Resilience and Vulnerability of River-Side Communities to Environmental Shocks in Loreto and Ucayali Regions, Peruvian Amazon

by

Laura Donohue
Supervisor: Prof. Oliver T. Coomes
Reader: Prof. Sarah Turner

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Department of Geography
McGill University
Montréal (Québec) Canada

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Abstract

Amazonian rivers provide significant opportunities for floodplain agriculture but also bring destructive floods, cause riverbank slumps, and force communities to relocate. This thesis aims to assess the resilience and vulnerability of river-side communities to environmental shocks in the Regions of Loreto and Ucayali of eastern Peru. Using data from the Peruvian Amazon Rural Livelihoods and Poverty Project (PARLAP), this study applies multivariate statistical techniques and mapping to identify patterns in community vulnerability among 919 communities along four Amazonian rivers. I find that riverbank slumping is a greater threat to community stability than large floods, and that the most vulnerable communities are those located in the floodplains without complementary access to land in the upland, often relocating to riskier locations. Sub-regional heterogeneity in environmental shocks and community stability is considerable, and initiatives aimed at reducing rural poverty must consider this variation in adapting strategies to the specific locales they target.

Chapter 1: Introduction

The 10-day weather forecast for Iquitos in November depicts the archetypal Amazon. It will be 34 degrees Celsius, but will feel close to 45 degrees, the air thickly saturated with water. There are thunderstorms today, as there will likely be tomorrow, the next day, and the foreseeable weeks. Peru's wet season is just beginning, and with its torrential downpours comes rising rivers, brimming with floodwaters that will overflow riverbanks and spill onto the vast floodplain. It is here that river-side communities face their biggest challenges as each tributary pulses with not only water, but also risk and opportunity.

As the Andes erode, sediment-rich rivers travel hundreds of kilometers down to the Peruvian lowlands. Here, the rivers leave nutrient-rich mudflats that are propitious for the planting of cash crops by *ribereños*, the mestizo people of the river (Takasaki *et al.*, 2001; Laraque *et al.*, 2009). Indigenous and mestizo communities are able to harness the dynamic floodplain as a source of livelihood, adjusting and working with the unpredictable flood regimes of the Amazon and facing the extreme challenges that come with living along flood prone, meandering rivers (Chibnik, 1994; Abizaid, 2007). As the rural poor in Amazonia often lack formal livelihood safety nets they must build their own anticipatory and responsive coping mechanisms to environmental shocks (Abizaid, 2007).

Past research highlights the differences in riverine rural economies (Coomes, 1998; Takasaki *et al.*, 2001) and varied responses to adverse conditions along Amazonian tributaries (Takasaki *et al.*, 2004; Coomes *et al.*, 2010; Takasaki *et al.*, 2010). Biophysical characteristics differ markedly from river to river in the Peruvian Amazon (Kalliola *et al.*, 1993) as do resource abundance and livelihood strategies (Coomes, 1998;

Chibnik 1994). To capture degrees of specialization, intra-community inequalities and asset levels, research on the rural poor in this region focused on the household scale. While this is advantageous in measuring differences in resource use and shock response in specific locales, it does not lend itself to large-scale models of shock vulnerability or of the movement of villages through time. Community stasis is not a reality when riparian people are constantly adjusting to the migratory nature of Amazonian rivers (Abizaid, 2007; Chibnik 1994). Individual mobility is known to aid in the subsistence activities of Amazonian agriculturalists (Newing, 2009), but community level movements are often overlooked. As village location may change to cope with floods, riverbank slumps, resource depletion and inter-community clashes, analysis at this scale is able to offer insights into specific risk aversion tactics and coping mechanisms at the community level, and thus inform policy, NGOs, and regional departments operating at this, and higher, scales.

Rural development and poverty alleviation initiatives will falter if they are not founded on a solid understanding of the array of coping mechanisms already employed by local communities and the people who know the land. Study of communities along four Peruvian rivers in the country's northeast will contribute to a deeper understanding of these mechanisms by presenting the patterns of risk and vulnerability to environmental shocks in the region.

1.1 Peruvian Amazon

Approximately 1.46 million people, less than 5% of the nation's total, populate Peru's interior (BCRP, 2012, 2013). The Region of Loreto covers 28.7% (368 852 km^2) of the country and borders Ecuador, Colombia and Brazil (BCRP, 2012). Ucayali Region, just south of Loreto (see Figure 1), covers 102 411 km^2 (BCRP, 2013). Average annual monthly temperatures vary between 22°C and 32°C, and the study region's humid, moist, tropical climate peaks in temperature from October to January (BCRP, 2012, 2013). While much of the interior can be classified as non-flooded upland, the floodplains are alluvial landscapes covered with scrawling riverine meanders, ridges, swales and lowland marshes (BCRP, 2012, 2013). Population densities are low compared to the coast, but Iquitos, the largest interior population hub, is home to some 500000 people and is one of the largest cities in the world accessible by only air and river (INEI, 2007). This urban center has grown steadily since the 1960s (Santos-Granero & Barclay, 2000) and is of high economic importance to surrounding communities, many of whom utilize the markets, secondary schools and hospitals of the city. Approximately 211 600 people live in Pucallpa, the capital of Ucayali Region (INEI, 2007). Many *ribereños* are drawn to urban economic opportunities of Iquitos and Pucallpa, and rural-urban linkages only strengthen as the cities sprawl (Santos-Granero & Barclay, 2000).

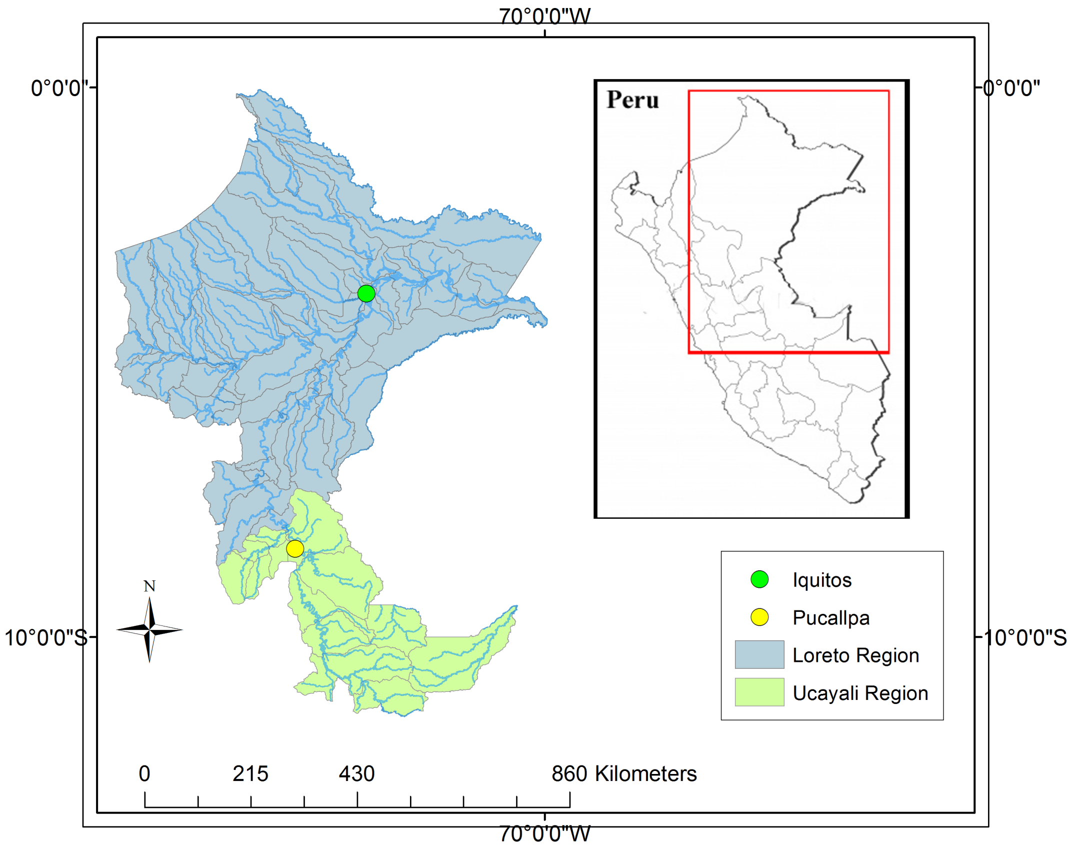

Figure 1: The Regions of Loreto and Ucayali and their capitals. Graphic by author. Data from the PARLAP project (2015) and the GADM database (2012).

Resilience in the fluctuating Amazon floodplain is thought to be the result of diversity in both resource management and recovery mechanisms (Pinedo-Vasquez, 2010). Though *ribereños* may self-identify as farmers, agriculturalists in this region practice a wide portfolio of activities for subsistence and income (Coomes, 1998). Agroforestry, non-timber forest product (NTFP) extraction, harvesting of timber, fishing and hunting complement agrarian livelihoods, and the mix of these practices is largely determined by the attributes of specific locales (Chibnik, 1994; Coomes, 1998). Dietary staples of *ribereños* include manioc and plantain, in addition to yams, sweet potato and a wide array of fruit that are largely eaten by children (Chibnik, 1994; Coomes, 1998). Fishing provides the main source of protein and, to a lesser degree, hunting, though this is variable by community location (Chibnik, 1994). Means of subsistence vary geographically and socially, as do disparities in wealth (Abizaid, 2007). Though the majority of the population lives below the national poverty line of $2 U.S. per day per person, there are substantial differences in access to resources that influence household and community level livelihoods and resilience to hazards across the region (Chibnik, 1994; Takasaki *et al.*, 2001).

Land availability and fertility is a key determinant of dominant livelihood strategies (Takasaki *et al.*, 2001, 2010). Figure 2 illustrates the main categories of land utilized in flood recession agriculture. The upland, which is never flooded, even in extreme events, is suited for the cultivation of subsistence crops such as manioc and plantains (Chibnik, 1994) and agroforestry plots (Takasaki *et al.*, 2004). Lowland *barreals*, or mudflats, are the most nutrient rich soils available for crop production (Chibnik, 1994). Replenished by sediment from annual flooding (Laraque *et al.*, 2009), mudflats are used to farm cash crops such as rice, making them an important economic resource (Chibnik, 1994). Unexpected or early flooding can result in the loss of market-bound crops and cash income, as rice is the largest single source of revenue in many *ribereños* villages (Chibnik, 1994). Because of the increased likelihood of crop loss to flooding, lowland agriculture is often characterized as "high-risk-high-return" (Takasaki *et al.*, 2004, p. 209).

In addition to land-type availability, location acts as a key asset to riverine communities as it defines a community's proximity to markets and natural resources (Salonen *et al.*, 2012). Those close to urban centers also tend to receive more governmental aid in the wake of an environmental disaster (Chibnik, 1994). Beyond this post-shock assistance from the state, remittances from family are cities is also of growing importance to rural agriculturalists (Adger *et al.*, 2002).

The benefits of peri-urban locations can be weighed against the trials of market-dependency as urban markets in the Amazon have the potential to be volatile (Doiran, 2013). Accordingly, diversifying income sources across urban and rural sites is thought to facilitate livelihood security (Barbieri *et al.*, 2009), and multi-sited households are common in the region (Gregory, forthcoming, Pinedo-Vasquez & Padoch, 2009) .

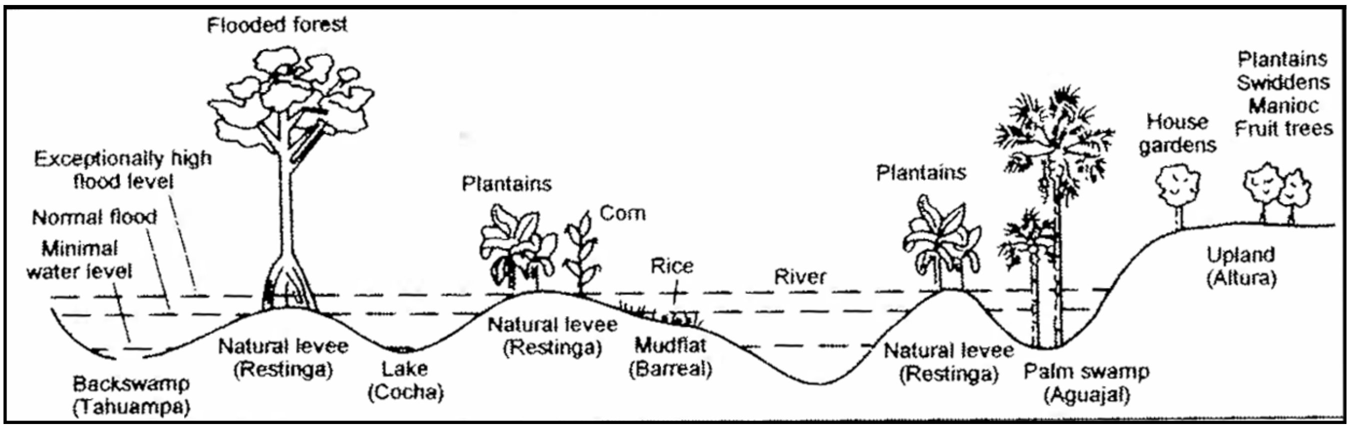

Figure 2: Primary land types and land uses in the Peruvian Amazon (From Chibnik, 1994, p. 22).

1.2 Environmental Risk

The loss of crops to large floods can be devastating to *ribereños*, but so can other threats. Along the central Ucayali, the main threat to well-being has been reported to be riverbank erosion (Abizaid, 2007). Unlike the main stem of the Amazon river, which is relatively stable, the Ucayali laterally migrates more rapidly (Kalliola *et al.*, 1992). This migration can fuel not only avulsions (channel abandonment or river recession), but erosion on the degrading cut bank that leads to riverbank slumps (Kalliola *et al.*, 1992). River recession, whereby a river moves way from a community, as for example when a point bar expands, can equate to the loss of access to fish and the river network, which is integral to intra-regional travel (Chibnik, 1994; Coomes *et al.*, 2010; Salonen *et al.*, 2012). Highly mobile rivers also create and destroy channel bars and mudflats (Abizaid, 2007). Lakes can become overgrown with vegetation and close, eliminating sites where fish would have been caught for sustenance and sale (Pinedo-Vasquez, 2010). The responses to environmental shocks are broadly characterized as *ex-ante* mechanisms, such as income diversification and *ex-post* strategies, such as asset-liquidation, wherein resources are sold or exchanged for goods and food to cope with shock (Takasaki *et al.*, 2004).

1.3 Research Aim

To date, research in the study region has focused on small numbers of communities in the vicinity of the two major cities, Iquitos and Pucallpa. Additionally, conservation tends to be of higher prominence in these studies than poverty. The Peruvian Amazon Rural Livelihoods and Poverty (PARLAP) project, described later, was developed with the objective of providing a greater understanding of rural poverty in the Amazon and to address to the lacunae in previous research on livelihood and poverty in the region. The present study draws on data from the PARLAP project and aims to describe the resilience and vulnerability of communities to environmental shocks in the Regions of Loreto and Ucayali.

