorrilla and Sandberg, 2008). To the greatest extent possible, these political-economic indicators of social vulnerability inform the empirical framework of this study and serve to complicate conventional measures of adaptive capacity.

Sustainable Livelihoods

Given the ways in which scholars have refined conceptions of vulnerability, perhaps one of the greatest enduring limitations to the framework is that, in its application, migration is often assumed to represent a last resort (Faist & Schade, 2013). Such studies also often fail to account for the myriad activities, beyond agriculture, that constitute rural livelihoods (Bebbington, 1999). In other words, while vulnerability studies are useful in elucidating many of the political-economic determinants of inequality or environmental burden, they often underrepresent the social and historical dynamics of migration in which mobility is a norm. Thus, they might often overestimate the propensity for environmental events, such as drought, change or introduce

patterns of migration. To account for the importance of migration as a *strategy*, rather than a last resort, this study employs the Sustainable Livelihoods Framework.

The Sustainable Livelihoods Framework considers explicitly the multiple and simultaneous ways in which rural households might compose their livelihoods. It thus takes into account a variety of assets, including produced, human, natural, social, and cultural, which together provide for a range of household capabilities (Bebbington, 1999). The advantages of using this framing to explore potential links between drought and migration in Mexico are twofold. First, rather than assuming migration to be undesirable, it situates the process within a range of livelihood strategies that households are likely to undertake at the same time. In representing migration as a valuable strategy for livelihood diversification, the Sustainable Livelihoods Framework has helped to reorient the process as part of the norm rather than the exception. Second, owing much to the New Economics of Labor Migration school of thought, it uses the household as the central unit of study (Faist & Schade, 2013). By focusing on the household scale, the framework serves to bridge opposing portrayals of agency as either structurally bound or actor-centered (Bebbington, 1999).

Reintegrating Migration Theory

The uncertainties within climate change estimates combined with the complexities of migration indeed make exploring potential interactions between the two a formidable challenge (Black et al., 2011). As research from Sustainable Livelihoods studies has shown (Bebbington, 1990; Eakin, 2005; Gray, 2010; Gray and Mueller 2010), migration often represents an important choice rather than inevitability. Negative effects of extreme weather events, such as drought, may thus manifest in reduced mobility rather than induced migration, particularly for the most

vulnerable populations. As such, this study follows the suggestion made by Black et al. (2011), and implemented by Hunter et al. (2013) to integrate understandings of human-environment interactions with "existing acknowledged drivers and intervening factors affecting migration" (Black et al., 2011: 436). The value in this approach, the authors argue, is in reintroducing the theoretical perspectives capable of explaining the often contradictory empirical findings of climate-migration studies.

Drawing heavily from Massey et al.'s review of migration theories (1994), Black et al. thus anchor their analyses of migration in Ghana and Bangladesh in terms of social networks, family ties, differential income opportunities, direct displacement, and political marginalization. Importantly, the authors note, these drivers exist and interact different between study sites and will likely demonstrate different sensitivities to environmental change. Environmental change is thus incorporated into the framework as both a direct influence (by affecting land productivity and habitability) as well as an indirect influence (by affecting all other social, political, demographic, and economic conditions, such as employment opportunities.) Though Black et al. acknowledge the utility of this approach as mainly a heuristic device, rather than empirical tool, this study takes it into consideration when selecting covariates indicative of cumulative migration processes and potential risk diversification strategies.

PAST EMPIRICAL WORK

Recent years have witnessed a surge in empirical migration scholarship aimed explicitly at identifying environmental influences. However, sustainable livelihoods and conventional migration scholarship and have long considered environmental factors as indirect influences on the use or availability of certain types of household-level assets, which in turn affect household

migration decisions (Bilsborrow, 1992; McLeman & Smit, 2006; McLeman and Hunter 2010). The following presents a brief overview of the ways in which scholars have explored the relationship between environmental conditions and migration as well as their general conclusions. In doing so, this review also highlights varying conceptions of vulnerability within both sustainable livelihoods studies and migration work, which has largely focused on broader, state or national scales. Where possible, it draws from recent work specifically concerned with processes of migration from Mexico to the United States.

General consensus remains that the majority of migration, particularly that which is related to environmental stress, will continue to take place within state borders rather than result in mass movements across international borders. As such, much of the existing research focuses on relationships between environmental stress and short-term, short-distance migration. In one such study, Meze-Hausken (2000) focuses her analysis of migration within dryland Ethiopia on drought and the vulnerability of sedentary farmers. Taking into account a variety of demographic, livelihoods, and environmental factors, Meze-Hausken correlates an index of vulnerability with the timing of migration, finding that migration typically follows in a chronology of other survival mechanisms, such as asset liquidation, food aid, or non-farming work. Similarly, Afolayan and Adelekan (1998) find that drought, in combination with worsening land degradation throughout certain regions of Africa, has led to an increased reliance on historical migration patterns. Such conclusions support the framing of environmental change and vulnerability as drivers of migration, and of migration as a "last resort" strategy that could become necessary in instances of traditional or state-led adaptation failure (Meze-Hausken, 2000: 401)

In acknowledging that migration has historically represented an important livelihood strategy for many people, other studies have hypothesized that, given the relative expense of migration, environmental stress might in fact constrain moves that would have otherwise been possible. Gray and Mueller (2012) find this relationship in rural Bangladesh, where disasters appear to impede mobility tied to access to natural resources, or environmental capital. In other cases, scholars have observed the tendency for drought to encourage higher rates of local migration, but decrease migration abroad (Henry et al. 2004). Along these lines, McLeman and Smit (2006) conclude that certain types of "capital endowments," namely financial and social, played an important role in determining who migrated out of eastern Oklahoma during the Dust Bowl. Findings such as these contradict conceptions of migration as a last resort, particularly in the case of long-distance moves, instead framing the process as an indication of adaptive capacity rather than failure.

Several studies suggest that places with established migration traditions (like Mexico and the United States) might demonstrate greater propensities for international migration in the event of drought (Bardsley and Hugo 2010). Four studies, thus far, have contributed to this line of inquiry specifically as it pertains to Mexico-US migration. The earliest of these was Munshi's (2003) exploration of migrant networks and employment in the United States. As part of their broader analysis, the authors use MMP data from 7 Mexican states along with state-level precipitation data as an indicator of agricultural productivity, finding that contributions to migrant networks stall during times of increased rainfall. The conventional reading of this result is that decreased rainfall must operate as a push factor, decreasing the potential returns on labor domestically, and encouraging employment abroad (Munshi et al. 2003; Nawrotzski et al. 2012; Hunter et al. 2013).

Feng, Kreuger, and Oppenheimer's 2010 national-scale study supports this conclusion. Using 2000 and 2005 census data along with state-level precipitation data (serving as a proxy for agricultural yield,) the authors employ econometric measures of semi-elasticity to correlate crop loss and migration. This methodology results in the finding that a 10% reduction in crop yields alone will push an additional 2% of the population to engage in international migration, again aligning with popular predictions of climate-induced migration. Large-scale estimates of future population flows have long been the provenance of migration scholarship, and indeed inform much of the public and policy debates on the topic. However, neoclassical approaches such as these necessarily overlook variation at finer spatial and social scales while also presuming broader political-economic dynamics to be static.

In this sense, Hunter, Murray, and Riosmena's (2013) study using MMP data and state precipitation estimates represents several important contributions to environment-migration research in Mexico. For one thing, in employing a sustainable livelihoods framework, the authors refine the level of analysis in respect to Feng et al.'s work, accounting for numerous findings that migration decisions are often made jointly within households rather than by individual rational actors (Massey et al. 1993). The authors also build on Munshi et al.'s work by incorporating households from regions outside historical sending states, where migration as a livelihood diversification strategy is less established, generally more costly, and thus might exhibit distinctive dynamics in relation to environmental stress.

