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Spatial Patterns of Raised Fields and Linguistic Diversity in Mojos, Beni, Bolivia

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SPATIAL PATTERNS OF RAISED FIELDS AND LINGUISTIC DIVERSITY IN MOJOS, BENI, BOLIVIA

by

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ABSTRACT

Throughout Amazonia, earthworks are found in areas of diverse linguistic and ethnic backgrounds. The distribution of these earthworks within various linguistic and ethnic areas suggests a multiethnic or multilinguistic network, in which interaction between these diverse groups occurred, creating diverse communities. Movement and communication within Amazonia along river networks allowed for this interaction. Interaction between groups in Amazonia may have also influenced the different methods of landscape modification. This thesis presents a GIS-based spatial analysis of raised fields, a type of agricultural earthwork found throughout the Llanos de Mojos (Mojos), located in the Beni Department of Bolivia. The distribution of fields, forest islands, and rivers was analyzed to distinguish the relationship between these features in the study area. The spatial analysis distinguished patterns between raised fields found along two sets of rivers, the Iruyañez and Omi Rivers, and the Yacuma and Rapulo Rivers. Spatial patterns found within these distributions were also compared to the distribution of linguistic groups in the area. Among these patterns, it is seen that one kind of agricultural earthwork is found in areas associated with different linguistic groups. The spatial patterns found among the raised fields and forest islands in relation to the linguistic groups in the area demonstrate the fluidity between groups in the region. Insight to movement and communication in Mojos can be understood through the interaction between linguistic groups and the distribution of archaeological features in the region.

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CHAPTER ONE: INTRODUCTION

This thesis presents an analysis of the spatial distribution of raised fields found in the Llanos de Mojos (Mojos) region in the Beni department of Bolivia (Figures 1-1 and 1-2). This region is characterized as a seasonally flooded savanna, in which many earthworks, such as raised fields can be found. These raised fields were constructed and maintained throughout the precolumbian era. The distribution of raised fields in Mojos will be analyzed to distinguish the relationship between the fields, forest islands, and river networks of Mojos, as well as how spatial patterns of these features compare with the distribution of linguistic groups in the region. Raised fields are part of the modified landscape, which may have been home to different linguistic and ethnic groups simultaneously, creating perhaps a multiethnic or multilinguistic network (Walker 2011b:292). The movement and means of communication throughout Amazonia can be attributed to the vast river systems that covered the region. This network included the exchange of languages, ethnic identity, subsistence, environmental change, and many other elements (Hornborg 2005). Being located on or near this network along the river systems therefore would be an advantage for communication and trade among the various cultural communities (Chisholm 2007).

The immense river network found in Amazonia is significant to the multiethnic communities that are described in ethnohistoric accounts. In recent research, shifts in languages and multilingualism have been documented in the region by scholars (Hornborg and Hill 2011). The extensive documentation of this throughout the ethnographic record sheds light on the creation of ethnic identity in Amazonia. Additionally, these linguistic changes contribute to cultural changes, with the diversity of knowledge and ideas of cultural importance being

reflected in languages (Balée 2013). According to Hornborg and Hill (2011:8), the construction of identity, including ethnic identity, in Amazonia was a continuous process. The diversity of ethnolinguistic identities are the result of the regional system of Amazonian groups (2011: 11). The regional systems found in Amazonia, as examined through ethnography and ethnohistory, have presented characteristics, such as multiethnic and multilinguistic identities. The boundaries of the groups within these systems are unclear, supporting the idea of fluidity between the groups (Neves 1999:229). The vast diversity found among Amazonian groups is also reflected in the diverse methods of landscape modification throughout the region (Balée 2013).

Erickson (2006) describes landscapes within Amazonia as being domesticated, in the sense that the environment was shaped by humans due to social demands. Heckenberger (2008) describes the landscape of Amazonia as being a socio-cultural landscape that is the result of the great variability of cultures found in the region. Historical ecology takes into account various elements of modified landscapes to interpret their meaning. This perspective looks at the landscape as having spatial and temporal characteristics, as well as the human-environmental relationship that is reflected in the landscape (Balée and Erickson 2006). Also, historical ecologists look to understand the intentionality behind human interaction with the environment and how it then transforms it (Erickson 2008). Combining this approach with archaeology can provide an insightful interpretation of the cultural significance and intentionality of the many earthworks across the Amazonian landscape.