This thesis is guided by four questions:

(1) how prevalent are environmental shocks faced by rural communities and what are

their impacts?; (2) what factors predict community migration?; (3) what explains the spatial patterns observed in environmental shocks and community relocation?; and (4) what are the underlying social patterns to resilience and stability in the face of shocks?

1.4 Thesis Structure

The following chapter presents the conceptual framework that guides and informs analysis undertaken in this thesis. Chapter 3 details the methodology used in data collection and analysis. Current conditions in the study region and the inter-regional differences in natural endowments are described in Chapter 4. Chapter 5 analyses shock incidence by communities and their characteristics, and Chapter 6 explores relationships between community movement and shock occurrence. The thesis concludes with a discussion and summary of main findings in Chapter 7.

Chapter 2: Conceptual Framework

The wide variability of livelihood portfolios discussed in Chapter 1 is consistent with Bebbington's (1999) framework for analyzing income strategies of the poor in the global South. Just as a single occupational title cannot summarize the strategic diversity of work the "average" *ribereños* completes, there is no singular measure of wealth that accurately denotes who is rich or poor within and across communities. Moreover, important differences exist in community land assets that condition the prospects and vulnerability of their households. For this reason, community level attributes and their varied effects on stability will be explored in this thesis. Three literatures are relevant to the thesis aim – the first draws on work that describes rural assets and examines how lack of access to these assets can fuel chronic poverty. Second, the literature on vulnerability is important to interpreting what fuels resilience in shock-prone systems. Finally, we draw on a sustainable livelihoods approach and mobilities literature to assess livelihoods in terms of their temporal and spatial viability.

2.1 Capital & Poverty Traps

2.1.1 Measuring Assets & Barriers

The human-environment system from which the rural poor draw resources is complexly intertwined. The five types of capital that constitute rural assets in the global South are defined as physical, human, social, natural and financial in nature (Bebbington, 1999; DFID, 1999; Ellis, 2000). These categories roughly translate to transport, shelter and water (physical needs), health and knowledge (human capital), networks and relationships (social capital), tangible and intangible natural resources (natural capital), and liquid assets (financial capital) (Sen, 1981; DFID, 1999; Ellis, 2000). The various forms of capital employed by the rural poor, often depicted in the form of an asset pentagon, are the means of generating monetary income but also hold cultural and social significance (Bebbington, 1999). In expanding livelihood analysis to the community scale, this thesis will focus on attributes that affect multiple forms of capital and will attempt to account for factors that alter access to assets (Ellis, 2000).

Livelihood frameworks can be useful for assessing the multiple means of making a living and how capabilities can be obscured by poverty (Scoones, 2009). These same frameworks can also be reflect Western biases which frame only specific means and forms of capitals as positive and put forth presumptions of "progress" and "development" of a very specific political mindset (Scoones, 2009). In light of this, a focus on local and regional politics and how these may alter individual access is useful in understanding power relationship and their effect on assets (Scoones, 2009). To understand the resilience among riverside farmers in Amazonia, the inter-community relationships that drive fissioning and community relocation should not be obscured by ideals that equate locational stability with success.

2.1.2 Poverty Traps

Poverty is defined as an inability to meet basic human needs and results from both geographic and socio-political determinants (Sen, 1981; DFID, 1999; Swinton *et al.*, 2003). Tracing how these determinants temporally shift can allow for identification of who was unable to take advantage of situations that benefitted other groups (Barrett *et al.*, 2006). How have opportunities in the past been acted on and what barriers limit income and asset growth (Barrett *et al.*, 2006)? The persistence of barriers that perpetually prevent people from meeting their basic needs and improving their well-being are termed *poverty traps* (Barrett *et al.*, 2006; Carter *et al.*, 2007). *Geographic poverty traps* occur in environments "where the underlying agro-ecological conditions, market access, or socio-political stability—or some combination of these—are such that there exist few pathways out of poverty in the absence of significant external interventions" (Barrett, 2005, p. 54). Understanding the nature of livelihood strategies requires scrutiny of barriers - "among desirable strategies, the higher the entry barrier, the higher the expected returns to the activity for those who can surmount the barrier, else the strategy would never be optimal and thus never chosen." (Barrett & Swallow, 2006, p. 5). When the optimal strategy is one that can not drive capital accumulation, poverty persists (Barrett, 2005). This is especially evident in shock-prone environments, as the ability to utilize such surpluses to cope with losses from shocks is integral for recovery from losses due to hazards (Dercon, 1998; Barrett, 2005).

Power and wealth, the base of productive assets available and factors increasing access to these assets are mutually reinforcing aspects of capital for which there are often key thresholds (Barrett *et al.*, 2006). Lack of access to state programs, inhibited by a lack of institutional knowledge, can distance people from state structures and prevent them from pressuring these systems to increase accessibility (DFID, 1999). Cooperation and coordination within groups can fortify positive structures that enable asset accumulation while the contrary can hinder progress (Barrett & Swallow, 2006). These examples represent a few of the cyclic traps that create chronic poverty. Interventions at these barrier points have the most potential for systemic change.

Though feedback loops occur at multiple interactive scales, it is the meso-scale that has the least knowledge available on what builds efficacy (Barrett & Swallow, 2006). A broadened analysis of poverty that accounts for the intermediate factors such as market accessibility, community level cooperation and public service access is therefore vital. This is a guiding theme to this thesis, which will attempt to identity key barriers at the community scale. The following section will address interactions between scales when assessing vulnerability.

2.2 Systems of Sustainable Livelihoods, Vulnerability, Risk and Adaptation.

Among the rural poor there is a spectrum of coping ability when faced with shocks. Diversifying the types of capital in use is a strategic coping mechanism (DFID, 1999; Turner *et al.*, 2003), and greater quantities and diversities of assets increase peoples' resilience when facing environmental shocks (Schwarz *et al.*, 2011). Approaches that link humans and ecosystems are useful in understanding the tactics that maximize benefits and minimize risks (Turner *et al.*, 2003; Webb *et al.*, 2010; Schwarz *et al.*, 2011). This thesis draws on the vulnerability framework of Turner *et al.* (2003) and community level vulnerability assessment map developed by Schwarz (2011) for predicting shock exposure and recovery.

2.2.1 Systems Approach

Figure 3 portrays components of vulnerability across multiple scales. Vulnerability is commonly cited as the sum of both exposure to hazards and sensitivity of a system (Ellis, 2000). The household level, highlighted in grey, is where many responses to external hazards occur, and these are deeply influenced by external biophysical and social spheres of the larger system (Turner *et al.*, 2003). The same state, market, and civil actors that govern access to assets also regulate the impact of hazards. Additionally, "… at the supracommunalevel, networks of far less formalized relationships have played an important role in establishing and sustaining alternative, nonagricultural forms of economic activity" (Sen, 1981, p. 2037). Post-shock trajectories are improved by access to capitals at this scale (Carter *et al.*, 2007). Locating the "critical interactions in the human–environment system that suggest response opportunities for decision makers" (Turner *et al.*, 2003; 8077) is a main goal of this thesis.

The vulnerability map in Figure 4 from Schwarz *et al.* (2011) identifies specific assessment factors not offered in Figure 3. This map addresses specific measures to consider in modeling vulnerability and predicting shock responses. Overlapping with the capitals model of the DFID (1999), the key assets highlighted in Figure 2 place emphasis on community level structures that affect resilience such as collective action abilities that improve social cohesion (Schwarz *et al.*, 2011). Figure 4 also indicates the importance of collective rights, which are known to alter the type of survival tactics employed by the rural poor, post-shock (Newing, 2009).

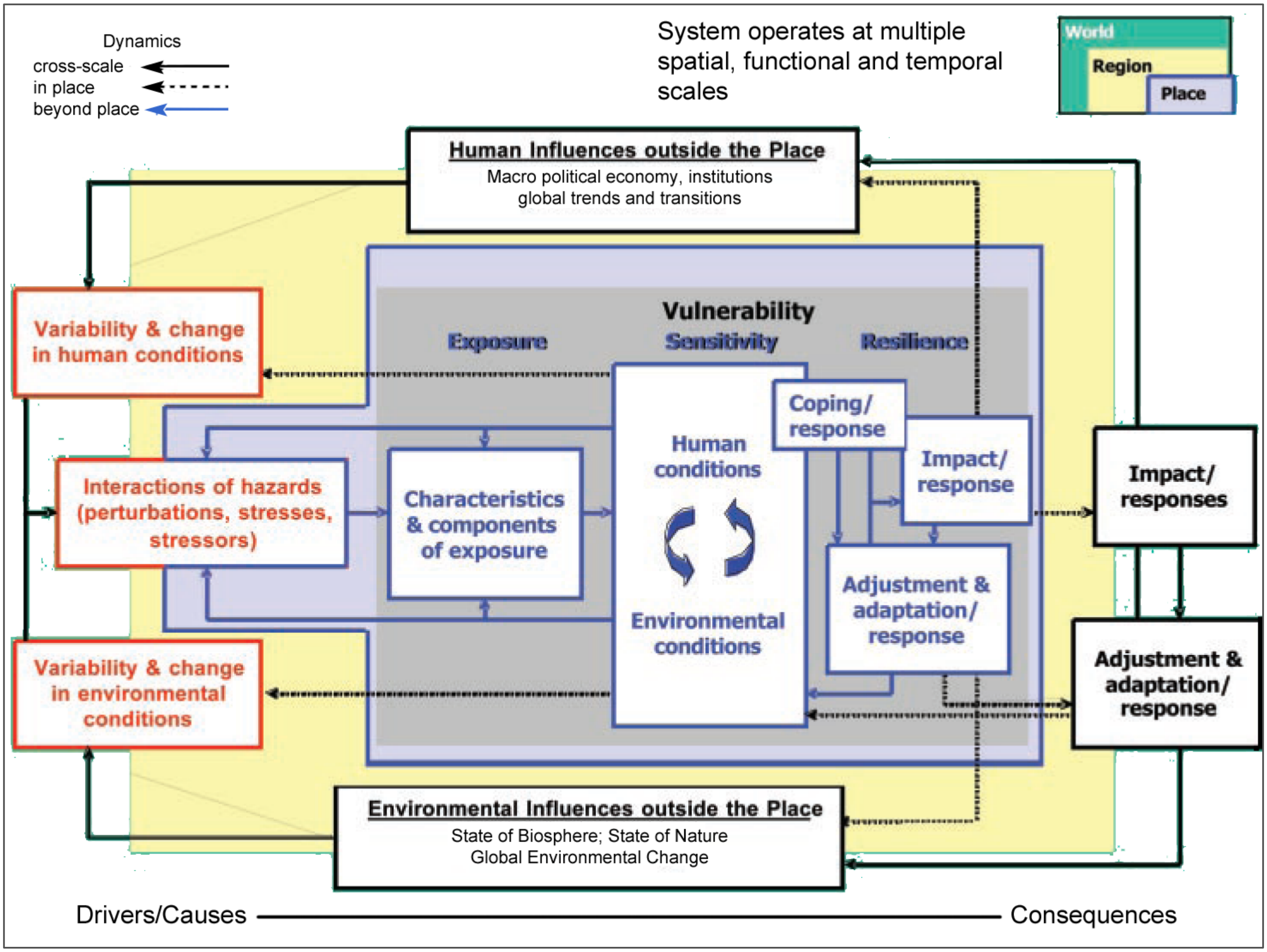

Figure 3: Vulnerability framework from Turner et al. (2003, p. 8077).

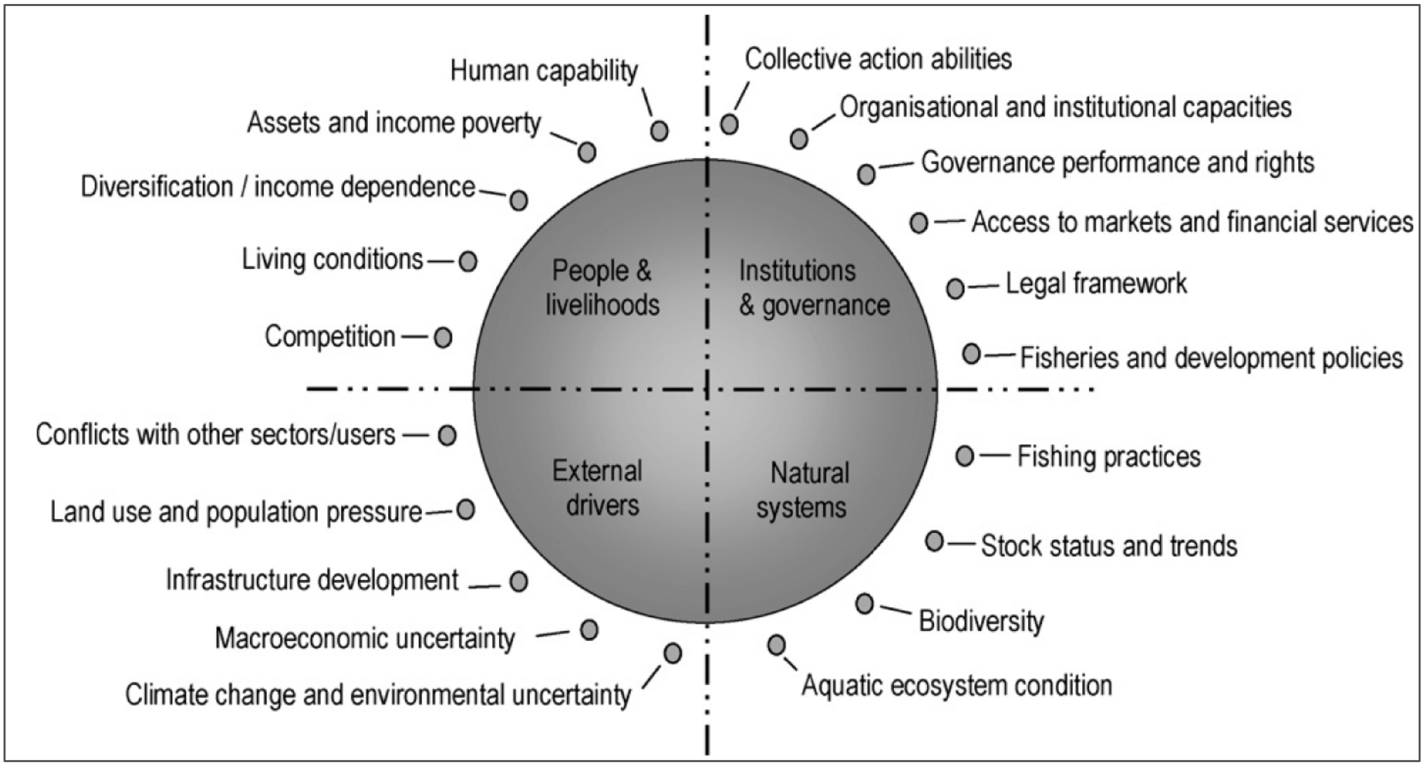

Figure 4: Integrated assessment map used to guide the vulnerability assessment. Schwarz *et al.* (2011, p.1130).