Results from this approach add nuance to prior conclusions regarding climate-driven migration by identifying previously unexplored variations in regional, household, and biophysical characteristics. The authors thus find that, consistent with Munshi (2003), increased rainfall in historical regions is associated with decreased migration, supporting the idea that years

of high potential production create disincentives for migration. However, they also note that extreme drought is strongly associated with decreased odds of migration in all regions. This finding aligns with Gray and Mueller's (2012) conclusion that environmental stress often acts to constrain, rather than push, migration as a livelihood strategy. The additional finding that households in non-historical regions experience such constraints under less dire drought conditions lends further weight to McLeman and Smit's (2006) suggestion that social and financial capital endowments largely determine who can and will migrate in response to drought.

Nawrotzski, Riosmena, and Hunter (2012) conduct a similar study using data from the 2000 Mexican census along with state-level precipitation collected by the MMP to explore the relationship between rainfall deficits and migration at the household level. Here, the authors consider representative data from all 32 states and, rather than classify regions as historical or non-historical, they consider general climatic characteristics and classify states as either dry or wet. Additionally, Nawrotzski et al. employ a new economics of labor migration framework rather than a sustainable livelihoods one, viewing the decision to migrate as a response to risk (such as market failure) rather than opportunity. Results from their study complicate the narrative of drought-induced migration by identifying a significant and positive relationship only within characteristically dry states. As these states are generally concentrated in the northern part of Mexico, Nawrotzki et al.'s findings also point to the enabling effects of social networks and prior migration history.

The studies mentioned above have contributed significant methodological improvements, as well theoretical depth, to quantitative environment-migration research. This study attempts to build on their findings, drawing most heavily from Hunter et al. (2013) in its conception of migration as a livelihood strategy. It also draws heavily from Gray and Mueller (2012), as well

as Eakin (2005), in its consideration of both environmental and political-economic vulnerability and livelihood constraints. However, this study also responds to an analytical weakness present in all drought-related studies of migration in Mexico, which is the use of aggregated precipitation data. Each one of the studies mentioned above relies on unweighted state precipitation averages to extrapolate experiences of drought at a smaller scale (except for Feng et al. (2010), whose focus was national). They all, therefore, rely on an ecological fallacy that assumes climatic homogeneity within states but significant variation between them. This study addresses that gap by employing new measures of drought estimation and interpolation in order to refine the scale at which drought-migration dynamics might be understood. My research question is thus threefold:

1. How do refined estimates of drought (by way of increased resolution and a standard, multidimensional measure of drought thus far ignored by environment-migration scholarship) in Mexico enhance, and perhaps complicate, our understanding of the environment-migration relationship?
2. To what extent can biophysical variables explain migration behaviors as responses to environmental change?
3. How does the experience of recurring drought affect migration responses to different levels of drought severity?

CHAPTER 2

MODELING MIGRATION

DEMOGRAPHIC DATA: THE MEXICAN MIGRATION PROJECT

Like Hunter, Murray, and Riosmena, (2013) as well as Munshi (2003), this project uses migration data from the Mexican Migration Project (MMP). The MMP is a collaborative research project based at the Princeton University and the University of Guadalajara, which has compiled socio-economic information related to Mexican-US migration since 1987 (see Massey et al. 1987 for an overview of the study). The dataset represents an important contribution to a field characterized, as McLeman (2013) notes, by broad and often unreliable data, and belongs to a pool of regional and sub-regional surveys that allow for high quality and high resolution sampling (e.g. Barbieri et al. 2010; Massey et al. 2010).

The MMP employs an ethnosurvey approach that combines qualitative and quantitative techniques from a variety of social sciences. The survey combines ethnographic techniques from sociology, anthropology, education, and psychology with survey methods popular in political science, demography, economics, and sociology (Massey, 1987). Such methodological synthesis, according to Massey, creates a database that is simultaneously rich in context and statistically backed. Semi-structured interviews thus take the shape of conversations. They touch on specific topics and queries, collecting identical information for each person, but in the order and phrasing of the interviewer's discretion (Massey, 1987). The MMP also collects community-level data, aimed at the broader socioeconomic context within which households operate, as well as household surveys in receiving communities in the United States and Canada. To date, the survey has reached 143 communities and more than 22,000 households and 150,000 individuals

in Mexico. Surveys in US destination communities have reached almost 1,000 households (MMP143).

COMMUNITY SELECTION

Each winter, the MMP randomly selects households from communities representing each of the four followings levels of urbanization to participate in the survey: ranchos (fewer than 2,500 inhabitants); pueblos (2,500 to 10,000 inhabitants); mid-sized cities (10,000 to 100,000 inhabitants); and a metropolitan area (typically a neighborhood within a large city or the state's capital). Because this study focuses on rural emigration, only ranchos and pueblos with 5,000 community members or fewer were selected for study. These communities represent what the National Institute of Statistics and Geography (INEGI) refers to as "la poblacion rural ampliado", or an extension of the conventional 2,500 person cut-off for rural classification. This reclassification was first utilized in 1978 in an attempt to reconceptualize the rural-urban dichotomy as a spectrum of population distribution, and is meant to represent a more complete set of rural communities (Unikel et al. 1976).

In addition to limiting the study sample by community population, this project also limits its sample by selecting study years between 1998 and 2012 (using study version MMP143). This selection was made based on early changes to the survey, mainly in the form of added variables. Variables added to the 1998 version related to the labor history of spouses, border crossing experiences, the use of English in various settings, and, of particular importance to this study, agricultural land tenure and access to credit. While the survey has been updated four times since, the nature of these initial changes and their relevance for this project warranted limiting the sample years to those after 1997. As seen in Map 1, the combination of these two restrictions results in a total sample size of 5,177 households in 39 communities and 16 states.

MAP 1: COMMUNITY SELECTION

VARIABLE SELECTION

Dependent variable

The MMP household-level file provides most of variables included in this study. The file contains data regarding household composition, economic activity, land tenure and ownership, business ownership, household amenities, as well as the migration histories of resident household members. The dependent variable for this study was derived from the household-level dataset and thus reflects households in which a resident household head, spouse, son, or daughter migrated to the United States within three years of the survey. (The MMP collects person-level data in such a way that sons and daughters living with extended family members might be counted as, for example, a daughter in one household and a niece in another. It was therefore not possible to include the migration experience of extended household members without potentially over-representing son/daughter migration.)

Because the MMP is a repeated cross-sectional survey that relies on retrospective migration data, a three year window serves to limit instances of recall error in which respondents either forget certain migration experiences or inaccurately recall the timing of them (Smith and Thomas, 2003). Perhaps of note, this window varies slightly from the recommendations Smith and Thomas (2003) offer based on their evaluation of retrospective data quality within the Malaysian Family Life Survey. There, the authors suggest using a two year recall window and a one month minimum duration in order to better capture short-term or local moves, which are most susceptible to recall error. Due to the saliency of international migration, however, both in terms of financial and psychological cost, a three year window still arguably avoids issues of omission and telescoping. The three year window also minimizes any changes to household characteristics that result from migration.

Based on these parameters, an average of 13.5% of households sent a migrant to the United States within three years of the survey. The percentage is slightly greater in communities within the historical sending region, with approximately 15.7% of households sending a migrant. In non-traditional sending communities, on the other hand, approximately 12.8% of households did so. Such regional differentiation is characteristic of Mexico-US migration, again, due to historical economic, infrastructural, and network ties between central-western Mexican states and the US (Durand and Massey, 2003).

Interestingly, the difference in migration rates is smaller than that identified by other recent studies. Hunter, Murray, and Riosmena (2013), for example, find a 44% difference in regional sending rates. Of note is that Hunter, Murray, and Riosmena include migration between 1987 and 2005, whereas this study focuses on the period between 1998 and 2012. The decrease in regional differentiation, at least in terms of migration prevalence, thus likely reflects an

ongoing shift in the geography of Mexico-US migration toward greater participation amongst non-traditional sending regions, largely due to recent rural economic restructuring (Saldaña-Zorrila and Sandberg 2009; Riosmena and Massey 2012).