As mentioned previously, raised fields are the specific earthworks found within the Amazonia landscape that will be discussed in this thesis. Raised fields are broadly defined as large, elevated planting surfaces, which are elevated above the flooded savannas (Erickson

2006:251). Raised fields, along with canals, platforms, and causeways, are found throughout Mojos and come in a variety of sizes, shapes, and orientations (Denevan 2001). Raised fields vary immensely throughout Mojos, giving archaeologists the opportunity to observe and analyze them in search of patterns and interpretations of their use (Walker 2008a:933-934). These fields can be seen as part of built environments, an interpretation which emphasizes the relationship between the landscape and the societies that constructed the landscape, as well has how the modified landscape thereafter impacts the societies (Walker 2012b:323).

Historically, as well as today, Mojos has been occupied by a diversity of ethnic and linguistic groups. The cultural history of the region implies that various groups were living in the region contemporaneously, which could have contributed to the differences and similarities of the earthworks, specifically raised fields, in Mojos (Denevan 1966b). At the time of Jesuit contact (1668-1768), the various groups in Mojos were living in widely dispersed settlements, and later were focused around several missions dispersed through the region (Block 1994:42-43). The Jesuits encountered over 30 groups, but distinguished 6 they considered to be most important within Mojos (1994:16). The mission system created by the Jesuits divided these linguistic groups geographically and culturally, an example of how boundaries developed among ethnic or linguistic groups may have resulted from the European Conquest (Block 1994:83; Neves 1999).

Raised fields, along with other earthworks, were constructed most likely by the various groups found in Mojos. These groups include the Movima, Cayuvava, Itonama, Baure, Mojos, and Canichana, each distinct linguistically and ethnically. Of these six groups, two are from the Arawak language family, while the other four are linguistically isolated. Ethnicity is defined here

as an identity that results from attributes and qualities that are associated with cultural groups (Hornborg 2005:593). Further, ethnic identity is communicated and could have been marked through language and material culture in the past (Hornborg and Hill 2011). However, there are many elements that make the association between language and material culture in Amazonia complex (Walker 2011a). Arawak speakers are often seen as the builders of the agricultural landscape, yet the linguistic diversity in Mojos can make this association difficult since groups of other linguistic affiliation have also contributed to the agricultural landscape (Walker 2011a). The question of identity can be addressed in various ways and has potential to be revealed through artifacts and the archaeological record.

Correlation between raised fields and the linguistic groups in Mojos is difficult, since there is little evidence for this in a chronological context (Denevan 1966b; Walker 2011a). The question of what archaeological findings can reveal and whether they can identify correlations with ethnic and linguistic groups has been presented by archaeologists and is an important question to address (Hornborg 2005). Spatial patterns among raised fields and forest islands in relation to the river systems and linguistic groups will be the focus of this project. This will be done through a GIS-based spatial analysis of the distribution and distances among each of these features. Through the analysis and observation of spatial patterns in the study area, this project will contribute to the understanding of the agricultural landscape of Mojos by answering several questions.

1. What does the comparison of distance between raised fields and forest islands tell us about where people are farming and living, respectively?

2. What does the distance between raised fields and the rivers tell us about the importance of access to the river networks?
3. Could the distribution of raised fields and forest islands in the northern section of the study area and southern section of the study area reflect the interaction between the Cayuvava and Movima linguistic groups found in these respective areas?

It is hypothesized that:

1. Based on the spatial distribution of raised fields and forest islands, differences between the northern and southern regions of the study area will not be significant, suggesting that there was interaction between groups found in the region.
2. The distance between raised fields and forest islands from the river systems demonstrates that the groups in the study area were part of a larger, dynamic network.

The spatial analysis of the raised fields in the region will contribute to the interpretations and perceptions of identities in precolumbian societies within a multiethnic region. Also, spatial patterns found among raised fields, forest islands, and rivers in relation to the linguistic groups found in the area will contribute to the understanding of interaction between distinct linguistic groups. Through these spatial patterns, it can be understood where fields were being constructed and utilized, as well as where groups were living in relation to the river network in the study area. The interaction between linguistic groups and their distance from the river networks could provide insight to movement and communication in Mojos. Through previous investigation of

the archaeological record, as well as historical and ethnographic accounts, further interpretations of the diverse groups in the area and whether interaction between these groups occurred prior to European contact can be made.