2.2.2 Sustainable Livelihoods

Analyses of resilience and stability would not be complete without accounting for long-term viability. In the literature, long-term viability is captured by the term "livelihood sustainability", wherein assets can be maintained in the face of shocks (Scoones, 1998). Sustainability is not realized if coping mechanisms degrade the resource base upon which these households rely on (Scoones, 1998; DFID, 1999). Additionally, if specific natural assets are lucrative at present, what is the likelihood of asset depletion? Will it "provide… opportunities for the next generation?"(Chambers & Conway, 1992, p. 7). In risk-prone environments where shock response may entail liquidation of assets that would be a source of future income, such concepts become invaluable (Maxwell &

Wiebe, 1999). Strength, steadiness and an ability to create livelihoods more based in choice than necessity aid communities in building their futures (Chambers & Conway, 1992; Ellis, 2000). Without sufficient wealth to invest in sustainable livelihoods communities may degrade current resources, momentarily reducing poverty at the cost of their future well being (Reardon & Vosti, 1995). In determining if asset stability is synonymous with locational stability, this section of my theoretical framework turns to the literature on mobilities.

2.2.3. Mobilities

Challenges faced in the analysis of rural mobility result from the multi-faceted nature of migration. This thesis draws on the classic concepts of “push” and “pull” elements, where people assess the potential positive and negative features of an origin and destination before making their decision to move (Lee, 1966). These risks or *intervening obstacles* (Lee, 1966) have the capacity to act as barriers to migration. Those who “do not have the resources for coping with the damages from natural hazards, other risks, and potential downturns” are often already marginalized and cannot relocate by choice, only by necessity (Adger *et al.*, 2002, p. 360).

Migration, temporary or permanent, is both a cause and result of complex environmental factors (De Haan, 1999; Carr, 2009; Parry *et al.*, 2010). Intra-regional migration is a known adaptive mechanism of indigenous and *ribereños* people living in Amazonian floodplains (Chibnik, 1994; Alexiades, 2009; Carr, 2009). Here it is worth distinguishing between what Binford (1980) terms *logistical mobility* and *residential mobility*, the former referring to the movement of individuals and the latter movements of groups. This thesis will focus on community mobility, but recognizes that "mobility is a property of individuals" (Kelly, 1992, p. 44).

Migration likelihood is governed by the same factors that govern access to assets, i.e., the physical, human, social, natural and financial environments of a specific place (Ellis, 2000; Scoones, 2009). Throughout history the need for subsistence has been characterized as a main force affecting mobility (Kelly, 1983). While resource depletion, environmental hazards, and community rifts can push relocation or fission (Carr, 2009), abundant land and resources (with good access), service provision and the benefits of land rights may draw a community to a particular location (Killick, 2008). This point represents an intersection of institutional and natural drivers of vulnerability, as once land is secured, migration will be less likely in the face of resource depletion (Newing, 2009). As Alexiades (2009) notes, mobility entails movements across transitory political, ecological and cultural boundaries. With these boundaries, the capitals of riverine communities are constantly shifting. How the spatial and social variability of assets affects mobility will be emphasized throughout this thesis.

2.3 Summary

Adaptation and flexibility are key factors in creating sustainable, long term forms of sustenance, and migration is often an important adaptive strategy (Bebbington, 1999). Capital is created, employed and destroyed in response to hazards, and measuring capital at the community scale will focus on factors that create systemic stability. This thesis will focus on the natural, physical, human, financial and social capitals that entail assets outside individual control.

Geographic poverty traps arise in areas deemed “unfavorable” because of their remoteness, lack of natural resources, and exposure to environmental shocks (Barrett, 2006). It is among the poorest groups, those that fall beneath the key thresholds of assets, that covariate shocks will do the most damage and result in the highest reduction in asset holdings. This thesis is based on the premise that these losses emanate outwards to broader changes in investments in social structures and educational achievement that perpetuate community vulnerability to shocks. Recognition of livelihood sustainability can be beneficial in informing asset analyses. The conceptual framework outlined in this chapter guides the empirical analyses and informs the assessment of spatial patterns of shock incidence and responses.

Chapter 3: Methods

This thesis employs descriptive analyses and multivariate modeling of community vulnerability to environmental shocks utilizing data from the PARLAP project. The following chapter will describe the motivations for the PARLAP project, methods utilized in survey design and administration, and the statistical techniques used in data analysis.

3.1 PARLAP Project

PARLAP is the largest poverty-focused survey as yet to be conducted in the Amazon basin. The project is a collaborative work conducted by researchers from McGill University (Prof. Oliver Coomes and Dr. Pablo Arroyo), University of Toronto (Prof. Christian Abizaid) and the University of Tokyo (Prof. Yoshito Takasaki) and is funded by grants from the Japan Society for the Promotion of Science. The PARLAP project aims to provide both community-level and household-level data that identifies the distribution and determinants of rural poverty in the Peruvian Amazon basin. Data collection was conducted in two phases: 1) a community level census undertaken in 2013-2014, and, 2) a household level survey that is currently underway.

3.2 Data Collection

Seven sub-basins were selected for study in the PARLAP project along the Amazon River, Napo River, Pastaza River and Ucayali River in Loreto and Ucayali regions (see Figure 5). These study sites were selected to ensure regional coverage and to capture the diversity of endowments, settlement conditions (e.g., upland and lowland), ethnicities, and varying distances to markets. Rather then administering surveys among a sample of communities, a census of communities was conducted in the study sub-basins. Results of a pilot test undertaken in the Mazan District (lower Napo river, see Figure 5), in which all communities in the District were visited, were compared to those of the 2007 National Census (conducted by the *Instituto de Nacional de Estadistíca e Informatíca,* INEI) and to a map of communities in the District developed by the *Instituto del Bien Común* (IBC), a Peruvian NGO that supports indigenous groups in Amazonia. Comparisons of results from the pilot test and the data from the INEI and the IBC yielded inconsistent numbers and locations of communities. As such, there was no reliable basis available for designing an effective community sampling protocol, and a complete census of communities in each sub-basin was required.

The census was conducted by two teams of four Peruvian interviewers based in Iquitos and Pucallpa. Community locations were determined using both the 2007 National Census and satellite imagery, and the teams revised the community list while surveying to ensure that all communities were identified and reached. One to two days were spent in each community to conduct the survey, where the teams met with village leaders and sought permission to conduct the interviews. Once permission was attained a focus group meeting was held with leaders and village elders, guided by a structured questionnaire. The questionnaire consists of nine pages that solicit detailed quantitative and qualitative information on community history, changes in resources, and locational attributes (Appendix A).

The specific questions from the questionnaire that are relevant to this thesis are those that are related to the environmental shocks that each community has experienced, the type of land available, community ethnicity and history. Data on environmental shocks were collected through retrospective questions. Communities were asked, “has the community ever experienced [environmental shock]?”Although dependent on participants’ memory, respondents were able to vividly recall the most extreme and disruptive events (also noted in Abizaid, 2007).

As the impacts of environmental shocks were recorded through free-listing, participant responses to shocks (i.e., the impacts of each shock) were coded as binary variables, indicating ‘yes’ results for communities that mentioned a specific consequence (e.g., the loss of planted crops or building damage). Given that this data set is based on a complete census in the river sub-basins, the summary statistics provided in subsequent chapters are taken to be true to the population.

After questionnaires were compiled and each digitally photographed they were electronically transferred to McGill and entered into a Microsoft Access® database before being converted to Stata® format (.dta). Project staff cleaned the data prior to analysis.

3.3 Data & Mapping Analyses

The community database consists of approximately 1400 variables describing the conditions in 919 communities. Analyses reported in this paper focus on a subset of 54 variables, primarily a mix of binary and string variables (see Appendix A for list of relevant variables). Stata/IC11.2® was used to compile tabulations and to conduct multivariate statistical analysis. The probabilities reported in the following analysis of shocks and movements are the frequencies of ‘yes’ answers to the respective survey questions. Model specification was informed by theory and known empirical relationships, and aimed at identifying the community differences that contribute to environmental shock exposure and community relocation. For the remainder of this thesis, community founding will refer to the year wherein the residents decided to settle the first site as a distinct community. Community establishment will reflect the year wherein the community (already founded) settled in the site it is located in at present.

Data were mapped to permit visualization and identification of patterns of community landholdings, ethnicity, environmental shocks and the frequency of community movement across basins. Shapefiles (.shp) of the river networks and District boundaries were provided by the PARLAP project (PARLAP, 2015). For the community point shapefiles, the .dta files used for empirical analysis in Stata® were converted to a .dbf file in Microsoft Access®. Following this, the community points were uploaded to ArcMap10.1® and projected utilizing the latitude and longitude coordinates taken at the football field of each community. Football (or soccer) fields were used as centroids because every community has a field and they are considered to be the center of the community. Shapefiles of each sub-basin, the regional borders and river networks were utilized in maps for context and for further visual analysis of patterns. Communities were color-coded by their attributes (e.g., ethnic identity, landholdings, if they had experienced a shock) in the thematic maps presented in this thesis. These maps, combined with the statistical analysis, provide the basis for analyses presented in the following chapters.

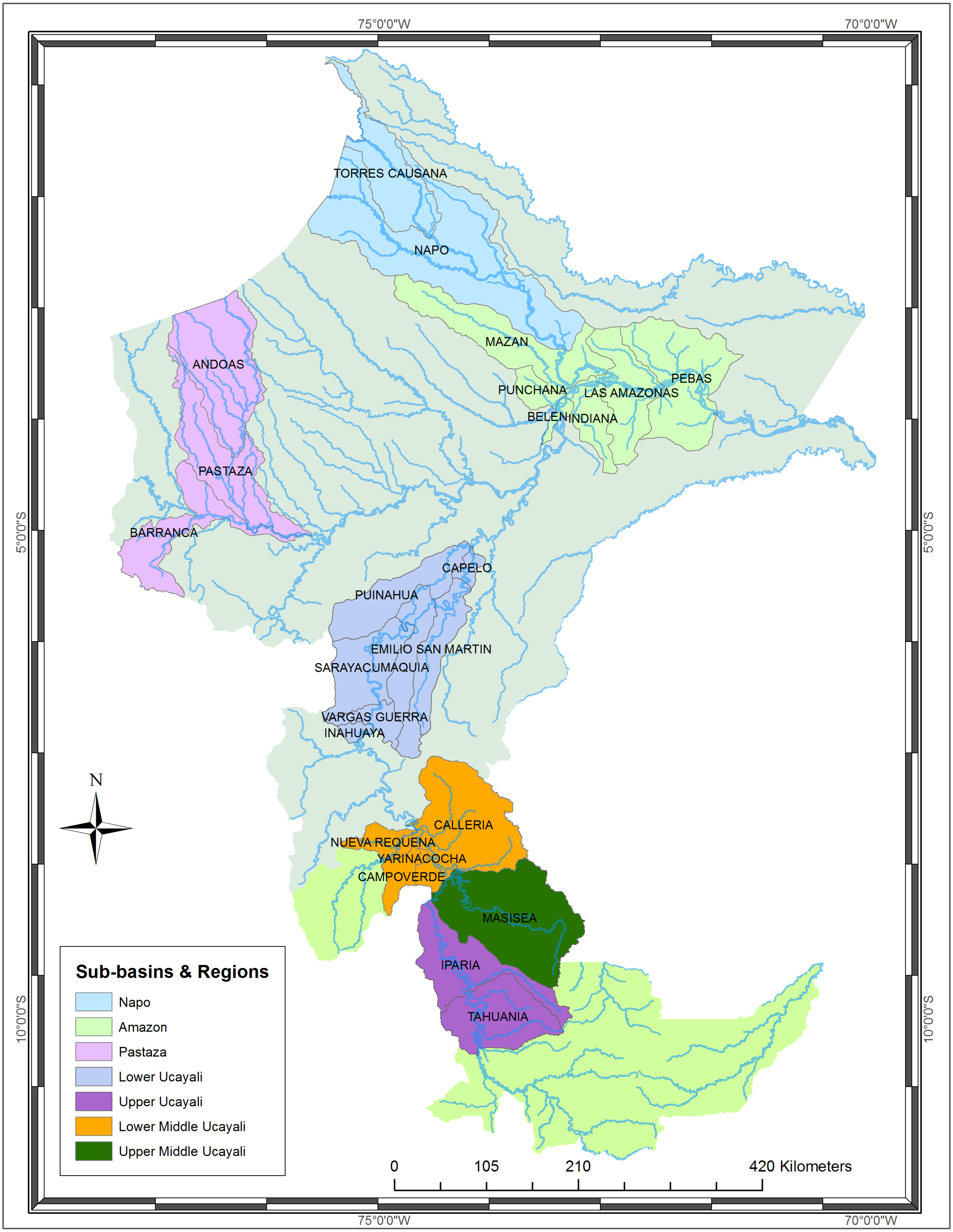

Figure 5: Map of study river basins and Districts.

Chapter 4: Study area

The diverse array of resource use and livelihood portfolios in rural Amazonia is known to stem from differences in land availability, local resource endowments and geographic remoteness among *ribereños* communities (Takasaki *et al.*, 2001). The following chapter describes briefly the demography, geography and key resources of the seven sub-basins analyzed in the PARLAP project.

Amazon River sub-basin

The Amazon River sub-basin is the smallest sub-basin in the study area (see Table 1). Communities in this sub-basin are predominantly non-native and located in the lowland. This sub-basin extends from Iquitos to the mouth of the Napo River (see Figure 6). Because of minimal access to upland landholdings and proximity to Iquitos, communities here report that many key timber and game species cannot be found near the community (Donohue & Coomes, 2014, unpublished report). Fish, game and timber are concentrated in older communities, which may be established in the better locations. Four communities in this basin identify as part of the Cocama-Cocamilla ethnic group (See Appendix A for a full list of ethnic groups and map of native community distribution).

Napo River sub-basin

The 177 communities in Napo River sub-basin are characterized by their relative evenness in landholdings and ethnic identity (see Table 1). Relative to the Amazon sub-basin, communities exhibit greater spatial dispersal from each other in addition to minimal differences between resource-rich and resource-poor communities in terms of game, fish and timber (Donohue &

Coomes, 2014). Thirty-one communities in this sub-basin identify as Quechua.