Independent Variables

Independent variables were selected to reflect both a livelihoods framework as well as a critical conception of those household or community characteristics that might contribute to vulnerability. This study follows the convention within sustainable livelihoods work of selecting variables representative of various forms of "capital assets," including human, financial, physical, social, and natural (Bebbington 1999; Hunter, Murray, and Riosmena 2013). It also includes measures consistent with Black et al.'s (2011) reintroduction of traditional migration indicators, acknowledging the importance of network ties as well as strategies of risk diversification.

Regional Characteristics

Since large-scale migration between the United States and Mexico began about one hundred years ago, sending communities have demonstrated a distinct (if evolving) spatial pattern. Two historical factors, in particular, contributed to the enduringly regional nature of US-Mexican migration (Durand et al. 2001). First, the construction of railway networks during the early 1900s allowed labor recruiters from the U.S. to bypass sparsely populated northern states and connect with labor forces further south (Durand et al. 2001). During this time, Guanajuato, Jalisco, and Michoacan arose as primary sending states. Second, the Bracero program, a U.S. wartime measure intended to bolster a diverted agricultural labor force, permitted the "temporary importation" of Mexican workers starting in the 1940s (Calavita, 1992). The extension of this early guest-worker program into the 1960s both strengthened and expanded upon pre-existing

infrastructural and social networks. During this time, the heartland of migration extended to the states of Durango, San Luis Potosi and Zacatecas. Durand and Massey (2003) add to that list smaller states, including Aguascalientes, Colima, and Narayit. The above listed states thus comprise the "historical region" referred to in this study, in which 1178 (or approximately 23 percent) of households reside.

Human Capital

Human capital assets serve to acknowledge the influence of such factors as household demographic composition, life cycle characteristics, and socioeconomic standing, particularly in the rural context (White and Lindstrom 2005). Human capital variables thus included the age, years of education, and marital status of the household head as well as the total number of family members in the household. The average household size in this study was slightly more than four members and the average age of household heads was around 50, 85 percent of whom were married. Educational experiences varied greatly between households. On average, though, household heads had just less than six years of formal schooling and 88 percent of all household heads were employed. Overall, household characteristics varied little between historical and non-traditional sending regions. Small differences included slightly larger household sizes in historical communities (4.7 vs. 4.3), fewer years of education (5.5 vs. 6), and lower employment rates (86 vs. 89 percent.)

Financial and Physical Capital

To account for financial and physical assets, this study includes indicators of occupation, land tenure, property type, and agricultural practices. Here, it is important to realize that many of these variables, such as use of irrigation or industrialized agriculture, warrant a particularly close

read, as some scholars (Liverman 1990, Eakin, 2005, for example) have noted the potential for "assets" to become vulnerabilities in times of economic or environmental stress.

Overall, 31 percent of households in this study had land and 28 percent engaged in farming, though rates varied between regions. Only 20 percent of households in historical sending regions had land, compared to 35 percent in non-historical regions. Similarly, only 17 percent of households in historical regions engaged in farming, versus 32 percent in non-historical regions, where households also tended to cultivate a greater portion of their land (2.9 hectares, on average, in non-historical regions vs. 0.9 in historical ones.) Few households used agricultural machinery (12 percent), and even fewer (7 percent) had land that was irrigated, though both are more common in non-historical regions where 8.6 percent (vs. 1.5 in historical regions) have irrigated land and 13 percent (vs. 9 in historical regions) use agricultural machinery. Taken as a whole, these measures indicate a high level of agricultural involvement and an evident dependence on rain-fed cultivation. Both of these characteristics are thought to make rural livelihoods particularly susceptible to weather fluctuations and climate change (Conde, Ferrer, and Orozco 2006). (Though, again, access to irrigation, because it often signals more risky or capital-intensive forms of agriculture, is might represent an inconsistent indicator of drought resilience.)

Of course, farmers have historically employed a variety of livelihood diversification strategies to adjust to environmental changes, such as those associated with El Niño events (Conde, Ferrer, and Orozco 2006). Along these lines, this study also considers household business activities, finding that a full 31 percent have at least one kind of business holding (ranging from street vending to factory or professional services), and that 27 percent engage in a business unrelated to agriculture. 10 percent of households engage in both farming and business.

These statistics are relatively consistent across the study, though we see a higher level of farm and business diversification in non-traditional regions, where 12 percent of households engage in both activities, as compared to 5 percent in historical regions.

Social Capital

Two variables were derived from MMP data to indicate types of social capital that influence migration. To measure current networks abroad, an index was created as a sum of all family members currently living in the United States. Here we see perhaps the starkest regional differentiation, as households in historical sending regions have, on average, 13 family members living abroad. Households in non-historical regions, on the other hand, have an average of 6.5 members in the U.S. Previous migration experiences amongst household heads shows similar, though less drastic, regional characteristics, with 33 percent of household heads in historical regions having migrated at least once before the survey year and 28.5 amongst non-historical households. Successive trips change the social contexts of migration by reducing the costs of international movement and often establishing it as a cultural or economic norm (Massey, Goldring, and Durand 1994; Fussell and Massey 2005; Massey and Riosmena 2010). These variables thus serve to control for the cumulative effects of past migration and social networks on the likelihood that a household sent a migrant during the study period. Additionally, by emphasizing conventional, and long-studied, migration drivers the inclusion of these variables reflects Black, Kniveton, and Schmidt-Verkerk's (2011) call for "reintegrated" frameworks.

Community-level Indicators

Several community-level variables were included in this study to reflect broader the social and economic contexts in which households experience various livelihood opportunities. For example, a number of studies have found a strong correlation between migration and local

opportunities for women to enter the formal labor force (Durand et al. 1996, Riosmena 2009). Durand et al. (1996) further note that female participation in the manufacturing sector operates as an especially useful indicator of broader economic dynamism, industrial development, and productive investment environments. Like Hunter, Murray, and Riosmena (2013) this study thus includes community measures of female labor force participation, both generally and in the manufacturing sector in particular, in order to highlight areas in which economic climates might encourage migration. As previous studies have found agrarian economies (in which more than half the male labor force works in agriculture) more likely to send migrants, this study also includes a community-level measure of male agricultural participation (Durand et al. 1996, Hunter, Murray, and Riosmena 2013).

TABLE 1
Means and Standard Deviations of Dependent Variable and Covariates (weighted)