CHAPTER TWO: AMAZONIAN ARCHAEOLOGY: PAST AND PRESENT

Recent research conducted throughout the Amazon is changing how the region is viewed and understood (Heckenberger and Neves 2009). The perception of Amazonia in the past was of a cultural backwater lacking the complexity that is found among the Andean cultures, yet research has demonstrated that there is evidence for complexity including social stratification and large, sedentary societies (Denevan 1966a). Communities in the Amazon transformed the landscape through agroforestry, urban settlements, water control, and transportation and communication networks (Erickson 2008:177). The idea of large, dense populations living in Amazonia prior to European contact can be supported by early explorer accounts of large villages, elaborate ceramics from archaeological sites, and historical accounts of social organization (Denevan 1970).

When taking into account recent research in Amazonia, scholars have argued that there the environment did not restrict population growth or development of social complexity (Neves 1999). The diverse environments found throughout Amazonia did not limit or constrain the possibilities of landscape management, but provided “an arena of agency” for indigenous groups (Cleary 2011:72). The changes in the landscape of Amazonia ranged from “subtle to complete transformation” (Denevan 2007:266). New developments in the field of archaeology have contributed to changes in interests, which has contributed to the increasingly in-depth studies of the Amazon (Heckenberger and Neves 2009). In eastern Bolivia, there is evidence of sociopolitical integration of groups within villages, specifically in Mojos, as well as a pattern of agricultural settlements among the various savanna tribes described by Denevan (1966a:346; 1966b).

The Llanos de Mojos (Mojos) region (Figure 2-1) is located in the Beni department of Bolivia. This region is known for its seasonally inundated grassland savanna, which covers approximately 110,000 km² (Walker 2008a). As a comparison, the area of the savanna is roughly the size of Virginia. Mojos is a part of the Beni basin, which is located between the Andean foothills and the Brazilian highlands (Denevan 1966b). This basin is drained by several major rivers including the Río Guaporé, Río Mamoré, and Río Beni, along with their tributaries. These rivers join at the Río Madeira, which is a tributary of the Amazon River (Denevan 1966b). The Mamoré River was the most important in the recent history of Mojos, due to its central location and the link it forms between Mojos and the Andes (Block 1994). The seasonal flooding of this region occurs during the 4-6 month wet season, with parts of the landscape under water between the months of January through March (Erickson 1995; Walker 2001). The region of Mojos is also extremely diverse linguistically and ethnically, as well as in regards to landscape modifications, which will be further discussed later in this chapter. The cultures in Mojos are characterized by several elements, such as raised field agriculture, fishing, and stratified societies (Crevels and van der Voort 2000:153). The diversity present in Mojos, as well as in Amazonia overall, is reflected in the cultural landscape and opportunities for research.

Linguistic Groups

The Amazon is one of the most linguistically and culturally diverse regions in the world, along with the similarly diverse highlands of New Guinea (Epps 2009). Within Amazonia, there are approximately 300 languages, subdivided into approximately 170 different language family groupings (Balée 2013). The Upper Amazon (Figure 2-2), which includes the region of Mojos, is

the zone of greatest linguistic diversity within the entire region of Amazonia (Lathrap 1970:70). According to Lathrap (1970:70), the patterns of distribution of languages within the Amazon provides insight to the means of transportation of people, which seems to be through the river networks in Amazonia. Four language families seem to be the largest and most widespread families of the Amazonian languages (Epps 2009). These families include the Tupí, Arawak, Carib, and Macro-Jê. The distributions of these language families spans the extent of the Amazon. The diversification of these language families can be interpreted as the result of time, as well as groups becoming isolated throughout the prehistory of Amazonia (Meggers 1975). However, the constant interaction between linguistic groups can also be seen in the languages through cultural and linguistic characteristics (Eriksen and Danielsen 2014).

The interaction between subgroupings of these diverse language families has led to multilingualism and cultural exchanges (Epps 2009). The boundaries and identities of Amazonian groups have continuously been created and changed through shifting conditions, which can be seen through physical geography, archaeology and ethnohistory (Hornborg and Hill 2011). In lowland South America, linguistic and ethnic identification often coincide, making it an interest for scholars researching models of distribution of indigenous languages or ethnic boundaries in the past (Neves 1999: 216). Understanding the identity of groups within these multilingual areas can be difficult due to various scenarios, such as groups adopting a new language and retaining their cultural beliefs or groups that change their cultural beliefs and continue speaking the same language (Meggers 1975).