Pastaza River sub-basin

The Pastaza is primarily is comprised of native and upland communities and is the most remote basin surveyed in the PARLAP project (see Figure 6). In contrast with other sub-basins, game is reportedly abundant in Pastaza communities and harvests of game and fish are high basin-wide (Donohue & Coomes, 2014). Five non-native communities located near the mouth of the Pastaza River tributary do though report low harvests of these resources (Donohue & Coomes, 2014). Twelve communities in this basin identify as part of the Achuar ethnic group, 32 as Kandosi and 28 as Quechua.

Ucayali sub-basins

The proportion of upland and native communities rises from down-river to up-river along the Ucayali. Unlike other sub-basins, along the Ucayali River there are fewer native communities in the upland than non-native communities. Minimal upland is available in the Lower Ucayali sub-basin, and game is abundant in non-native communities (Donohue & Coomes, 2014). Fish are a key resource to communities in this sub-basin as harvests peak here. The Lower Ucayali is unique in that resource abundance appears to be highest among the youngest communities, whereas in the Amazon, Pastaza, Middle and Upper Ucayali sub-basins the more key species are found in the oldest communities (Donohue & Coomes, 2014).

The Lower-Middle, Upper-Middle and Upper Ucayali sub-basins have minimal fish stocks with average harvests of 8kg per good night of fishing (in contrast with an average of 50kg per night in the Lower Ucayali, see Donohue & Coomes, 2014). When moving upstream from the Lower Ucayali to the Upper Ucayali sub-basin, the number of native communities increases. In the Lower Ucayali sub-basin there are 33 Cocama-Cocamilla communities, four Shipibo communities, one Quechua community and one Aidesep community. The are 23 Shipibo-Conibo communities in the Lower-Middle Ucayali and 21 in the Upper-Middle Ucayali. The Upper Ucayali has a sizable Ashaninka population (37 communities) and Shipibo-Conibo population (35 communities) as well as seven Shipibo communities. The city of Pucallpa is located in the Lower-Middle Ucayali sub-basin.

Table 1: Community attributes by river sub-basin.

	Amazon	**Napo**	**Pastaza**	**Ucayali**			
				Lower	**Lower Middle**	**Upper Middle**	**Upper**
Area (km^2)	2 623	34 848	21 299	29 695	17 342	15 511	15 154
Elevation (mean masl)	92.3	98.3	130.3	113.9	151.9	161.5	175.1
Number of Communities	140	177	115	176	141	70	100
Number of Residents	43 438	49 449	24 968	86 453	27 339	15 160	28 231
Upland (%)	30.7	58.8	58.3	13.6	39	71.4	56
Native (%)	15.0	15.1	88.7	39.2	19.2	35.7	81
Year Founded (mean)	1956	1963	1970	1949	1969	1975	1973
Year Established (mean)	1964	1969	1973	1973	1980	1980	1984

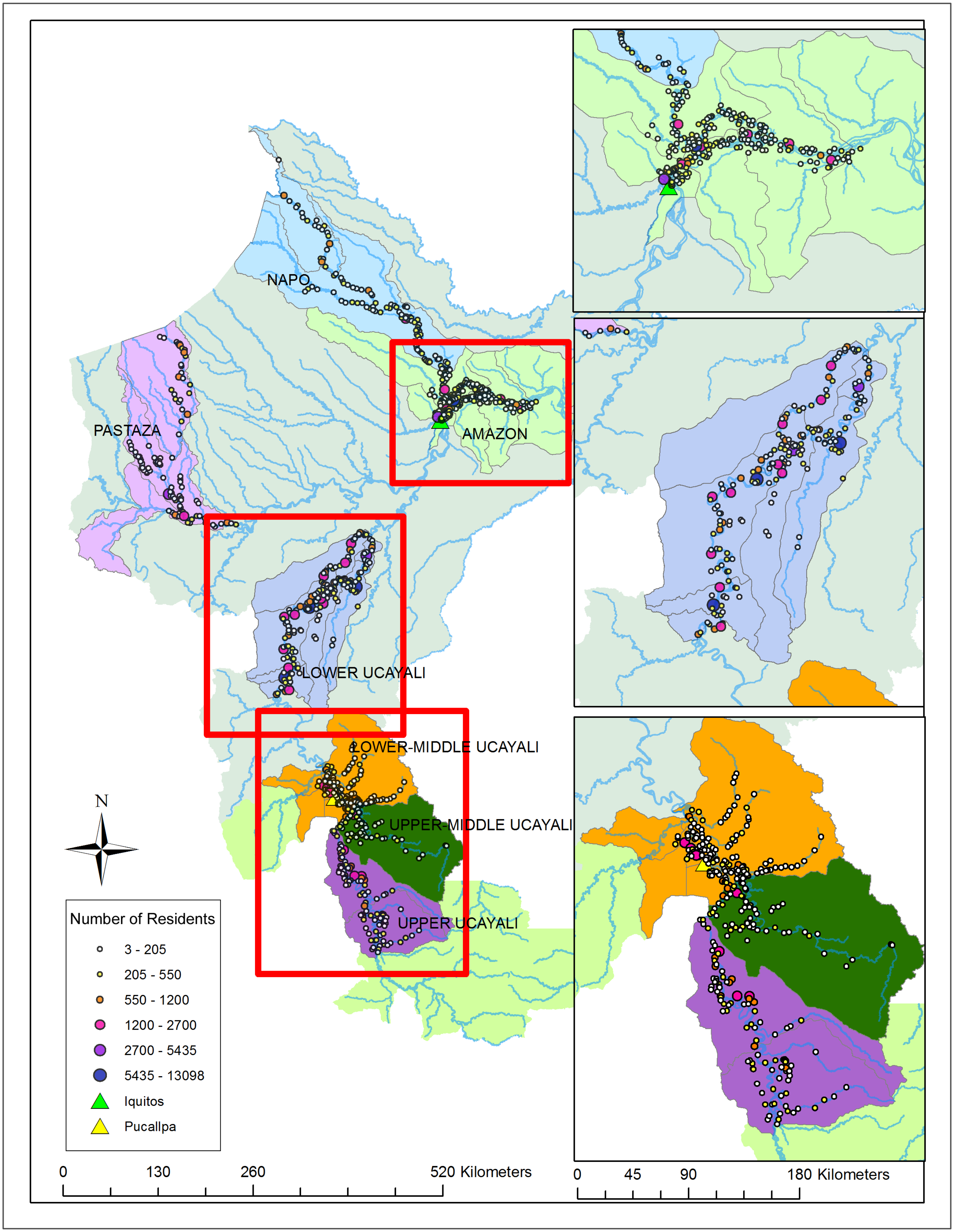

Figure 6: Study community location and size.

Chapter 5: Community Location & Environmental Shocks

As discussed in Chapter 3, community location plays an important role in determining the abundance of local natural assets. Choices in community siting also influence exposure to environmental hazards, as upland areas, typically richer in game and timber, can also serve as insurance in the face of large floods (Takasaki *et al.*, 2004). In the lowland the opportunities for market agriculture on the mudflats make investments in the floodplain attractive, but these investments have the potential to be lost to large floods, riverbank slumping or riverine recession.

The following chapter addresses the research question of quantifying the occurrence of environmental shocks; specifically floods, epidemics, riverbank slumps, river recessions, lake closures, mudflat losses and mudflat gains. The importance of resources and risks in location choice are highlighted, in addition to the community attributes that heighten vulnerability. Finally, the spatial distribution of riverbank slumps along the study rivers is mapped.

5.1 Community Founding

When attempting to ascertain the link between community location and exposure to environmental shocks, a natural starting point is to examine what drives the original founding decision. Table 2 identifies the reported reasons for community founding in the original location. The most important pull factors to a site are the availability of natural resources and agricultural land (cited by 29.5% and 24.3% of communities, respectively) and the most common push factors are escaping riverbank slumps (16.9% of communities) and community division (11.8%).

As locational choice differs substantially between native and non-native communities, it is intuitive that decisions for choosing the founding location would also diverge. Table 2 indicates

that non-native communities are more frequently concerned about access to agriculture and natural resources than are native communities. Social drivers of location, such as community fissioning and school access, have heightened importance among indigenous communities (32% of communities) relative to non-native communities.

A key factor that has influenced all communities, whether they are native or non-native, is the type of land being sought (see Table 2). Lowland communities that only have lowland landholdings report having chosen this location because of better access to agricultural land, more so than other communities. In contrast, upland communities with land only in the upland report being influenced more by community division and school access than other communities when choosing a site.

5.2 Community Fission

Communities may divide or "fission" if discord or internal conflict becomes acute; families leave *en masse* and seek to found a new community elsewhere. One hundred and nine communities (11.8% of survey) reported having fissioned or separated at a previous location as a reason for founding, but over 20% have reported experiencing fissioning in their current location (see Table 3). About 30% of these communities (n=70) reported the reason for community fission. The most frequently reported causes were social and resource conflicts (28.6% and 21.4%, respectively). Riverbank lumps and large floods also are reported to have lead to separation

(18.6% and 15.9%, respectively). Thus, large covariate shocks are not only a driver of original founding location, but act to motivate community fissioning.

5.3 Environmental Shocks

Among the greatest threats exacerbating cyclic poverty for riverine communities are those environmental shocks that directly degrade assets vital to coping mechanisms (Abizaid, 2007; Alexiades, 2009). Floods and droughts can cause crop losses, and in more dramatic instances can result in losses of houses and livestock, which are vital to resilience (Takasaki *et al.*, 2004). River recession reduces access to fish and fresh water. Epidemics such as cholera, malaria and dengue fever also threaten rural Amazonians, occasionally being worsened by flood occurrence (see Appendix B). Along with floods and epidemics, riverbank slumps are a major hazard to riverine communities. Bank slumping occurs on instable riverine cut banks, which are progressively eroded as the channel path migrates laterally (Abizaid, 2007). Valuable mudflats are lost in certain locales as river channels migrate and the floodplain changes course; in others mudflats are created, providing new farming opportunities for nearby communities. The following section reports on the prevalence of environmental shocks experienced by communities.

5.3.1. Shock Occurrence

The most prevalent shocks in the study region are floods and epidemics, having been reported by 82% and 76% of communities, respectively (see Table 4). Slumps have occurred in 33% of communities, and are notably concentrated along the main tributaries of the major rivers (see Figure 7). This pattern is most evident along the Lower-Middle Ucayali, where there is the densest proportion of communities that are located in the lowland and only have lowland landholdings. Communities along lower-order rivers have rarely experienced slumps in contrast to those along the Ucayali river, where many have reported a large riverbank slump. The frequency of the other river-associated shocks is as fallows: river recession (53%), lake closure (25%) and mudflat loss/gain (20%) (see Table 4).

Epidemics are reported to be commonly experienced in the region with 76% of communities having indicated experiencing malaria, cholera, dengue or other diseases since community establishment. The occurrence of environmental shocks is strongly related to the types of land held by the community. Virtually all lowland-only communities have experienced a large flood (98.3%) in contrast to upland-only communities (39.3%) (see Figure 8). For riverbank slumps and river recession, the rate of incidence for lowland-only communities is double the rate in upland-only communities. This ratio is even greater for mudflat loss (>6 times upland rate) and mudflat gain (>28 times the upland rate).

5.3.2. Probit Models

The ubiquity of floods and epidemics makes visual patterns difficult to discern. For this reason and to further test trends noted in Section 5.3.1, probit regression modeling was undertaken to assess the key predictors of these shocks.

Equation 1 describes the probit model utilized to predict the probability of a community experiencing a particular type of shock. As discussed in Chapter 3, community establishment reflects the year when a community settled in its current location, whereas community founding reflects the year a community first formed at a previous location or here if the community did not move. The time that has passed since founding year (in years) was captured by the variable "*AgeFou*". *"No.Households"* is the number of households in a community. "*Ethnicity"* is a dummy variable to indicate a native community and "*Lowland*" is a dummy variable to capture lowland communities. The elevation of each community, in meters above sea level, is included by the variable "*Elevation*". The remaining variables are dummy variables for each sub-basin, leaving the Amazon sub-basin as a control.

$$P(Shock) = \alpha + \beta_1 AgeFou + \beta_2 No.Households + \beta_3 Elevation + \beta_4 Ethnicity + \beta_5 Lowland + \beta_6 Napo + \beta_7 Pastaza + \beta_8 LowerUcayali + \beta_9 LowerMiddleUcayali + \beta_{10} UpperMiddleUcayali + \beta_{11} UpperUcayali \quad \text{Eq. (1)}$$

The results of the probit regression models for each major shock are presented in Table 5. The following section reports and interprets the results of these models, referencing both the log-odds coefficients and the marginal effects of these coefficients on shock probability.

Lowland location has a large positive impact on the likelihood of experiencing a large flood, increasing the probability of experiencing a large flood by 30.2% (see Table 6 or Appendix B for full marginal effects tables). The remaining statistically significant predictors of floods are higher community age (though this is a minimal effect, +0.1%/year), and location in the Napo or Lower Ucayali basin (increasing the probability by 12.5% and 16.6%, respectively). Communities located in the Upper-Middle Ucayali have a lower likelihood of experiencing a flood. This model has the highest pseudo r-squared value of any models used in this paper (0.36, see Table 5), meaning flood probability is predicted best by Eq. 1 relative to other shocks.

The strongest positive coefficients for epidemic occurrence are the sub-basin dummy variables, and are largest for the Pastaza basin, followed by Napo and Lower-Middle Ucayali location (odds ratios: 0.902, 0.423 and 0.411, respectively, see Table 5). These translate to increases in the probability of experiencing an epidemic of 25% for Pastaza communities, +11.9%. for Napo communities and +11.6% for Lower-Middle Ucayali communities, given all other variables are held constant (see Table 6). Native communities have an 8% higher likelihood of having experienced an epidemic relative to non-native communities. The most commonly reported epidemics are cholera, malaria and dengue fever. A total of 286 communities reported deaths occurring due to epidemics.

Riverbank slumps are predicted by lowland location, in addition to being located along the Napo, Upper-Middle Ucayali and Upper Ucayali rivers. Communities in the Napo are 13% more likely to experience a riverbank slump relative to the Amazon, and those in the Upper-Middle and Upper Ucayali rivers show higher increases of 23% and 27%, respectively (see Table 6).

River recessions, lake closures and mudflat losses and gains occur more frequently in lowland communities. Mudflat loss is more likely in communities in the Middle and Upper Ucayali and the Napo basin (see probit model results, Table 5). For the Middle and Upper Ucayali, this also coincides with a greater count of reported losses than gains of this fertile land type (see Figure 9). The greatest positive net change of mudflats occurs in the Lower Ucayali, though the regression results do not indicate that this location is a significant predictor of mudflat gains (see Table 5).

Although community age has a minimal, but statistically significant, effect on the odds of experiencing all shocks, grouping communities by era of establishment (that is the two decades within which the community was established in the current location) shows trends for the incidence of epidemics and riverbank slumps (see Figure 10). Epidemics are most prevalent among communities that have been in their current location for the longest period of time (>50 years), declining steadily by era. The reverse is true for riverbank slumps, which are least common in old communities and have a heightened prevalence in communities established within the last 15 years.