	All Communities		Historical Sending Communities		Non-Historic Sending Regions	
	Mean (SD)		Mean (SD)		Mean (SD)	
Outcome of interest						
Proportion of households sending a migrant within three years of survey	0.135	(0.373)	0.157	(0.411)	0.128	(0.361)
Household characteristics						
Total members in household	4.360	(2.089)	4.712	(2.554)	4.251	(1.915)
Age of household head	48.983	(15.123)	48.403	(15.628)	49.154	(14.968)
Schooling years, household head	5.859	(4.148)	5.501	(3.977)	5.969	(4.169)
Percent of household heads married	0.852	(0.358)	0.844	(0.367)	0.854	(0.356)
Household head employed	0.879	(0.322)	0.859	(0.367)	0.885	(0.356)
Financial and Physical Assets						
Owns land	0.312	(0.465)	0.200	(0.431)	0.345	(0.473)
Primary landholding is in ejido	0.151	(0.356)	0.080	(0.304)	0.172	(0.368)
Owns a business	0.313	(0.461)	0.255	(0.437)	0.331	(0.467)
Owns a non-agricultural business	0.273	(0.445)	0.235	(0.426)	0.285	(0.449)
Amenities index	13.851	(2.086)	13.472	(2.476)	13.968	(1.956)
Agricultural Assets						
Hectares of land	3.710	(99.890)	4.308	(15.296)	3.526	(0.148)
Hectares cultivated	2.462	(97.356)	0.903	(3.031)	2.943	(0.170)
Owns livestock	0.182	(0.403)	0.180	(0.424)	0.183	(0.396)
Total livestock owned	1.615	(17.873)	1.951	(9.123)	1.511	(19.722)
Engages in farming	0.288	(0.455)	0.171	(0.415)	0.324	(0.465)
Uses agricultural machinery	0.123	(0.340)	0.091	(0.326)	0.133	(0.343)
uses fertilizers	0.233	(0.424)	0.157	(0.403)	0.257	(0.430)
uses insecticides	0.217	(0.413)	0.148	(0.393)	0.239	(0.418)
average use of industrial agr (out of 3)	0.573	(1.058)	0.396	(1.043)	0.628	(1.061)
Engages in farming and owns business	0.109	(0.307)	0.052	(0.241)	0.127	(0.323)
Land is irrigated	0.069	(0.255)	0.015	(0.123)	0.086	(0.280)
Migration-Specific Social Networks						
Network in US (# of family members)	7.927	(15.006)	12.990	(18.908)	6.493	(13.359)
Household head has previous migration experience	0.331	(0.462)	0.470	(0.491)	0.285	(0.447)
Percent HH migrated in last 3 years	0.083	(0.262)	0.084	(0.262)	0.083	(0.262)
Spouses migrating in last 3 years	0.018	(0.106)	0.038	(0.155)	0.011	(0.086)
Daughters migrating in last 3 years	0.007	(0.082)	0.009	(0.096)	0.008	(0.077)
Sons sons migrating in last 3 years	0.026	(0.155)	0.026	(0.152)	0.027	(0.156)
Commnnity characteristics						
Female labor force participation	0.239	(0.066)	0.260	(0.043)	0.232	(0.070)
Female employmetn in manufacturing	0.208	(0.141)	0.112	(0.076)	0.237	(0.148)
Male participation in agriculture	0.484	(0.152)	0.439	(0.072)	0.498	(0.170)
Community migration prevalance	0.157	(0.115)	0.256	(0.176)	0.127	(0.073)
Households	5177		1178		3999	
Communities	39		10		29	

Natural Capital

Consistent with the sustainable livelihoods framework, this study examines the role of natural capital, or lack thereof, in shaping migration. In particular, this project explores the potential for experiences of drought to affect household migration decisions. Drought variables were derived from a simple interpolation of Palmer Drought Severity Indices (PDSI), which are recorded monthly at weather stations throughout Mexico. The PDSI was developed in 1965 to provide a comprehensive measure of drought, taking into account temperature and Available Water Content (AWC) in addition to just precipitation (Palmer, 1965). This method allows for all elements of the water balance equation (evapotranspiration, soil recharge, runoff, and moisture loss) to inform classifications of drought, making it particularly useful for understanding impacts on agriculture (Willeke et al., 1994). Despite a set of well-documented limitations (Alley, 1984, Willeke et al., 1994, for example,) the PDSI remains perhaps the most widely used drought index (Mishra and Sing, 2010).

A sustainable livelihoods framework suggests that in the event of decreased agricultural viability, which we would expect to see in regions heavily dependent on rain-fed cultivation, migration will become an important strategy for livelihood diversification (Gray and Mueller 2010; Hunter et al. 2013). Integrating the new economics of labor migration theory, we might predict a similar relationship, with migration serving as an alternative to formal risk management institutions, such as crop insurance (Stark and Bloom, 1985; Massey et al. 1993. At the same, however, critical vulnerabilities studies (Liverman 1990; O'Brien et al. 2004; Eakin 2005) emphasize that while drought might increase the attractiveness of migration it by no means guarantees that a household will engage in it. On the contrary, the consequences of drought, particularly in the context of recent economic restructuring, might very well be to limit

household adaptive capacity to a point where migration is no longer a feasible option. Due to the theoretical complexity of the drought-migration relationship, as well as the lack of empirical consistency on the topic, this study directly engages with increasingly common assumptions that climate change will lead to mass migrations.

In many ways, this study follows the lead of Hunter, Murray, and Riosmena (2013), whose work on rainfall patterns and US migration suggests a positive, though varying, relationship between rainfall drought and migration. However, it differs significantly in a number of ways, including its community selection, timeframe, and of central importance, its estimations of drought. The drought variables included in this study differ from those in Hunter, Murray, and Riosmena's in two ways, the first of which is discussed below, as it pertains to variable selection, the second of which will be discussed in the Methods section below, as it relates to variable calculation.

First, whereas the previous authors calculate drought using standard deviations from a 30-year mean, or "climate normal", this project instead employs the Palmer Drought Severity Index (PDSI). Both methods of calculating drought are popular, and Hunter et al. indeed note that the calculation of "normals" is often used synonymously with the term climatology (Argues et al. 2012). Their methodology most closely resembles the Standardized Precipitation Index (SPI), in which precipitation data at each location is fitted to a normal distribution and deviations from the "norm" then standardized (for a detailed description of the SPI see McKee et al. 1993 and 1995). Because of its usefulness at multiple time scales, and arguably because of its simplicity, this type of index is has gained global popularity and is often used to identify emerging droughts and initiate mitigation plans (Hayes, 1999).

The PDSI, on the other hand, was developed in 1965 to provide a comprehensive calculation of drought by incorporating soil moisture and temperature (rather than just precipitation) to estimate all components of the water balance equation (Palmer 1965). The main motivation for this development was to take into account the duration of dry or wet spells, with the understanding that, for example, a wet month (one that might represent a significant deviation using the SPI) in the middle of a long dry spell might not necessarily signify the end of a drought. The PDSI is relatively more complex than the PSI, which results in different strengths and weaknesses. For example, while the PDSI addresses environmental moisture status more explicitly than the PSI, the particulars of its calculations leave it open to a variety of critiques (Heim 2002). One of the most common critiques of the PDSI is that its computational "backstepping" procedure creates a lag that makes the index less useful for identifying real-time droughts (Heim 2002). This, of course, is not of issue for retrospective work such as this project. The most popular and effective use for the PDSI is, in fact, assessing the impacts of climate variability on processes that are particularly sensitive to soil moisture, such as rain-fed agriculture (Willeke et al. 1994). Given the relative strengths and weaknesses inherent to both indices, the PDSI was selected for this study based on its sensitivity to moisture and temperature thus its suitability for regions where rain-fed cultivation is common.

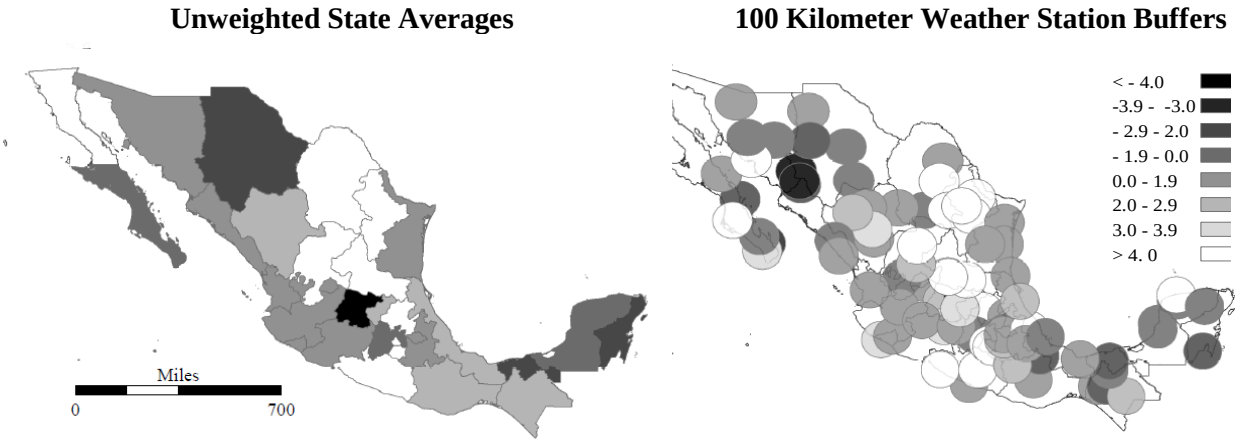
METHODS

Drought Interpolation

The second difference between this project and Hunter, Murray, and Riosmena's (2013) relates to the methods by which we estimate drought, and therefore, the scale at which the any effects of drought on migration are discernable. Hunter et al. (2013) employ unweighted state precipitation

averages, which represents a popular method of standardization within environmentally-concerned social science research (see also Feng et al. 2010). However, this technique could yield associations that are the result of an ecological fallacy, essentially assuming that all communities within a state, regardless of their location, have the same "average" experience of drought. Map 2 displays unweighted state PDSI averages and serves to show how the use of state boundaries as enumeration units might overlook important variation in local experiences of drought. This project offers a simple yet theoretically significant improvement to and Hunter, Murray, and Riosmena's methodology. Rather than relying on state boundaries to frame estimates of a biophysical phenomenon, this project uses a measure of spatial proximity.