Archaeological data on regional, multiethnic systems in Amazonia have not been fully assessed, but there is data for multiethnic regional systems seen in ethnographic and

ethnohistoric records (Neves 1999). An example of a linguistic area that is inhabited by various linguistic groups is the Vaupés in the northwest Amazon (Epps 2009:589). Groups in this region maintain multilingualism through several practices, such as linguistic exogamy and economic interaction (Epps 2009:589). Other regions, such as the Upper Xingu, demonstrate that sub-groups from various language families, including Arawak speakers, live in multilinguistic societies, incorporating characteristics from the different cultural groups (Heckenberger 2010). The Orinoco Delta also demonstrates multiethnic systems that may have been stronger in the past (Heinen and García-Castro 2000:561). Heinen and García-Castro (2000:562) present populations in the Orinoco Delta that are linguistically affiliated with the Carib and Arawak language families and share a similar social organization. Trade and interaction within the Orinoco Delta led to populations being multilingual and acculturated (Heinen and García-Castro 2000:572).

Within Mojos, rich linguistic diversity exists, contributing to the various ethnic groups and identities found throughout the region (Denevan 1966b:40). The existence of these different linguistic and cultural groups occurred across the region and throughout time (Calandra and Salceda 2004). Denevan (1966b) argued that cultural influences from the prehispanic era may be a combination of Amazonian and Andean characteristics, while in some areas of the region the influences can be oriented more towards the Amazon (Walker 2011a). The spread of languages and cultures, whether through migration or trade, can be attributed to movement along the many rivers in the region (Van Valen 2013). Block (1994) discusses that the prehistoric people of Mojos come from Amazonian origin and moved out of the central Amazon via the river networks. These prehistoric inhabitants brought with them agriculture practices based on manioc, leading to the necessary modification of the landscape to grow and cultivate these crops.

According to Jesuit accounts during the Mission Period spanning from about 1668-1768, there were dozens of tribes speaking a diverse quantity of languages, however six tribes were distinguished and considered important (Denevan 1966b; Block 1994). These linguistic and ethnic groups (Figure 2-3) include the Mojo and Baure, considered part of the Arawakan language family, and the Cayuvava, Itonama, Movima, and Canichana, considered linguistically unclassified (Métraux 1948:425; Denevan 1966b). Construction and use of earthworks spans across these various groups in Mojos. They each addressed the issue of seasonal flooding in the savannas and had sociopolitical features, such as social stratification. Jesuit missionaries note that villages among these various groups had chiefs, as well as individuals they interpreted as "shamans" (Block 1994:27). Social structure and stratification within these groups is also reflected in their language through terminology. Linguistically, these groups also held and enforced the importance of kinship extended outside of the nuclear family (Block 1994:25).

Information on the six linguistic and ethnic groups found in Mojos have been detailed by several scholars (Denevan 1966b; Métraux 1948). The Mojo, Baure, Canichana, Movima, Cayuvava, and Itonama groups each had similar yet distinct characteristics. The location of origin for these various groups is not exactly known since in early literature a distinction was not made between the Arawak speakers (Mojo) and the tribes from other linguistic origins (Métraux 1948). However, their location today coincides with their respective locations at the time of contact or with the location of the Jesuit Missions (Crevels and van der Voort 2000:156). The Mojo language was forced on the small tribes, which spoke their own languages. The sociopolitical organization of these groups varied (Eder 1985). Mojo groups were noted as agriculturalists, growing crops such as corn, cotton, potatoes, and peanuts (Eder 1985). While the

Mojo groups were noted as proficient farmers, clearing fields in forests, the Baure were described as being more “civilized” than the other groups (Métraux 1948). The Canichana were seen as fierce cannibals and did not live in villages, while the other three independent linguistic groups (Movima, Cayuvava, and Itonama) lived in villages and practiced agriculture (Métraux 1948). Movima groups today practice subsistence horticulture, and participate in hunting and fishing (Lai 2010:35). The Cayuvava and Itonama lived in large villages. All three of these groups lived along rivers, being both farmers and fishermen. For the Movima, the rivers served as a means of movement and provided ways for commerce during the time of European contact (Lai 2010:34). The landscape modifications that were practiced by the linguistic groups in Mojos are also features of Arawak groups in the larger region of Amazonia.