5.4 Impacts of Environmental Shocks

The previous sections of this chapter have demonstrated the higher incidences of large floods and riverbank slumps among lowland communities. As these shocks are reported to be the most detrimental to riverine peoples (both in past research, see Abizaid, 2007, and this survey), the impacts of these shocks would be indicative of what is being risked by locating in shock-prone areas. Communities were asked to report the impact of large floods and riverbank slumps, and the counts of these responses are available for analyses. As these variables were created using free listing, systematic comparisons of losses across basins are not possible; the most frequent concerns across all communities can be highlighted (see Tables 7 & 8).

The most commonly reported impact of large floods was the loss of mature crops (n= 389 communities), followed by the loss of planted crops (n=251, see Table 7). Over a hundred communities report having lost livestock and/or having had buildings damaged by large floods. Floods ahave prompted individuals to migrate from the community, and on rare occasions contaminated the water supply, and lead to sickness and death of community members.

The effects of riverbank slumps are less frequently reported due to the lower prevalence of this shock, but are arguably greater threats to long-term livelihood sustainability. As indicated in Table 8, although only 37 communities report having lost crops due to riverbank slumps, 187 mentioned having lost land and 133 lost houses to riverbank slumping. These highly damaging shocks have reportedly forced 112 communities to relocate.

5.5 Summary

Non-native communities are drawn to locations by natural resources and agricultural opportunities. Because of the availability of richer soils in lowland environments, non-native communities tend located in lowland, where they face greater hazards and potential conflict when selecting a site. Though resource access remains important for native communities, particularly those in the upland, indigenous communities are more frequently established due to community division and conflict than their non-native counterparts. Community division is most typically driven by social conflict, resource conflict and by a specific natural hazard, riverbank slumping.

Large floods, riverbank slumps, lake closure, river recession and mudflat loss and gain are concentrated among lowland communities that do not have access to secure lands in the upland. Epidemics are concentrated in the most remote areas and among native communities as well as older communities.

Avoidance of riverbank slumping is cited not only as a driver of community founding but also as a cause of community division. This shock is far from universally experienced across the study region, but causes some of the most detrimental losses to assets, often forcing communities to relocate after losing crops, livestock and homes. The heightened frequency of slumps in recently established communities suggests that displaced communities may actually be moving to more, rather than less, vulnerable locations. To confirm if recently settled communities are more shock prone and to further assess what indicates riskier environments, patterns of community movement will be explored in the following chapter.

5.6 Figures & Tables

Table 2: Reasons for community founding.

Reason for Founding	Agriculture	Natural Resources	Escape Riverbank Slump	River Access	Community Divide	School Access	Escape Conflict
N=919	223 (24.3)	271 (29.5)	155 (16.9)	24 (2.6)	108 (11.8)	98 (10.6)	32 (3.5)
Community Type							
Non-Native N=494	137 (27.7)	137 (27.7)	76 (15.4)	12 (2.4)	49 (9.9)	58 (9.7)	15 (3.0)
Native N=425	86 (20.2)	134 (31.5)	79 (18.6)	12 (2.8)	59 (13.9)	50 (11.8)	17 (4.0)
Land Mix							
Upland Only N=89	17 (19.1)	15 (16.8)	16 (18.0)	1 (1.1)	19 (21.3)	12 (13.5)	5 (5.6)
Upland with Lowland Landholdings N=276	221 (19.9)	85 (30.8)	51 (18.4)	6 (2.3)	37 (13.4)	24 (8.9)	16 (5.8)
Lowland with Upland Landholdings N=154	32 (20.8)	43 (27.9)	26 (16.9)	5 (3.0)	21 (13.6)	19 (12.3)	6 (3.9)
Lowland Only N=400	119 (29.7)	128 (32.0)	62 (15.5)	12 (3.0)	31 (7.8)	43 (10.8)	5 (1.2)

Counts listed, percentages of subpopulations in parentheses.

Table 3: Frequency of reported causes of community fission (N=70)

	Has Separated	**Reason for Separation**	River-bank Slump	Large Flood	Re-source Conflict	Social Con-flict	Educational Oppor-tunities	Too Remote
Total Count	213		13 (18.6)	11 (15.7)	15 (21.4)	20 (28.6)	8 (11.4)	10 (14.3)
Reported Reason	70							

Counts listed, percentages of communities that gave reason for fission listed in parenthesis.

Table 4: Percent of communities that have experienced specific shocks

Shock Type	Flood (%)	Epidemic (%)	Riverbank Slump (%)	River Recession (%)	Lake Closed (%)	Mudflat Loss (%)	Mudflat Gain (%)
	81.61	76.28	32.75	53.10	24.81	20.78	19.15

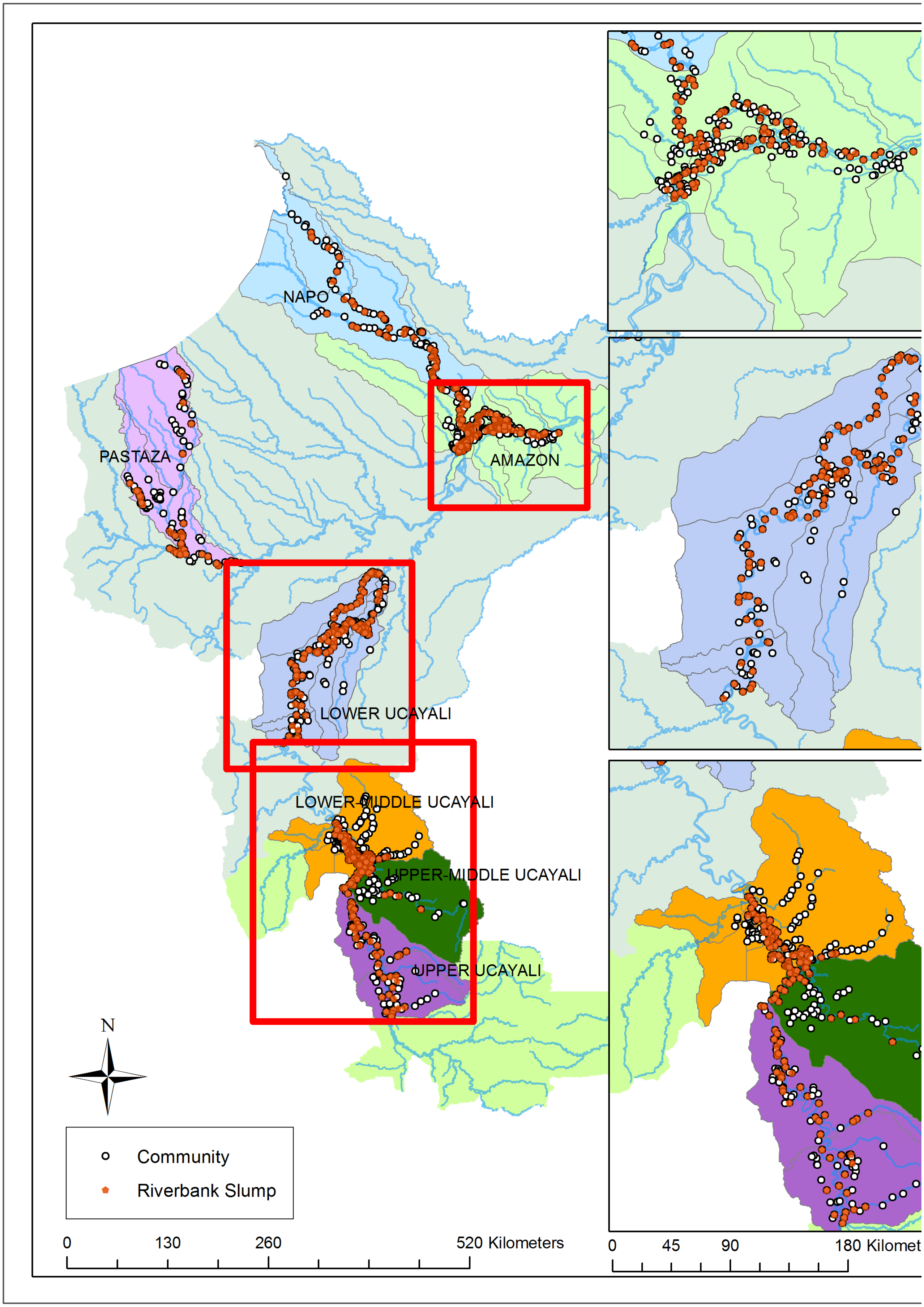

Figure 7: Riverbank slump occurrence by basin.

Table 5: Probit regression results predicting occurrence of shocks.

	Flood	Epidemic	Riverbank Slump	River Recession	Lake Closure	Mudflat Loss	Mudflat Gain
Lowland	1.731***	-0.0117	0.645***	0.516***	0.289***	0.425***	0.726***
	(0.167)	(0.114)	(0.106)	(0.100)	(0.109)	(0.116)	(0.120)
Native	-0.181	0.298**	-0.100	0.0785	0.0766	-0.231*	-0.00436
	(0.152)	(0.118)	(0.108)	(0.109)	(0.110)	(0.126)	(0.125)
No. Households	0.00142	-0.000531	0.000123	0.00109	-0.00119*	0.000816	-0.000185
	(0.00140)	(0.000696)	(0.000611)	(0.000947)	(0.000681)	(0.000736)	(0.000594)
Age (from founding)	0.00577**	0.0112***	0.00404***	0.00329	0.00189	0.00423**	0.00544***
	(0.00273)	(0.00204)	(0.00149)	(0.00230)	(0.00152)	(0.00207)	(0.00160)
Elevation	0.00237	-0.00368	-0.00476	-0.0081***	-0.00448	-0.014***	-0.00306
	(0.00314)	(0.00320)	(0.00302)	(0.00294)	(0.00351)	(0.00425)	(0.00352)
Napo	0.689***	0.423**	0.392**	0.182	-0.0525	0.774***	0.299
	(0.250)	(0.187)	(0.175)	(0.169)	(0.178)	(0.182)	(0.184)
Pastaza	-0.329	0.902***	0.307	-0.231	-0.236	0.528*	-0.0240
	(0.268)	(0.285)	(0.239)	(0.223)	(0.240)	(0.277)	(0.275)
Lower Ucayali	0.805**	-0.0610	0.0705	0.331*	0.0940	-0.253	0.143
	(0.342)	(0.179)	(0.171)	(0.175)	(0.173)	(0.211)	(0.183)
Lower-Middle Ucayali	-0.0218	0.411*	0.372	-0.0665	0.244	1.219***	0.148
	(0.277)	(0.247)	(0.243)	(0.233)	(0.260)	(0.302)	(0.276)
Upper-Middle Ucayali	-0.638**	-0.219	0.686**	-0.112	-0.256	0.987***	-0.354
	(0.307)	(0.276)	(0.278)	(0.273)	(0.321)	(0.357)	(0.392)
Upper Ucayali	0.218	0.0995	0.790***	0.291	0.100	1.610***	0.00170
	(0.332)	(0.307)	(0.301)	(0.288)	(0.324)	(0.368)	(0.354)
Constant	-0.391	0.353	-0.707**	0.499	-0.368	-0.143	-1.347***
	(0.390)	(0.370)	(0.335)	(0.340)	(0.390)	(0.454)	(0.388)
N	887	887	887	887	887	887	887
Pseudo R-sq	0.3549	0.0941	0.0619	0.1189	0.041	0.1093	0.0993
Wald chi2	165.96	80.4	61.53	129.01	36.06	90.61	89.52
p	7.98e-30	1.23e-12	4.81e-09	2.76e-22	0.000166	1.27e-14	2.07e-14

Regression coefficients listed, standard errors in parentheses.
* = p<0.1 **=p<0.05 ***=p<0.01

Table 6: Marginal effects of shock probit models.

Variable	Flood	Epi-demic	Riverbank Slump	River Re-cession	Lake Closure	Mudflat Loss	Mudflat Gain
Lowland	0.302***	-0.0033	0.218***	0.180***	0.088***	0.107***	0.177***
Native	-0.032	0.084**	-0.034	0.027	0.023292	-0.058**	-0.001
No. Households	2.28E-04	-1.5E-04	4.16E-05	3.81E-04	-3.6E-04	2.04E-04	-4.50E-05
Age	0.000**	0.003***	0.001***	0.001	0.001	0.001**	0.001
Elevation	0.004	-0.001	-0.002	-0.003***	-0.001	-0.003***	-0.001
Napo	0.120***	0.119**	0.132***	0.063	-0.016	0.194***	0.073
Pastaza	-0.057	0.255***	0.103	-0.081	-0.072	0.132*	-0.006
Lower Ucayali	0.140**	-0.017	0.024	0.115*	0.029	-0.064	0.035
Lower-Middle Ucayali	-0.004	0.116*	0.126	-0.023	0.074	0.306***	0.036
Upper-Middle Ucayali	-0.111**	-0.062	0.231**	-0.039	-0.078	0.248***	-0.086
Upper Ucayali	0.038	0.028	0.268***	0.101	0.031	0.404***	4.12E-04

* = p<0.1 **=p<0.05 ***=p<0.01

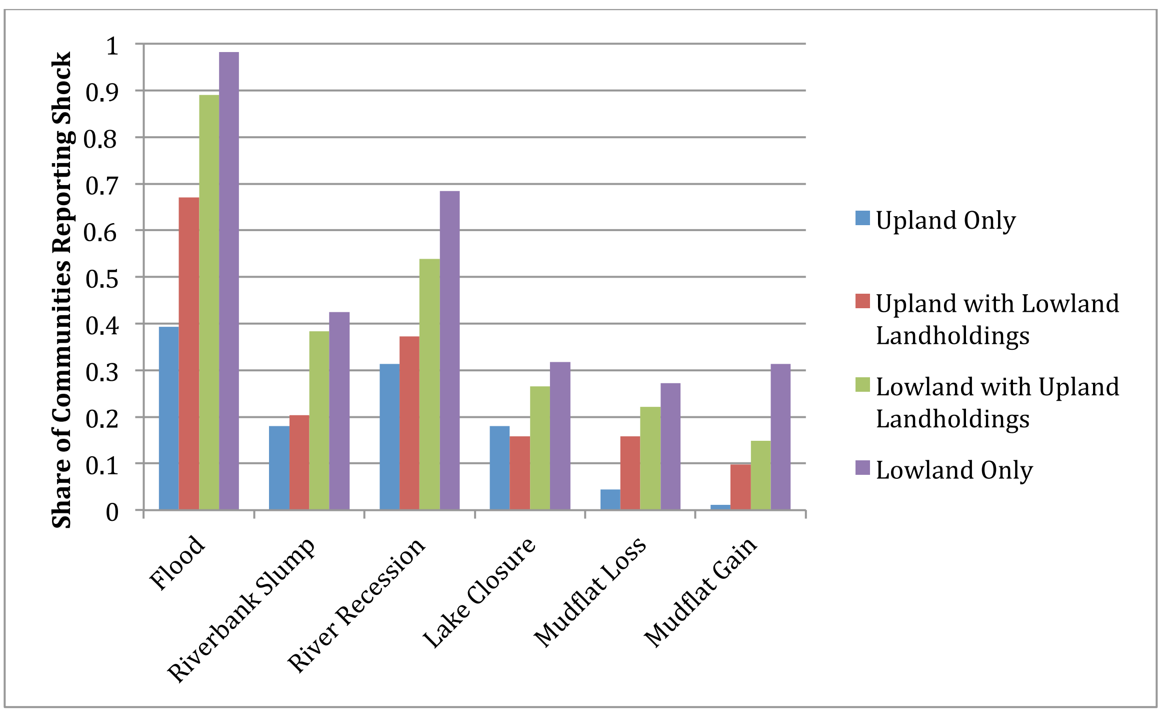

Figure 8: Occurrence of river-driven shocks by community landholdings.