MAP 2: PDSI AVERAGES 2010



First, instead of aggregating weather station data to the state level and then establishing a state average, I merged all MMP communities to the nearest weather station. All study communities except for one were within a 100 km (~60 mi) radius of a weather station and were subsequently assigned the PDSI values based of the closet one. Though a very simple interpolation technique, (in the future, more advanced methods would likely include distance

from oceans and topography) this method addresses McLeman's (2013) call for increasing model sophistication in two ways: 1) theoretically, in that a biophysical event is conceived of spatially rather than as contained within political boundaries and 2) empirically, in that estimates of drought are calculated at a more granular level and are thus likely to better represent actual experiences in the study communities. Map 2 displays the weather stations used to assign drought estimates and their corresponding 100 km buffers. Importantly, the areas of assumed homogeneity are much smaller than in they are in Map 1, allowing less room for distant experiences of drought to influence local estimations.

Table 2 shows the results of interpolated drought estimations. According to these measurements, 29 percent of households experienced mild to moderate drought (with PDSI values between -1.00 and -2.99) during the year of survey, 19 percent experiencing it 1 year prior, and 14 percent 2 years prior. Severe to extreme drought (PDSI values less than -3.00) affected 19 percent of households during the survey year, 15 the year prior, and only 2 percent two years prior.

Interestingly, these interpolations indicate a greater level of climatic consistency for households in historic sending regions, with fewer instances of extreme drought or wetness. However, here it is important to note both the geographical concentration of these states, compared to all others included in this study, as well as the fact that the majority of households in this study resided in non-traditional states, thus providing a substantially more household-years of drought data. In this sense, conclusions regarding climatic consistency or regional difference are difficult to draw.

TABLE 2
Means (proportions) and Standard Deviations of Interpolated Drought Estimates

	All Communities		Historic Sending Region		Non-Historic Sending Regions	
	Mean	SD	Mean	SD	Mean	SD
Same year						
Extreme drought same year	0.12	(0.32)	0.00	(0.00)	0.15	(0.36)
Severe drought	0.19	(0.39)	0.00	(0.00)	0.24	(0.43)
Moderate drought	0.29	(0.45)	0.44	(0.50)	0.24	(0.43)
Normal	0.82	(0.38)	0.70	(0.28)	0.03	(0.03)
Moderately wet	0.02	(0.14)	0.08	(0.28)	0.00	(0.00)
Very wet	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Extremely wet	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Year prior to survey						
Extreme drought	0.10	(0.30)	0.00	(0.00)	0.13	(0.33)
Severe drought	0.15	(0.35)	0.08	(0.28)	0.16	(0.37)
Moderate drought	0.19	(0.39)	0.08	(0.28)	0.22	(0.41)
Normal	0.85	(0.36)	0.00	(0.00)	0.23	(0.42)
Moderately wet	0.06	(0.24)	0.00	(0.00)	0.08	(0.27)
Very wet	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Extremely wet	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
2 years prior to survey						
Extreme drought	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Severe drought	0.02	(0.14)	0.00	(0.00)	0.03	(0.16)
Moderate drought	0.14	(0.35)	0.53	(0.50)	0.03	(0.16)
Normal	0.81	(0.40)	0.00	(0.00)	0.24	(0.43)
Moderately wet	0.10	(0.30)	0.00	(0.00)	0.13	(0.33)
Very wet	0.04	(0.19)	0.00	(0.00)	0.05	(0.22)
Extremely wet	0.04	(0.19)	0.00	(0.00)	0.05	(0.22)
Households	5177		1178		3999	
Communities	39		10		29	

Modeling Migration

Multivariate analysis concerned with the timing of migration requires event history analysis. Timing is, of course, central to this study, as understanding the relationship between drought and migration requires measures of both drought severity at various times as well as drought duration. Because, as discussed earlier, the MMP is a cross-sectional survey containing retrospective migration data, pseudo-observations are used in the place of longitudinal data. To create these, I generate a pseudo-panel spanning up to 4 years per household (the survey year and three years prior), depending on the household's migration experience.) I then use discrete time-

event survival analysis and fit a logistic regression over the household years of exposure (Singer and Willet 2003). Households are thus censored either at the point of data collection or the year of first migration within that window (Allison 1982; Hunter, Murray, and Riosmena 2013). Again, this window was selected to limit recall error and to account for the static nature of most covariates included in the model. (Most household and community variables are only calculated for the year of the survey. Including them for multiple years thus assumes they remain stable over time, an assumption that becomes more problematic the further back a recall window extends.)

Drought levels are parameterized according to PDSI indicators of extreme, severe, and moderate drought, as well as three corresponding measures of wet conditions. Models III – VI thus explore migration as a function of:

1. Sustainable livelihoods indicators of migration,
2. PDSI indices the same year and one year prior,
3. PDSI indices indicating same-year experiences of moderate to severe drought as well as indicator of past drought experiences (one and two years prior). This model builds off Model 2 and begins to explore relationships between drought severity and duration;
4. Interactions between current and past experiences of drought. This model builds off Model 3, addressing the potential for the impact of current drought conditions to be affected by drought events in the recent past.
5. A dummy variable distinguishing between current experiences of extreme and non-extreme drought compared to normal conditions, and past experiences of drought

6. Interactions between the current year dummy variables used in Model V and past drought experience

Several dummy variables were created during the modeling process in order to account for multicollinearity. Business holdings are classified as agricultural, cattle-related, or non-agricultural; financing is broken down into formal bank loans and informal loans from family and friends; household land use is classified as having land, using that land for agriculture, and having access to irrigation. The reference category for all of these variables is the absence of any business, loans, land, or drought. Model fit is assessed using AIC and likelihood ratio tests between models using the ANOVA function. As a logit link was used, Tables 3 and 4 present models showing the log odds of a household migration function of each of these models.

CHAPTER 3

RESULTS AND DISCUSSION

RESULTS

Table 3 shows the results of the first two discrete-time event history models. The sustainable livelihoods indicators used in Model I represent household and community-level control variables. Results from this model are largely consistent with theoretical expectations. Human capital and life cycle characteristics indicate that household head age and employment are all negatively associated with migration. This decreased likelihood of migration at the end of life-cycle is consistent with several recent studies (Nawrotzki, Riosmena, and Hunter 2013; Hunter, Murray, Riosmena 2013), and supports general findings that, as households age and children move out, migration becomes relatively more expensive for a household in terms of human capital (Juelich 2011).