Arawak speakers throughout Amazonia have shared cultural elements and are described as living in regional societies, incorporating and interacting with other groups (Heckenberger 2010). They are attributed as being the carriers of different ideas and earthwork forms since the distribution of the language family spans such a wide range (Nordenskiöld and Denevan 2009). The expansion of this language family spans throughout South America and into the Caribbean, accompanied by a “cultural matrix” of features (Eriksen and Danielsen 2014). These features include, but are not limited to, religious ceremonies, ceramics, systems of naming places, and landscape management (Eriksen 2011:5). These features were dispersed throughout Amazonia via the regional network in which Arawak speakers came into contact with neighboring groups (2011:8-10). The first feature to disperse via this regional network is high intensity landscape management, which can be seen practiced in many areas of Amazonia (Eriksen 2011:226). The construction of earthworks, for ceremonial purposes as well as agricultural purposes, expanded

throughout Amazonia via this network (Eriksen 2011). Landscape modifications utilized for agricultural purposes, such as raised fields, can be seen across Amazonia.

Heckenberger (2013) discusses how field farming, which is the use of raised fields to manipulate the soil, has been noted as a characteristic of Arawak groups, with examples in Bolivia and the Greater Antilles. In Mojos, Arawaks have been attributed with building the agricultural landscape of the region (Walker 2011a). An example of this is the automatic identification of the ring ditch tradition with groups that speak Arawak. However, ethnohistorical accounts have detailed that the Canichana, whom are not Arawak speakers, also utilized ring ditches (Walker 2012c). With the diversity of groups constructing and utilizing earthworks throughout the Amazon, it is difficult to directly associate a specific group with the earthworks.

Throughout the network of linguistic and ethnic groups within Mojos, it is possible that many societies were composed of multilingual speakers, which could result in a diverse, multiethnic social group within the overall community (Walker 2011a). The indigenous people present today are associated with these diverse earthworks found in Mojos (Walker 2011b). The variation in size, shape, and scale of earthworks create patterns throughout Mojos. These could potentially be a result of the ethnic, cultural, and linguistic diversity of the region. The recognition of not just linguistic diversity, but environmental and cultural diversity is also reflected throughout the languages of linguistic groups in Amazonia (Balée 2013).

Archaeology and History

The concept of Tropical Forest Cultures in the Upper Amazon is a starting point for understanding how archaeology in the Amazon has developed. Archaeology since the 1940s has

been influenced by the Tropical Forest Culture concept (Neves 1999). This concept was presented by Donald Lathrap, who defines the characteristics of a tropical forest culture and its origin (Lathrap 1970). There are technological aspects and linguistic aspects of the explanation of this concept that has influenced the interpretation of Amazonian archaeological sites. The definition of Tropical Forest Culture includes the idea of riverine people, shared cultural elements, intensive root crop agriculture, and exploitation of food resources from varying bodies of water (Lathrap 1970:47). Dugout canoes, tools for grinding foods, and basketry are technologies of the Tropical Forest Culture. Evidence of these elements can be seen in the archaeological record and ethnohistorical accounts. Earthworks, such as ridged fields, have also been attributed to the Tropical Forest Culture (Lathrap 1970:160-163).

Previously in Amazonian archaeology, it was believed that the population density of Amazonia was very low because of the low carrying capacity (Meggers 1996). The archaeological evidence at the time did not present enough supporting evidence for large, dense populations during the precolumbian era (Meggers 1996). According to Meggers (1992), settlement behavior observed both in ethnographic data and recovered in archaeological data is similar both in the precolumbian period and surviving groups. In regards to the Tropical Forest Culture concept, Meggers (1954:809) discussed that cultures that settle in areas of tropical forests are limited by the environmental potential and then reach only the level of a Tropical Forest Culture. Meggers (1954) argued that advanced cultural traits could not diffuse into tropical forest areas and cultures that tried to colonize the area were unsuccessful. However, the pristine environment and small population believed to define Amazonia is not the case. The interaction between the cultures and their environment, in ways such as earthworks and

subsistence systems, is reflected in the archaeological record (Eriksen and Danielsen 2014:155). The connection between the environment in Amazonia and culture was an important key to understanding the prehistory of Amazonia.