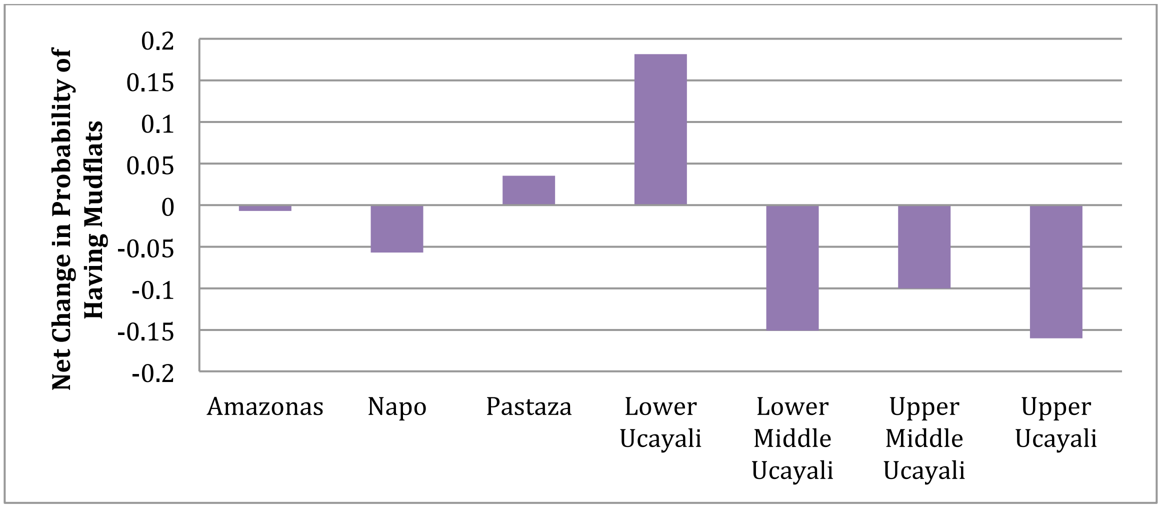

Figure 9: Net change of availability of mudflats by river sub-basin.

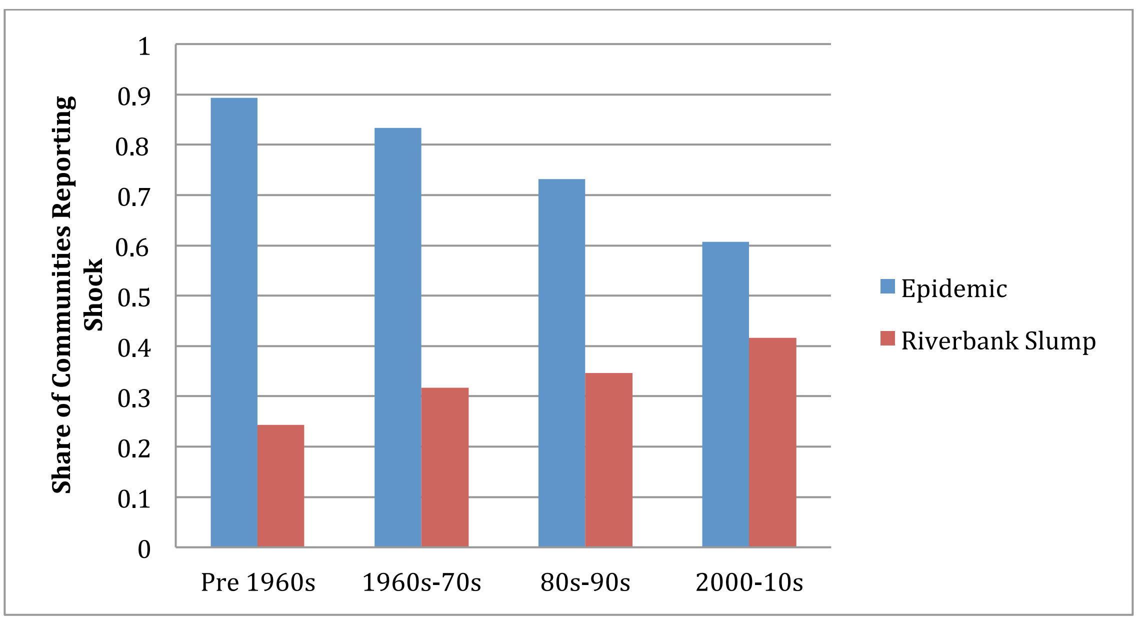

Figure 10: Occurrence of epidemics and riverbank slumps by era of establishment.

Table 7: Reported effects of floods.

Result of flood	N	%
Loss of planted crops	251	33.5
Loss of mature crops	389	51.9
Loss of livestock	102	13.6
Deaths occurred	6	0.8
Building damage	110	14.7
Water contamination	7	0.9
Individual migration	75	10.0
Sickness	9	1.2

Percentages listed are of total communities who report experiencing a flood (n=750).

Table 8: Reported effects of riverbanks slumps.

Result of Shock	N	%
Annual Landslide	38	12.6
Loss of Crops	37	12.3
Loss of Houses	133	44.2
Loss of Land/Farms	187	62.1
Forced Relocation	112	37.2
Loss of Port	17	5.0

Percentages listed are of total communities who report experiencing a riverbank slump (n= 301).

Chapter 6: Community Relocations and Stability and Environmental Shocks

"Forged amidst the unstable fluxes of an extractive economy, much of [Amazon] peasantry has long been used to high mobility, spatial dispersion and social atomization" (Alexiades, 2009, p. 17). When a village's economy is centered upon natural resources or market-oriented agriculture that is reliant on rich mudflat soils, environmental change can make migration a key adaptive strategy for survival of the community. As Carr (2009) notes, rural-rural migration is typically more about livelihood security than the accumulation of assets. The following chapter examines where community movement is most abundant among the case-study basins and identifies where the correlates of community locational instability are concentrated. These patterns are compared to the attributes predicting shocks outlined in Chapter 5 and conclusions about the interdependence of shocks and mobility are drawn.

In the following empirical analysis of community movement the term "stable" will be used to identify communities that responded "no" when asked if the community has moved since founding. Migration data are missing for 21 of the 919 communities in the survey and thus these communities were dropped from the analysis in this section.

6.1 Community Stability and Environmental Shocks

The movement and resettlement of communities is common to this region, with 36% of surveyed communities having reported moving at least once since founding. The highest ratio of mobile to stable communities occurs in the Lower Ucayali, where just over half of the communities (52%, see Figure 11) report having moved at least once. Whereas communities in the Napo and Amazon have seldom moved more than once, along the Ucayali communities tend to move more frequently; in some cases communities have moved ten times since founding. In contrast to this, less than a fifth of communities in the Pastaza report having moved (18%, see Figure 11), and no communities in this basin reported having moved more than three times.

As is the distribution and occurrence of environmental shocks, community location and land holding type are likely to be important in understanding community mobility. Unlike in the shock analysis, where location was viewed as a cause of experiencing a shock, the location-land mix will be viewed as an outcome of having moved. Table 9 illustrates the increased likelihood of having moved with increased landholdings in the lowland. Of the 326 communities that report being mobile, only 11 communities that are situated in the upland (with only upland landholdings) reported having relocated. Countering this, 187 communities, (48%) of "lowland only" communities, reported moving. As data are not yet available on the location-land mix of previous community locations, we cannot infer the degree to which, upon moving, communities are changing their circumstance. We can, however, assess the associations between current conditions and whether or not communities have moved through probit analysis.

6.2 Probit Models

The probit model used to predict if a community has moved (equation below), utilizes the same variables as Equation 1 where data are available. "*No.Households*" was dropped because the number of households before the community moved is not known. "*Upland*" and "*Elevation*" were not used because prior locations and landholdings are not known. Sub-basin, ethnicity, and age remain controlled for in this model.

$$P(Move) = \alpha + \beta 1\ AgeFou + \beta 2\ \ Ethnicity + \beta 3\ Napo + \beta 4\ Pastaza + \beta 5\ LowerUcayali + \beta 6\ LowerMiddleUcayali + \beta 7\ UpperMiddleUcayali + \beta 8\ UpperUcayali \quad \text{Eq(2)}$$

Table 10 presents the result of the probit analysis. The results suggest that older communities will have slightly higher propensities to have moved. The log-odds coefficient of 0.006 translates to a marginal effect of +0.6% for every additional year a community has aged (Table 10). Relative to the Amazon, being located in the Lower Ucayali and Lower Middle Ucayali increases movement probability by 19% and 17%, respectively. Movement is also more likely in the Upper Ucayali (log-odds coefficient of 0.479 and marginal effect +17%).

High mobility of communities along the Ucayali River is evident in Figure 12, which indicates the number of times a community has moved by basin. Not only are communities along the Ucayali more likely to have moved, but also the frequency of moves in the Lower, Lower-Middle and Upper Ucayali sub-basins is higher. Within these sub-basins we find that communities that have moved multiple times are spatially clustered. Also apparent in Figure 12 is the relative stability among communities located along smaller tributaries. Along the Lower-Middle and Upper Ucayali, in particular, visual inspection shows greater stability on low-order rivers, where most communities have not moved since founding. Community mobility does not appear to be related to ethnicity, as the probit model coefficient of this variable was not statistically significant

6.3 Shock Prevalence and Community Movement

Mobility is a mechanism for maintaining successful livelihoods in risk-prone environments such as Amazonia (Alexiades, 2009) and, as seen in Chapter 5, environmental shocks can cause the loss of long-term and short-term capitals and prompt community relocation. Inferences on this relationship are based on comparisons of the rates of both movements and shocks and how these phenomena overlap, as the potential for reverse causality renders directional modeling an invalid method.

Table 11 presents the incidence of environmental shocks according to community mobility. We observe that all shocks, with the exception of epidemics, have higher probabilities of occurrence in communities that have moved at least once compared to those that have remained in a single location. The most acute of these contrasts is for riverbank slumps, which show a 32% higher incidence among communities that have moved relative to static communities. When comparing shock frequency by number of moves, the rate of shocks increases with the number of moves for riverbank slumps and mudflat losses/gains. These patterns are most dramatic in the Lower-Middle Ucayali, where riverbank slumps have occurred in 65.6% of communities that have moved, compared to 5% of stable communities (see Appendix C). These results suggest that communities may be moving to more, rather than less, vulnerable locations.

6.4 Summary

This chapter has explored the research questions “what factors predict community migration?”, “what are the underlying social patterns to resilience and stability in the face of shocks” and “what explains the spatial patterns observed?”. The degree of community mobility in each of the sub-basins of study was assessed. Communities in the Lower, Lower-Middle and Upper Ucayali sub-basins were found to have higher likelihoods of having moved and more frequent changes in locations. When communities do move, their most frequent destination is a lowland location where upland landholdings are not available. Chapter 5 illustrated how such lowland locations increase the likelihood of experiencing river-related shocks and also how riverbank slumps force community relocation. The results reported in this thesis support the notion that environmental shocks drive locational instability. This was illustrated by the heightened frequencies of shocks among mobile communities, most dramatically for riverbank slumps. Communities that have moved in the past appear to be more exposed to shocks in their new (current) locations than those that have been stable, suggesting an increase in vulnerability with community relocation.

6.5 Figures & Tables

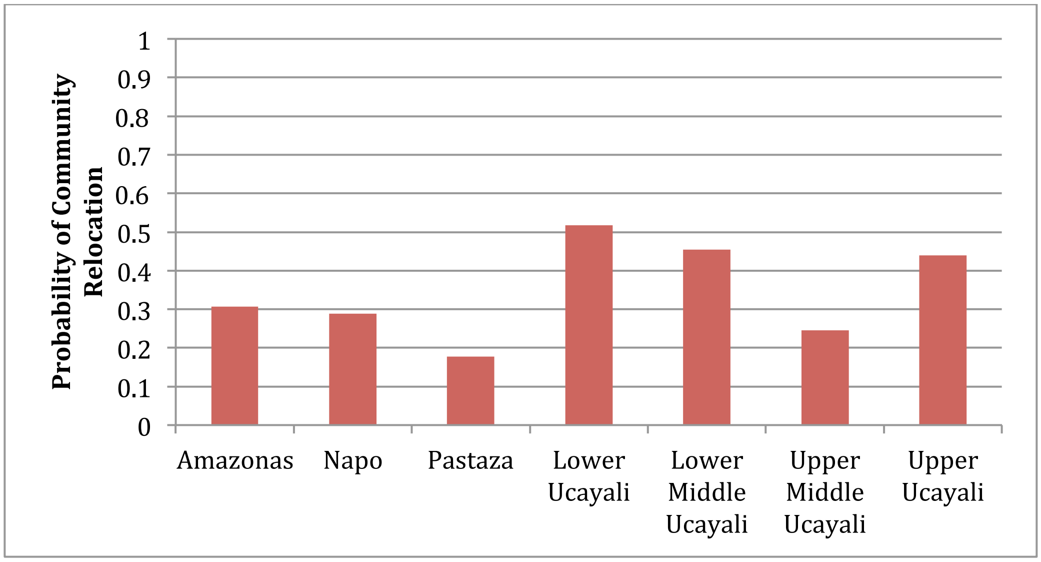

Figure 11: Probability of community relocation by sub-basin.

Table 9: Community relocation by current locational landholdings.

Land Mix	Communities have Moved	Total N (%)
Upland Only	11	86 (12.8)
Upland with Lowland Landholdings	71	273 (26.0)
Lowland with Upland Landholdings	57	150 (38.0)
Lowland Only	187	391 (47.8)
Total	326	900

Table 10: Probit regression of community mobility.