The negative association between additional years of household head education and migration is significant, though relatively small ($100 \cdot [\exp\{-0.03\} - 1] = 4$ percent lower odds), whereas we see a much larger difference between employment and unemployment, with an associated $100 \cdot [\exp\{-0.67\} - 1] = 49$ percent lower odds of migration. At first glance, these findings might appear inconsistent with expectations that, due to the cost of migration, households with greater levels of human capital would be more capable of sending migrants (Massey et al. 1994). However, this inconsistency likely points to the link between the possession of certain types of human capital (such as education) and access to local livelihood diversification opportunities. Indeed, employment locally reduces the imperative to find work abroad. Scholars have also theorized that the returns on formal schooling are relatively greater

within Mexico than in the U.S., particularly for immigrants working without documentation (Taylor et al. 1996). In other words, this finding supports the idea that, while the option of international migration is out of reach for the poorest households, it might lose appeal as households gain greater access to local livelihood opportunities (Massey et al. 1994).

Indicators of social capital, including ties to U.S. migration networks and the household head's previous migration experience, demonstrated strong collinearity. These associations are unsurprising, though as a result, only previous migration experience is included in the final adjusted model. As anticipated, there exists a very strong and positive relationship between household migration during the four year window and the experience of household head migration in prior years. This finding supports long-standing theorizations of cumulative causation and role of social capital in reducing both the psychological and financial costs of international movement (Fussell and Massey 2004). As expected, primary landholdings in ejidos were positively correlated with the odds of migration, likely reflecting both a greater historical dependence on agriculture as well as the more recent effects of significant land tenure change and privatization.

Interestingly, nonagricultural business holdings were negatively associated with migration (by $100 \cdot [\exp\{-0.46\} - 1] = 37$ percent lower odds) while cattle businesses demonstrated a strong and positive correlation (of $100 \cdot [\exp\{1.00\} - 1] = 127$ percent greater odds). One potential explanation for this might be that, while owning a business might indicate access to local livelihood opportunities, the risks related to agricultural businesses, particularly cattle, might encourage a greater diversity of livelihood strategies. The capital intensity and the potential for high returns from cattle production might also encourage international migration as a means to acquire capital for further productive investment (Durand et al. 1996). As might be

expected in a rural context, relatively few of the households included in the study owned land without engaging in any form of cultivation. Households fitting this category, however, demonstrated a positive correlation with migration, the strength of which ($100 \bullet [\exp\{1.26\} - 1] = 219$ % greater odds) was surprisingly. There is no clear theoretical explanation for this, though one reason might be that land quality in these places might is so poor or degraded as to preclude agricultural production, thereby leaving migration as an attractive or necessary livelihood strategy.

Households that had financed any vehicles, property, land, business holdings with credit were less likely to have sent a migrant during the study window than households with no demonstrated loan histories. Additionally, the negative effect of formal bank loans was stronger than the effect of loans from family or friends. These findings support the argument stemming from the New Economics of Labor Migration literature that migration play an important role in strategies of risk diversification in the absence of formal credit or insurance institutions (Eakin, 2005).

Finally, indicators of broader economic conditions and livelihood opportunities demonstrate the expected positive association with migration. Female participation in the manufacturing sector is particularly indicative of migration, supporting previous findings (Durand et al. 1996, Riosmena 2009) that higher rates of female labor force participation signify especially positive investment climates and, in turn, encourage migration and remitting. Interestingly, regional characteristics (i.e. residing in either historical or non-traditional sending regions) were not a significant predictor of household migration. This suggests either that the other control variables in the model accounted for the factors that differentiate the regions or

that, as migration becomes more common in non-traditional regions, that geographical distinction is less salient.

PDSI dummy variables representing each of the six Palmer classifications were added in Model II. Here, the reference category includes all PDSI values between -1.9 and +1.9 and represents "near normal" conditions. Findings from this model complicate popular prognostications of drought-induced migration. While severe drought (PDSI values between -3.0 and -3.9) demonstrates a positive (though only marginally significant) relationship with migration, the strongest relationship we see is in fact the negative one between extreme drought (PDSI values – 4.0 or less) and household migration. According to Model II, households that experienced extreme drought also experienced lower odds (100 • [exp{-0.98 } – 1] = 62 percent) of migration for that same year. Extreme wet conditions had a similarly significant and even more negative effect. PDSI values from the year prior indicate similar, though typically weaker and less significant effects on migration, with extreme conditions most obviously exhibiting an inhibiting effect. Interestingly, the experience of a wet year (any PDSI values between 2 and 2.9) is positively correlated with migration, increasing the odds (by100 • [exp {0.45} – 1] = 57 percent) in comparison to a near normal year.

Overall, results from Model II suggest that while less extreme experiences of drought might encourage livelihood or risk diversification through migration (though, again, the statistical significance of this finding was small,) the worst droughts actually appear to reduce a household's capacity to send a migrant, at least internationally. In this sense, Model II demonstrates a few overlaps with findings from Hunter et al. (2013), who found that, particularly in non-historical regions, more extreme levels of drought might act to impede mobility rather than catalyze it. However, these results also complicate the state-level conclusions from

Nawrotzki et al. (2013) and Feng et al. (2010), which support the hypothesis that reduced rainfall will lead to higher migration rates.

Based on the results of Model II, Models III and IV then combine PDSI classifications into general indicators of intensity in order to more closely analyze the potential effects of duration and frequency. First, I combine moderate and severe classifications (PDSI values between -3.9 and -2.0) into a general indicator of non-extreme drought. This aggregation was chosen based on similar variable behavior in Model II, again, as both classifications demonstrated a positive but statistically insignificant effect on migration. Second, I derive a variable representing any experience of drought within the previous two years, adding an interaction term in Model IV to identify any added effects of having experienced both past and current drought.

These models elaborate on Model II in a number of ways. First, combining indicators of moderate and severe drought into one measure in Model III results in a significant and positive correlation with migration (by $100 \cdot [\exp\{0.37\} - 1] = 45$ percent greater odds). This finding provides strong evidence that households experiencing milder levels of drought are more likely to send a migrant than households experiencing either extreme drought or none at all. We also see that past recent experiences of drought are negatively associated with migration, which is not altogether surprising, especially given that this classification includes past experiences of extreme drought. What is striking in these results, however, is the interaction between current and past experience. This finding indicates that while households are more likely to send a migrant during a moderate to severe drought year, if they have experienced consecutive or recurring drought, they are significantly less likely to engage in migration (by $100 \cdot [\exp\{-0.58\} - 1] = 44$ percent lower odds**.)**

To test the possibility that the interaction term in Model IV is merely picking up a lagged effect of extreme drought from previous years (in other words, still modeling the effects of intensity rather than duration or frequency) Models V and VI disaggregate the indicator of previous drought experience. In doing so, they include a dummy variable that compares extreme and non-extreme drought to normal conditions, interacting them with past experiences of drought. Findings here are largely consistent with other models, though the magnitude of effects is much greater. For example, accounting for other livelihood variables, extreme drought in this model is associated with a $100 \bullet [\exp\{-3.04\} - 1] = -95$ percent lower odds of migration. Even considering the large standard error, a 95 percent confidence interval estimates the associated odds of migration to be between –98 and –87 percent. The effects of non-severe drought are similarly amplified, with the odds of migration increasing by 55 percent in this model. The results from interacting years of drought experience similarly indicate that, though moderate to severe drought seems to encourage migration, the experience of consecutive or recurring drought impedes it. (Results from the interaction with extreme drought were omitted due to insufficient data.)