	Probit Model Results	Marginal Effects
Native	0.019	0.007
	(-0.102)	(0.0357)
Age (years)	0.006***	0.002***
	(-0.002)	(0.001)
Napo	0.090	0.003
	(-0.16)	(0.560)
Pastaza	-0.323	-0.113
	(-0.198)	(0.069)
Lower Ucayali	0.543***	0.190***
	(-0.156)	(0.054)
Lower-Middle Ucayali	0.501***	0.175***
	(-0.158)	(0.054)
Upper-Middle Ucayali	-0.044	-0.015
	(-0.205)	(0.072)
Upper Ucayali	0.479***	0.168***
	(-0.184)	
Constant	-0.895***	
	(-0.158)	
N	895	
Pseudo R-sq	0.0064	
Wald Chi1	60.68	
p	3.16E-10	

Coefficients listed, standard errors in parentheses.
* = p<0.1 **=p<0.05 ***=p<0.01

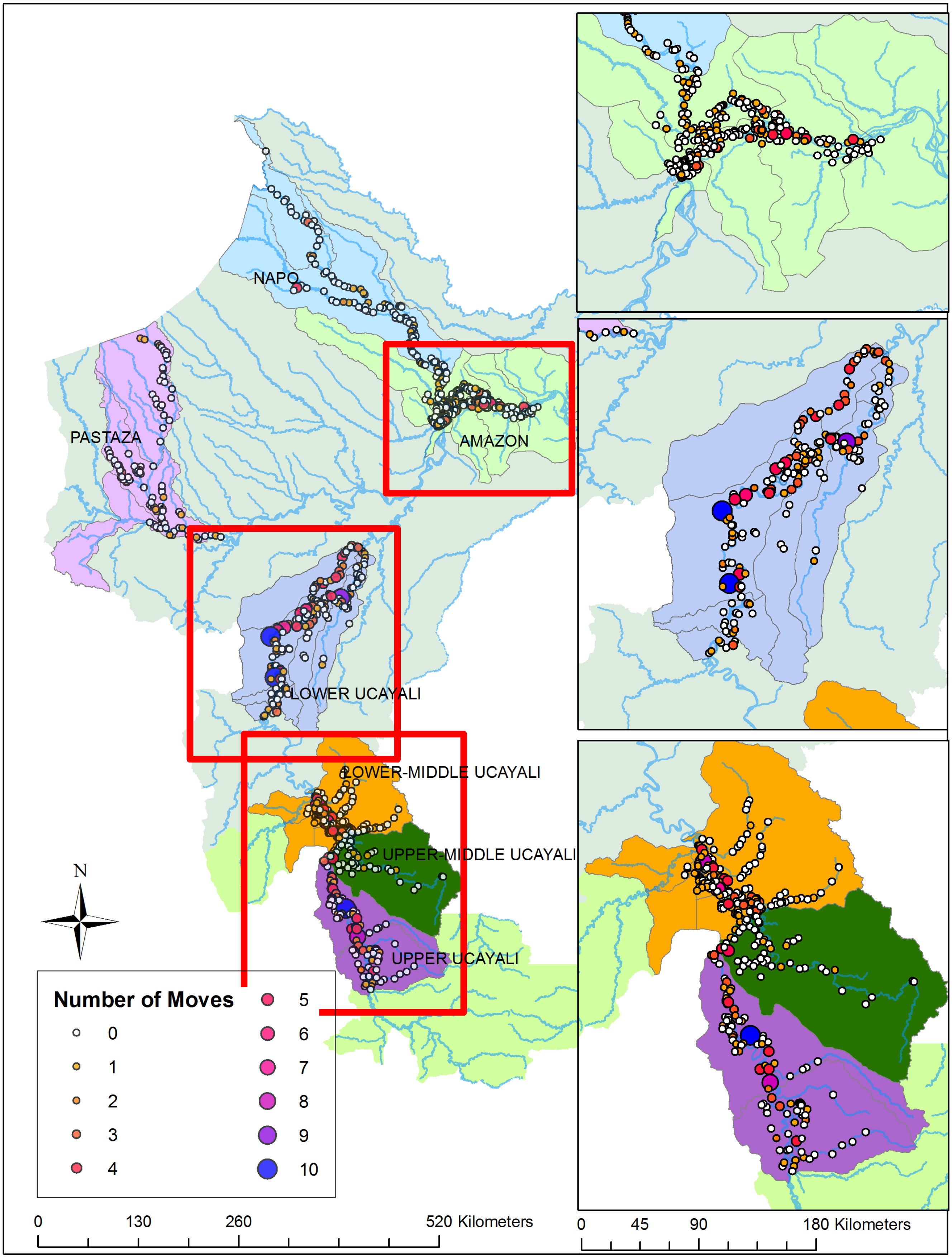

Figure 12: Number of moves by river basin, attributes sized by number of moves.

Table 11: Frequency of reported shocks by community mobility.

Community	N	Flood	Epidemic	Riverbank Slump	River Recession	Lake Closure	Mudflat Loss	Mudflat Gain
Has Not Moved	574	436 (76.0)	442 (77.0)	122 (21.3)	268 (46.7)	120 (20.9)	93 (16.2)	81 (14.1)
Has Moved	326	298 (91.4)	245 (75.2)	174 (53.4)	211 (65.7)	106 (32.5)	95 (29.1)	89 (27.3)
No. of Moves								
1 Move	204	183 (89.7)	157 (77.0)	91 (66.7)	124 (60.8)	59 (28.9)	49 (24.0)	44 (21.6)
2 Moves	39	35 (89.8)	29 (74.4)	26 (63.6)	30 (76.9)	17 (43.6)	13 (33.3)	10 (25.6)
3 Moves	44	43 (97.7)	31 (72.0)	28 (72.0)	33 (75.0)	17 (38.6)	15 (34.1)	18 (40.9)
>3 Moves	39	37 (94.9)	28 (71.4)	29 (78.6)	24 (61.5)	13 (33.3)	18 (46.2)	17 (43.6)

Counts listed, percentages in brackets below.

7. Discussion & Conclusions

This thesis provides insights into the experience of riverine communities in the face of environmental shocks. Prior to this analysis, the abundance, distribution and effects of shocks at the regional scale in the study area could not be quantified. With the aim of improving the understanding of community level vulnerability to environmental shock and the impacts of hazards, this thesis analyzed the reported experiences of all communities in sub-basins studied in part of the PARLAP project. Statistical analysis identified the community attributes that increase the likelihood of shock incidence and community relocation. Mapping the data enriched the results of this analysis by allowing the visualization of the patterns anticipated by the statistical models as well as those patterns not indicated by the numerical results. Conclusions on the distribution of risk in the study region are drawn, informed by relevant literature and past reports on resource use in the study area.

The Peruvian Amazon is an environment ruled by transient economic opportunities, in addition to frequent environmental shocks. Chapter 5 explored the first research question: "how prevalent are environmental shocks faced by rural communities and what are their impacts?". Floods and epidemics are omnipresent throughout the study area. While riverbank slumps are less abundant, they are the only shock cited to be responsible for the founding of communities. Our results concur with past studies that suggest that riverbank slumps have the capacity to be the most detrimental shocks to riverine peoples. This conclusion stems from the findings that these shocks are drivers of location selection, community fission and heightened community mobility. Although comparing loses from shocks remains qualitative as the free-listing of impacts does not allow systematic assessments across communities, property damage and loss is clearly the main impact of riverbank slumps. Additionally, natural disasters often drive community relocation in the study area.

Chapter 6 sought to identify the factors that predict community migration. Movement is frequent among lowland communities, particularly those with no available upland to act as a buffer to shocks. Spatial analysis highlighted the dense clusters of mobile communities around urban centers and around more laterally active rivers (i.e., the Ucayali). More stable, low order tributaries of the Ucayali are lined with more stable communities and communities that report fewer riverbank slumps. All river-related shocks are highly correlated to the number of community moves, and this relationship, again, is strongest for riverbank slumps.

Chapters 5 and 6 address the third and fourth research questions, "what explains the spatial patterns observed in environmental shocks and community relocation?" and "what are the underlying social patterns to resilience and stability in the face of shocks?". The reported benefits of lowland locations for communities are access to agricultural and natural resources as well as market integration because of the market-oriented nature of lowland crops. As discussed in Chapter 4, more recently established communities in the Amazon and lower Napo report having less abundant game, timber, and fish species that are vital for both subsidence and market income. Shock prone communities in these sub-basins also report relocating more frequently. Because this mobility fuels more recent establishment in lowland areas, where valuable game and fish species are reportedly less abundant, movement as a result of shock may result in worsened, not improved, access to natural resources. Despite these challenges, our data indicate that communities remain pulled *or* pushed to floodplains by the benefits, for example, of increased government assistance after a major flood via Iquitos or Pucallpa. (Chibnik, 1994). As Maxwell (1999) describes, there exists "…government preference for symptom-oriented intervention at the level of consumption… rather than systemic interventions at the level of livelihood production" (p. 843). The long-term benefit of this hypothesized aid access is dependent on the type of intervention made by governments.

The link between results of the resource analysis to patterns of movement in the Ucayali proved less intuitive. In the Lower Ucayali sub-basin, where recently established communities report the highest average fish harvests, the heightened mobility of lowland communities is likely both the result of shocks and their seeking increased access to valuable fish species. With the abolishment of the Agrarian Bank that formerly subsidized rice production (Chibnik, 1994), communities along the Ucayali that previously favored cash cropping have recently shifted towards fishing for cash income (Pinedo-Vasquez, 2010). Further analysis is necessary to quantify relationships between the rate of mobility and the agricultural base to determine if mobility in this sub-basin is in fact the result of resource pull or if it is primarily due to the push of environmental shocks. As existing literature on lateral riverine migration rates indicate that the movement of the Ucayali is rapid relative to the Amazon River and suggest that such physical disturbances will drive agricultural suitability and biodiversity, studies should consider how these factors influence the rate of community relocation in this basin relative to the Amazon and Napo (Kalliola *et al.*, 1993, Salonen *et al.*, 2012).

As Carr (2009) finds, "evidence from origin and destination regions suggest that the populations most at risk for frontier migration are the poorest of the poor " (p. 370).

Although not situated on a "frontier" *per se*, communities that have relocated in the Napo and Amazon sub-basins are likely left to select those sites with less abundant natural resources. This is evidence of a geographic poverty trap among lowland communities in these sub-basins, as the communities that relocate to cope with riverbank slumping decrease access to natural resources, thus narrowing their asset base, which is in turn vital for coping with other environmental shocks. Communities here are both more vulnerable to shocks, and less able to cope with shock post-relocation. In contrast to this, along the Lower Ucayali River the most recently established communities have the highest fish harvests, as well as significant gains of fertile mudflats. The data indicate that while relocation remains a coping mechanism to recover from riverbanks, heightened mobility may also be a strategic method of attaining valuable natural assets in the Lower Ucayali sub-basin.

When describing riverine livelihoods in Peru, Coomes (1998) found that "the upland represents security" (p. 46). This thesis confirms that upland landholdings act to decrease exposure to environmental shocks that lowland-located communities report. Beyond distinctions in landholdings, our regional analysis confirms the importance of place in predicting vulnerability, as community mobility and response to shocks is highly variable from sub-basin to sub-basin. Recognizing the dynamism in location of riverine peoples is crucial to understanding poverty, as many communities move at least once, and some communities move up to ten times. Interventions at the community scale aimed at reducing poverty must consider the heterogeneity in shock incidence and community vulnerability in tailoring strategies to enhance community resilience to environmental shocks. Identifying where individual choice and environmental pressures intersect to drive resource use and the construction of livelihood portfolios would be invaluable in understanding the distribution of poverty and geographic poverty traps. The locations where shocks drive relocation, and relocation further increases vulnerability to shocks is where more interventions are required to increase the adaptive capacity of communities.

In extending the results of this thesis to the realm of policy, it is apparent that lowland communities without access to upland would benefit from enhancement of their abilities to capitalize on the greater availability of mudflats and proximity to urban centres these locations offer. Such initiatives will aid in sustaining and improving livelihoods and resilience in shock prone environments.

Regional analyses as conducted in this study are a double-edged sword: they permit us to make broad generalizations about large-scale patterns, but lack the descriptive power of more ethnographic analyses of complex phenomena such as migration and coping mechanisms. Equipped with the regional scale insights provided by this thesis and other studies conducted with data from the first wave of the PARLAP project, the second wave of surveys at the household level will be better informed by regional trends when considering household livelihoods and poverty. Future research would benefit from greater knowledge of conditions of pre- and post-move community locations to better understand the drivers of community location choice.

This thesis has explored the reported environmental shocks faced by *ribereños* and native communities across the Regions of Loreto and Ucayali. By utilizing an in-depth census in the study area, this thesis has focused on the experience of all communities rather than individual case studies to identify patterns in vulnerability at the regional level which are relevant to policy decision-makers. This thesis has furthered the understanding of the causes of poverty in the Peruvian Amazon and, by extension, can inform initiatives aimed at reducing poverty and increasing resilience in riverine communities.

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Appendix A – Community Questionnaire, List of Relevant Variables and Additional Information on Native-Identified Communities

List of Relevant Variables

AnoFou – The year of community founding.
AnoEst – The year of community establishment.
DecFou – The decade of community establishment.
DecEst – The decade of community establishment.
FouAgr – The community was founded here for agricultural resources.
FouNatRes – The community was founded for natural resources.
FouBar – The community was founded here to escape riverbank slumping.
FouRiv – The community was founded here to better access a river.
FouEsc – The community was founded here due to community fission.
FouCon – The community was founded here to escape conflict.
Native – Community type (native/nonnative).
ElevM – Community elevation (masl).
Basin – Basin community is located within
SubBasin – Subbasin community is located within.
ComAlt – The community is situated in the altura (upland).
ComBaj – The community is situated in the bajo (lowland).
TieAlt – The community has land in the altura (upland).
TieBaj – The community has land in the bajo (lowland).
Ind – The community has experienced a large flood.
IndSem – The flood caused a loss of planted crops.
IndCul – The flood caused a loss of mature crops.
IndDam – The flood caused a loss of or damage to buildings.
IndLif – The flood caused a loss of life.
IndCaz – The flood caused loss of wild animals.
IndAgu – The flood caused contamination of water.
IndMig – The flood caused migration/displacement of residents.
IndEnf – The flood caused sickness/disease.
Epi – The community has experienced an epidemic.
EpiMal – The community has experienced malaria.
EpiCho – The community has experienced cholera.
EpiDen – The community has experienced dengue.
EpiFlu –The community has experienced flu (gripe).
EpiDia – The community has experienced diarrhea.
EpiTos – The community has experienced tosferina (pertussis/whooping cough).
EpiHep – The community has experienced hepatitis.
EpiSto – The community has experienced stomach infection.
EpiVir – The community experienced viruela (smallpox).
EpiYel – The community has experienced yellow fever.
EpiSar – The community has experienced sarampion (measles).
Bar – The community has expiernced a riverbank slump.
BarCrp – The riverbank slump caused a loss of crops.
BarPar – The riverbank slump caused a loss of land/farms.
BarLan – The riverbank slump caused loss of the community area/forced relocation.

Sep – The community has separated from another community.
SepBar – The separation was caused by a riverbank slump.
SepFld – The separation was caused by a large flood.
SepRes – The separation was caused by conflict over land/resources.
SepSoc – The separation was caused by social conflict.
SepEdu – The community separated to pursue educational opportunities.
SepDis – The community separated due to remoteness.
RioDry – The river receded from the community.
Coc – The lake closed.
FueBar – The mudflat disappeared.
NewBar – The community has a new mudflat.

Additional Information on Native-Identified Communities

Table 1: List of ethnic groups.

Ethnic Group	Sample Size
Achuar	12
Achuar, Quechua	1
Ashaninka	43
Capanahua	1
Cocama-Cocamilla	38
Kandosi	32
Maijunas	1
Quechua	60
Shipibo	13
Shipibo-Conibo	79
Witoto	4
Yagua	3
Aidesep	1
Shapra	1
Arabela	2
Awajun	1
Ashaninka, Shipi	1
Shipibo-Conibo, Cocama	1

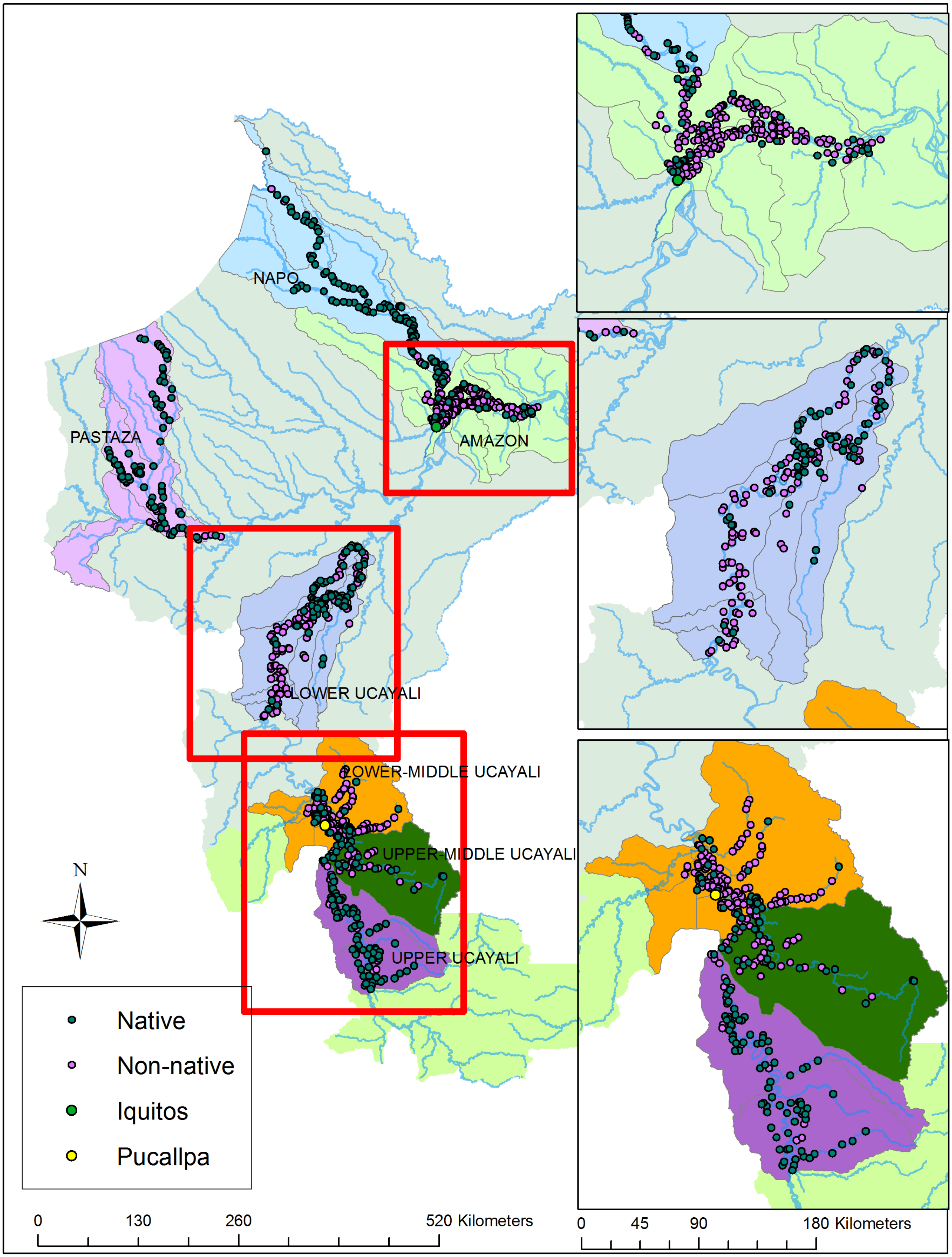

Figure 1: Native community distribution.

Appendix B – Additional Tables for Chapter 5

Table 1: Marginal effects of flood probit model.

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Lowland	0.301621	0.022103	13.65	0	0.2583	0.344941
Native	-0.03152	0.026646	-1.18	0.237	-0.08375	0.020705
No. Households	0.000248	0.000244	1.02	0.31	-0.00023	0.000726
Age	0.001005	0.000467	2.15	0.031	8.97E-05	0.00192
Elevation	0.000412	0.000548	0.75	0.452	-0.00066	0.001485
Napo	0.120017	0.042054	2.85	0.004	0.037594	0.202441
Pastaza	-0.05732	0.046487	-1.23	0.218	-0.14843	0.033797
Lower Ucayali	0.140246	0.058813	2.38	0.017	0.024974	0.255518
Lower-Middle Ucayali	-0.00379	0.048275	-0.08	0.937	-0.09841	0.090828
Upper-Middle Ucayali	-0.11121	0.053169	-2.09	0.036	-0.21542	-0.00701
Upper Ucayali	0.037899	0.057801	0.66	0.512	-0.07539	0.151187

Table 2: Marginal effects of epidemic probit model.

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Lowland	-0.0033	0.032074	-0.1	0.918	-0.06616	0.059569
Native	0.084131	0.033104	2.54	0.011	0.019248	0.149013
No. Households	-0.00015	0.000196	-0.76	0.445	-0.00053	0.000235
Age	0.00316	0.00055	5.75	0	0.002083	0.004238
Elevation	-0.00104	0.000902	-1.15	0.249	-0.00281	0.000727
Napo	0.119306	0.052183	2.29	0.022	0.017029	0.221582
Pastaza	0.25466	0.079368	3.21	0.001	0.099102	0.410219
Lower Ucayali	-0.01721	0.050643	-0.34	0.734	-0.11647	0.082044
Lower-Middle Ucayali	0.116127	0.069552	1.67	0.095	-0.02019	0.252447
Upper-Middle Ucayali	-0.06182	0.077914	-0.79	0.428	-0.21453	0.090888
Upper Ucayali	0.0281	0.086713	0.32	0.746	-0.14185	0.198055

Table 3: Marginal effects of riverbank slump probit model.

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Lowland	0.217713	0.033638	6.47	0	0.151783	0.283642
Native	-0.03381	0.036551	-0.92	0.355	-0.10545	0.037832
No. Households	4.16E-05	0.000206	0.2	0.84	-0.00036	0.000446
Age	0.001363	0.000499	2.73	0.006	0.000385	0.002341
Elevation	-0.00161	0.001014	-1.58	0.113	-0.00359	0.000383
Napo	0.13234	0.058407	2.27	0.023	0.017864	0.246815
Pastaza	0.103452	0.080628	1.28	0.199	-0.05458	0.26148
Lower Ucayali	0.023779	0.057763	0.41	0.681	-0.08943	0.136992
Lower-Middle Ucayali	0.125524	0.081656	1.54	0.124	-0.03452	0.285566
Upper-Middle Ucayali	0.231433	0.092642	2.5	0.012	0.049858	0.413009
Upper Ucayali	0.266723	0.100319	2.66	0.008	0.070101	0.463344

Table 4: Marginal effects of river recession probit model.

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Lowland	0.179578	0.033342	5.39	0	0.11423	0.244926
Native	0.027325	0.037855	0.72	0.47	-0.04687	0.101519
No. Households	0.000381	0.000329	1.16	0.247	-0.00026	0.001025
Age	0.001145	0.000794	1.44	0.149	-0.00041	0.002701
Elevation	-0.00282	0.001011	-2.79	0.005	-0.0048	-0.00084
Napo	0.063433	0.058883	1.08	0.281	-0.05198	0.178842
Pastaza	-0.08051	0.07739	-1.04	0.298	-0.23219	0.071171
Lower Ucayali	0.115173	0.060585	1.9	0.057	-0.00357	0.233918
Lower-Middle Ucayali	-0.02315	0.080946	-0.29	0.775	-0.1818	0.1355
Upper-Middle Ucayali	-0.03912	0.095037	-0.41	0.681	-0.22538	0.147154
Upper Ucayali	0.101365	0.100177	1.01	0.312	-0.09498	0.297707

Table 5: Marginal effects of lake closure probit model.

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Lowland	0.087873	0.032964	2.67	0.008	0.023265	0.15248
Native	0.023292	0.033389	0.7	0.485	-0.04215	0.088734
No. Households	-0.00036	0.000207	-1.75	0.079	-0.00077	4.24E-05
Age	0.000574	0.000462	1.24	0.214	-0.00033	0.00148
Elevation	-0.00136	0.001063	-1.28	0.2	-0.00345	0.000721
Napo	-0.01597	0.054123	-0.3	0.768	-0.12205	0.090105
Pastaza	-0.07191	0.073026	-0.98	0.325	-0.21504	0.071219
Lower Ucayali	0.028575	0.052678	0.54	0.588	-0.07467	0.131822
Lower-Middle Ucayali	0.074331	0.07894	0.94	0.346	-0.08039	0.229051
Upper-Middle Ucayali	-0.07773	0.097589	-0.8	0.426	-0.269	0.113544
Upper Ucayali	0.030512	0.098452	0.31	0.757	-0.16245	0.223474

Table 6: Marginal effects of mudflat loss probit model.

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Lowland	0.106696	0.028867	3.7	0	0.050118	0.163273
Native	-0.05799	0.031553	-1.84	0.066	-0.11984	0.00385
No. Households	0.000205	0.000185	1.11	0.268	-0.00016	0.000567
Age	0.001062	0.000517	2.05	0.04	4.83E-05	0.002075
Elevation	-0.00342	0.001058	-3.23	0.001	-0.00549	-0.00134
Napo	0.194055	0.045392	4.28	0	0.105088	0.283022
Pastaza	0.132457	0.069218	1.91	0.056	-0.00321	0.268121
Lower Ucayali	-0.0635	0.052865	-1.2	0.23	-0.16711	0.040117
Lower-Middle Ucayali	0.305655	0.074636	4.1	0	0.159371	0.45194
Upper-Middle Ucayali	0.247491	0.089158	2.78	0.006	0.072745	0.422237
Upper Ucayali	0.403717	0.090978	4.44	0	0.225403	0.58203

Table 7: Marginal effects of mudflat gain probit model.

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Lowland	0.176481	0.028706	6.15	0	0.120218	0.232743
Native	-0.00106	0.030401	-0.03	0.972	-0.06065	0.058526
No. Households	-4.5E-05	0.000144	-0.31	0.756	-0.00033	0.000238
Age	0.001322	0.000387	3.41	0.001	0.000563	0.00208
Elevation	-0.00074	0.000857	-0.87	0.386	-0.00242	0.000936
Napo	0.072695	0.044805	1.62	0.105	-0.01512	0.160511
Pastaza	-0.00583	0.066783	-0.09	0.93	-0.13672	0.125064
Lower Ucayali	0.034674	0.044368	0.78	0.435	-0.05229	0.121634
Lower-Middle Ucayali	0.035961	0.066972	0.54	0.591	-0.0953	0.167223
Upper-Middle Ucayali	-0.08618	0.094998	-0.91	0.364	-0.27237	0.100015
Upper Ucayali	0.000412	0.086174	0	0.996	-0.16849	0.169311

Table 8: Reported effects of riverbanks slumps.

Result of Shock	N
Annual Landslide	38
Loss of Crops	37
Loss of Houses	133
Loss of Land/Farms	187
Forced Relocation	112
Loss of Port	17

Appendix C – Additional Tables for Chapter 6

Table 1: Marginal effects of mobility probit model

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Native	0.006755	0.035691	0.19	0.85	-0.0632	0.076707
Age	0.002127	0.000679	3.13	0.002	0.000796	0.003457
Napo	0.003155	0.056025	0.06	0.955	-0.10665	0.112961
Pastaza	-0.11296	0.069065	-1.64	0.102	-0.24832	0.02241
Lower Ucayali	0.189806	0.053707	3.53	0	0.084542	0.295071
Lower-Middle Ucayali	0.175145	0.054407	3.22	0.001	0.06851	0.28178
Upper-Middle Ucayali	-0.01527	0.071779	-0.21	0.832	-0.15596	0.125411
Upper Ucayali	0.167596	0.063575	2.64	0.008	0.042992	0.292201

Table 2: Probability of riverbank slump by sub-basin and community mobility.

	Amazon N=43	Napo N=60	Pastaza N=26	Lower Ucayali N=61	Lower-Middle Ucayali N=46	Upper-Middle Ucayali N=23	Upper Ucayali N=37
No Moves	20 (21.5) n=93	34 (27.6) n=123	20 (22.7) n=88	20 (23.5) n=85	4 (5.0) n=77	13 (25.0) n=52	11 (19.6) n=56
Has Moved	23 (56.1) n=41	26 (52.0) n=50	6 (31.5) n=19	41 (45.0) n=91	42 (65.6) n=64	10 (58.8) n=17	26 (59.1) n=44
# of Moves							
1	10 (50.0) n=22	24 (55.3) n=45	6 (33.3) n=18	11 (25.6) n=44	24 (58.5) n=41	5 (41.7) n=12	11 (50.0) n=22
2-3	10 (71.4) n=14	2 (50.0) n=4	0 (0.00) n=1	19 (58.4) n=33	11 (73.3) n=15	2 (100.0) n=2	10 (80.0) n=14
4+	3 (60.0) n=5	0 (0.00) n=1	n/a	11 (78.6) n=14	7 (87.5) n=8	3 (100.0) n=3	5 (62.5) n=8

Counts listed, percentage of total number of communities who have reported a riverbank slump in brackets. N = number of communities who report having experienced a riverbank slump, n = number of communities who report having moved *X* number of times.