TABLE 3

DISCRETE TIME LOGIT PREDICTING THE LIKELIHOOD OF HOUSEHOLD-LEVEL MIGRATION

	(I)			(II)		
	β	(SE)	Sig.	β	(SE)	Sig.
Human Capital						
Members	-0.05	(0.02)	*	-0.05	(0.02)	*
Age of household head	-0.07	(0.00)	***	-0.06	(0.00)	***
Household head years of education	-0.02	(0.01)		-0.01	(0.01)	
Household head married	0.58	(0.17)	***	0.58	(0.17)	***
Household head employed	-0.65	(0.15)	***	-0.64	(0.15)	***
Social capital						
Household head has previous migration experience	2.34	(0.08)	***	2.35	(0.08)	***
Financial and physical capital						
Owns nonagricultural business	-0.46	(0.09)	***	-0.44	(0.10)	***
Owns agricultural business	0.12	(0.27)		0.07	(0.27)	
Owns cattle business	1.00	(0.31)	**	1.00	(0.31)	**
Engages in irrigated farming	-0.77	(0.22)	***	-0.67	(0.22)	**
Engages in farming	0.19	(0.12)		0.14	(0.12)	
No farming performed on land	1.16	(0.20)	***	1.10	(0.20)	***
Hectares of land	0.00	(0.00)		0.00	(0.00)	
Owns livestock	0.04	(0.10)		0.02	(0.10)	
Prime landholding is in ejido	0.35	(0.14)	*	0.39	(0.14)	**
Financed with loans from bank	-1.18	(0.29)	***	-1.16	(0.30)	***
Financed with loans from family or friends	-0.81	(0.23)	***	-0.82	(0.23)	***
Community-level capital						
Male participation in agriculture	0.54	(0.27)	*	0.39	(0.29)	
Female participation in manufacturing	1.07	(0.27)	***	0.51	(0.29)	.
Historical region	0.07	(0.09)		-0.13	(0.11)	
Natural capital - same year						
Extreme				-0.98	(0.27)	***
Severe				0.46	(0.18)	*
Moderate				0.14	(0.14)	
Wet				0.45	(0.14)	**
Very wet				0.73	(0.33)	*
Extremely wet				-1.35	(0.60)	*
Natural capital - one year prior						
Extreme				-0.68	(0.23)	**
Severe				-0.08	(0.21)	
Moderate				-0.06	(0.14)	
Wet				0.42	(0.15)	**
Very wet				0.37	(0.26)	
Extremely wet				-0.99	(0.43)	*
Intercept	-1.34	(0.33)	***	-1.18	(0.34)	***

Notes: ***$p < 0.0001$, ** $p < 0.01$, * $p < 0.05$, . $p < 0.10$

TABLE 4
DISCRETE TIME LOGIT PREDICTING THE LIKELIHOOD OF HOUSEHOLD-LEVEL MIGRATION

	(III)			(IV)			(V)			(VI)		
	β	(SE)	Sig.	β	(SE)	Sig.	β	(SE)	*Sig.*	β	(SE)	Sig.
Human capital												
Members	-0.05	(0.02)	*	-0.05	(0.02)	*	-0.05	(0.02)	*	-0.05	(0.02)	*
Age of household head	-0.07	(0.00)	***	-0.07	(0.00)	***	-0.07	(0.00)	***	-0.07	(0.00)	***
Household head years of education	-0.02	(0.01)		-0.02	(0.01)		-0.01	(0.01)		-0.02	(0.01)	
Household head married	0.57	(0.17)	***	0.56	(0.17)	***	0.58	(0.17)	***	0.58	(0.17)	***
Household head employed	-0.63	(0.15)	***	-0.62	(0.15)	***	-0.63	(0.15)	***	-0.62	(0.15)	***
Social capital												
Household head has previous migration experience	2.34	(0.08)	***	2.34	(0.08)	***	2.34	(0.08)	***	2.33	(0.08)	***
Physical and financial capital												
Owns nonagricultural business	-0.48	(0.09)	***	-0.47	(0.09)	***	-0.47	(0.09)	***	-0.45	(0.10)	***
Owns agricultural business	0.08	(0.27)		0.09	(0.27)		0.06	(0.27)		0.08	(0.27)	
Owns cattle business	1.01	(0.31)	***	1.02	(0.31)	***	1.03	(0.31)	***	1.02	(0.31)	***
Engages in irrigated farming	-0.73	(0.22)	***	-0.72	(0.22)	**	-0.66	(0.22)	**	-0.64	(0.22)	**
Engages in farming	0.14	(0.12)		0.14	(0.12)		0.14	(0.12)		0.15	(0.12)	
No farming performed on land	1.14	(0.20)	***	1.15	(0.20)	***	1.13	(0.20)	***	1.15	(0.20)	***
Hectares of land	0.00	(0.00)		0.00	(0.00)		0.00	(0.00)		0.00	(0.00)	
Owns livestock	0.05	(0.10)		0.05	(0.10)		0.04	(0.10)		0.03	(0.10)	
Prime landholding is in *ejido*	0.39	(0.14)	**	0.37	(0.14)	**	0.39	(0.14)	**	0.36	(0.14)	**
Financed with loans from bank	-1.24	(0.30)	***	-1.23	(0.30)	***	-1.24	(0.30)	***	-1.23	(0.30)	***
Financed with loans from family or friends	-0.82	(0.23)	***	-0.82	(0.23)	***	-0.82	(0.23)	***	-0.81	(0.23)	***
Community-level capital												
Male participation in agriculture	0.44	(0.27)		0.54	(0.28)	*	0.41	(0.28)		0.52	(0.28)	.
Female participation in manufacturing	0.80	(0.28)	**	0.85	(0.28)	**	0.79	(0.28)	**	0.96	(0.28)	***
Historical region	0.17	(0.10)	.	0.18	(0.10)	.	0.12	(0.10)		0.16	(0.10)	.
Current year moderate or severe drought	0.37	(0.11)	***	0.72	(0.17)	***						
Any experience of drought within past two years	-0.49	(0.10)	***	-0.36	(0.11)	**	-0.42	(0.11	**	-0.35	(0.12)	**
Current year moderate or drought & past drought experience				-0.58	(0.22)	**						
Drought severity and duration - dummy variables												
Current year extreme drought							-0.87	(0.27)	**	-3.04	(1.00)	**
Current year moderate to severe drought							0.33	(0.11)	**	0.69	(0.17)	***
Current year extreme drought & past extreme										2.87	(1.05)	**
Current year moderate to severe drought & past moderate to severe										-0.57	(0.22)	*
Intercept	-1.21	(0.34)	***	-1.29	(0.34)	***	-1.21	(0.34)	***	-1.29	(0.34)	***
Observations	20043			20043			20043			20043		

Notes: ***$p < 0.0001$, ** $p < 0.01$, * $p < 0.05$, . $p < 0.10$

DISCUSSION

Empirical analysis

Climate models predict a 1 ˚C to 6 ˚C increase in average temperature throughout Latin America by the end of the 21st century, along with an increase in water stress and in both the frequency and intensity of extreme weather events (IPCC 2014). The possible effects of such changes on patterns of human mobility have piqued the concern of policymakers around the world and have sparked a surge in scholarly inquiry (Vlassopoulous 2013). Findings from this research, however, are far from consistent, as are their methodological and theoretical underpinnings. This study engages with past research on drought and migration to call into question the assumptions that underlie of a great deal of this work and inform general understandings of vulnerability, migration, and a climate-changed future.

Findings from this study first and foremost highlight the complex and multi-scalar convergence of cultural, political, and economic factors that affect migration. Generally speaking, however, this study lends support to framings of migration as informed by household-level livelihoods and asset characteristics. Model results also suggest that, while migration might indeed represent an important historical or social process, or even rite of passage for some (Durand et al. 1996), households with greatest access to local livelihood opportunities are not the most likely to engage in it. Neither, though, are the most vulnerable households, for whom the resources to engage in such a risky and expensive process are simply out of reach.

In its specific treatment of drought, this study offers a number of improvements over previous estimations of household experience. Methodologically, this study represents the first attempt at downscaling drought measurements in relation to migration in Mexico. Prior studies have all used unweighted state precipitation averages as their drought indicators, relying on a

broad assumption that drought characteristics vary between states but not within their borders. The ecological fallacy implicit in such an assumption is inconsistent with evident concerns, particularly for Nawrotzki et al. (2012) and Hunter et al. (2013), for local patterns of variability. By interpolating PSDI values based on a 100 km buffer, rather than aggregating them to represent state-level experience, this study allows for an analysis of drought at a scale more commensurate with its analysis of local livelihoods.

Results from this methodological approach offer new insight into the potential effects of drought on migration and add nuance to both spatial and temporal scales of analysis. Particularly relevant in light of enduring predictions of increasing drought severity and frequency (IPCC 2007, IPCC 2014), this study finds a non-linear relationship between the magnitude of drought and the odds of household migration. Rather than operating as a universal push factor, my models suggest that the worst droughts exhibit a strong and negative effect on households' ability to engage in international migration. This finding supports recent work by Nawrotzki et al. (2012) and Hunter et al. (2013) and significantly complicates the common argument that social vulnerability drives climate-induced migration (Afolayan and Adelekan 1998; Meze-Hausken 2000).

On the contrary, this study suggests a framing of migration as a *capability* (except in cases of direct displacement), which is inconsistently attractive, but also inconsistently available, to households based on their access to a range of livelihood opportunities (Gray and Mueller 2012; Faist and Schade 2013). The finding that household responses to drought are influenced not only by drought intensity but by duration or frequency as well further calls into question predictions of mass climate-induced displacement. Thus, though previous identifications of a positive correlation between drought (less extreme forms) and migration do find weight in Model

II, this study demonstrates that recurrence of drought, even mild forms, might act cumulatively to constrain mobility.

Knowledge Production

In light of these findings, and their close alignment with a livelihoods framing of "environmental capital" (as either enabling or constraining migration, rather than universally impelling it,) one question this research points to is why such results appear to be so inconsistent with popular expectation and general trends in the environment-migration literature. Why is it that, given the psychological and financial expense of migration, studies finding that environmental stress might actually reduce it are so uncommon as to challenge "conventional" expectations (Feng et al. 2010)? With a brief exploration of this question, the following discussion evaluates this study within the context of other environment-migration work as well as the broader production of climate-related knowledge.

One explanation to the question above might begin with, as a number of scholars have pointed out, a deeply rooted Malthusian approach to human-environment studies, which assumes inevitable conflict between population and resources (Barnett and Adger , 2007; Hulme, 2009; Faist and Schade, 2013). As Faist and Schade (2013) argue, this approach has continually manifested in popular narratives regarding the relationship between migration and the environment. These narratives tend to frame migration as the consequence of environmental degradation, arguing that it, in turn, pushes populations to more fragile lands, creating a cycle of degradation, displacement, and conflict (Hartmann 2010). Indeed, climate-induced conflict studies have received arguably even more scholarly and political attention than climate-related migration (Suhrke 1993; Barnett and Adger 2007, Reuveny 2007, IPCC 2014).

Discussions of climate-related impacts, both in terms of migration and conflict, are thus thinly veiled in concerns for international security as well as a markedly fearful construction of nature. In some sense, the proliferation of climate modeling, stemming from the natural sciences in the early 2000s, provided both the data and methodologies that have simultaneously revitalized a dualistic framing of nature and linked it to notions of security in the post 9/11 world (Oliver-Smith 2012). To date, scholarship exploring the effects of these discursive ties on the production of climate-related conflict and migration knowledge (for examples, see: Liverman 2009; Demeritt 2009; Hulme and Mahony 2010; Hulme 2011) has largely remained the provenance of science and technology research. By and large, environment-migration studies have yet to reflect on their role in reproducing this discourse, an omission that likely contributes to the continual framing of the environment as a driver, rather than enabler, of migration. Addressing the relationship between environment-migration scholarship and the perpetuation of a securitized immigration discourse should therefore be an ongoing priority for researchers, particularly those concerned with such a highly politicized border as that between the US and Mexico.

Along these things, a livelihoods approach was selected for this study for the explicit purpose of complicating Malthusian assumptions of a destructive relationship between people and the environment. However, analysis here indicates that such an approach might actually risk going too far in the other direction, by either underrepresenting the structural causes of poverty or by unintentionally naturalizing the experience of it. For example, despite a concerted effort to critically engage with notions of vulnerability, the variables selected to identify vulnerability at the household scale (such as access to credit and dependence on capital-intensive agriculture) were ultimately insufficient for identifying broader structural relations of power. Those

variables, and the models overall, largely fail to connect the dynamics of household vulnerability to the historical and enduring political economic inequities that tie rural Mexican households to flows of global capital.

Additionally, while a livelihoods approach succeeds in reorienting the process of migration as one of agency rather than determinism, its construction of the "adaptive migrant" might risk naturalizing conditions of insecurity. Critical development theory has thus connected the growing popularity of such concepts as resilience and adaptation with the spread and justification of neoliberal policy reforms (Duffield 2010; Reid 2012). Many of these reforms, of course, directly contribute to the conditions of insecurity under which adaptation is necessary. Indeed, studies have shown that the implementation of NAFTA actually resulted in an increase in migration, despite the agreement's stated intention to reduce it (Riosmena and Massey 2012).

LIMITATIONS AND CONCLUSION

In response to the previous discussion, certain limitations within the model, both theoretical and empirical, identify interesting avenues for future research. Methodologically speaking, an important improvement to the modeling technique used here would be to include multiple levels of analysis. Multilevel modeling would account for the clustering of data and errors within communities and drought buffers, allowing for a more accurate representation of household-level variation. Increasing the number of study and drought-years would also contribute to a more nuanced understanding of drought-migration dynamics. Again, based on the parameters of this study, only 39 of the 143 MMP communities are represented in the results. Widening the study period would essentially increase the number of communities by two per year, contributing both geographical and social diversity to the data. Finally, this study cannot distinguish between quantum and tempo effects and does not account for variability in the

duration of household migration experiences. These distinctions are central for understanding the nuances of changing migration patterns and thus present important opportunities for future work.

In terms of model specification, interaction terms might be added to further investigate the effects of neoliberal economic restructuring on vulnerability and migration responses to drought. In light of Eakin's (2005) findings, indicators of market integration might look at the percent of land grown for market production, rather than subsistence, and interact those terms with drought experience. Similarly, as this study did not take into account agricultural specialization at either the regional or municipality scale, future studies might incorporate measures specifically related to export crop production. Exploring the effects of changing environmental conditions on coffee cultivation, for example, might contribute to the identification of possible spatial patterns in drought-related migration as well add nuance to understandings of the link between trade liberalization and population movement (Gay et al. 2006).

Finally, this study highlights the challenge of defining and then modeling vulnerability, agency, and motivation. While a sustainable livelihoods framework demonstrates significant methodological advantages in relation to more econometric techniques for understanding drought-migration dynamics, it is self-limiting in that it focuses only the household scale. Accounting for the broader relations of power that shape not only agricultural and social landscapes, but discursive ones as well requires reflective engagement in the process of knowledge production. Scholars interested in the environmental dynamics of population movement must thus take care to position their own knowledge and assumptions within such a highly politicized field. The statistical analysis included in this study should therefore inform,

though not limit, future qualitative research geared toward the inclusion of more localized knowledge and experience.

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APPENDIX

TABLE A1
DISTRIBUTION OF HOUSEHOLDS WITHIN COMMUNITIES

	Community ID	Number of Households
	53	106
	57	221
	58	110
	62	161
	67	82
	68	110
	75	107
	78	197
	79	150
	81	100
	86	151
	92	105
	94	167
	96	167
	99	142
	100	97
	101	101
	102	193
	103	98
	104	150
	105	105
	109	96
	111	101
	113	103
	114	119
	116	157
	117	155
	120	165
	122	200
	125	199
	127	100
	128	147
	131	97
	135	204
	136	146
	137	95
	139	100
	142	150
	143	100
Total	39	5,177

TABLE A2
DISTRIBUTION OF WEATHER STATION DATA

	Weather Station ID	Number of Households
	6040	523
	8040	297
	8107	150
	10017	107
	11024	97
	13074	309
	14066	365
	15126	323
	16144	193
	17028	312
	19048	151
	22063	195
	25045	161
	25062	252
	27083	250
	29002	167
	29031	142
	30075	482
	30192	105
	30229	150
	31019	346
	31042	100
Total	22	5,177