The understanding and interpretation of the dynamic interaction between the environment and culture as reflected in the landscape is the focus of historical ecology. Historical ecology allows for scholars to further understand and present information on how people have shaped the environment and manipulated the landscape in prehistory, specifically in Amazonia (Balée 2013:32). In Amazonia, it can be seen that nature influences cultural activities and beliefs, yet culture also influences nature (Balée 2013:33). Native groups of Amazonia modified the landscape by burning forests, as well as building anthropogenic forest islands and mounds as a way to transform and manage the landscape (Erickson 2008). The environment within Amazonia can be seen as humanized, with intentional human-driven transformations and management (Balée 2013:177). In this case, the cultural imprints, or traces, of native groups of Amazonia can be seen on the landscape (Balée and Erickson 2006). The landscape in Amazonia can be seen as a "meaningful unit" for its inhabitants (Eriksen and Danielsen 2014:162). Additionally, the diversity of the Amazonian landscape is encoded in the numerous languages found in the region (Balée 2013).

Within research regarding Amazonian archaeology, environmental variables have to be taken into consideration to understand cultural and social processes of indigenous groups (Neves 1999). The boundaries of land and water shift in the Amazon, due to the climate and rainfall (Cleary 2001). The climate and rainfall have played a role in the environment that is found in the Amazon, which then influences how the landscape has been modified. In the Amazon, humans

have modified the landscape in various, diverse ways (Schaan 2011). The landscape of the Amazon can provide insight to the many cultures that have inhabited it throughout the centuries, and in this way landscape can be seen as humanized (Balée and Erickson 2006).

The landscape of Amazonia demonstrates how nature and culture can coexist and affect each other (Cleary 2001). In research regarding landscape modifications, earthworks have been an interest for Amazonian archaeology throughout the years. Native inhabitants of the Amazon were not restricted within their settlements, but interacted with their environment, shaping and maintaining it (Erickson 2010). To shape and create the many earthworks found within the landscape, Amazonian groups had to intentionally build these earthworks and maintain them (Schaan 2011:180). The interests and investment of the landscape to groups of the past makes them of interest to Amazonian researchers.

The landscape that is seen throughout Amazonia in the present-day is a result of past modifications and human activity (Erickson 2006). It is believed that landscape transformation across the Amazon approximately spans between 500 BCE and CE 500 (Schaan 2011:73). Research on various types of earthworks span across several areas of Amazonia. These various types of earthworks have similarities that have dispersed through a network that spans throughout all of Amazonia, including the Guianas, Venezuelan llanos, the Upper Xingu, the central Amazon, and Mojos (Hornborg, Eriksen, and Bogadottir 2014). The purposes of raised fields throughout this regional network were both ceremonial and agricultural. The modification of the landscape into earthworks made the landscape “a high-productive resource” for the diverse groups found throughout Amazonia (Eriksen and Danielsen 2014:158). The connection for the

earthworks across Amazonia is that they are a part of the vast region that was a part of the Arawak regional system.

The idea of the Arawak regional exchange system has been theorized and argued by several scholars (Eriksen 2001; Eriksen and Danielsen 2014). The Arawak regional exchange system expanded throughout Amazonia, spanning from Brazil to the Orinoco-Guianas region, and west to where the Amazon meets the Andes (Eriksen 2011). Through this system, the Arawak matrix, a concept defined by Eriksen as the "cultural repertoire including material and non-material culture as well as language," was diffused (2011:10). The Arawakan matrix includes concepts such as a tendency to establish alliances with linguistically related groups, an elaborate set of ritual ceremonies, topographic writing, and establishing settlements along major rivers (Eriksen and Danielsen 2014:153-154). High intensity landscape management was also part of this exchange system (Eriksen and Danielsen 2014:154). Concepts such as the development of sedentary and socially complex societies, as well as the vast material and symbolic meanings embedded into the landscape, are associated with high intensity landscape management (Neves and Petersen 2006:286). Arawak speaking societies are seen as responsible for the vast spread of landscape management, such as the creation of earthworks, throughout the regional exchange system. The spread of earthworks can be seen throughout various locations, including Acre, Riberalta, the Guianas, and Mojos. Earthworks throughout these locations include geoglpyhs, enclosure sites, ditches, and canals.

Geometric earthworks, including shapes such as circles, rectangles and composite figures, have been found in the floodplains and upland areas of the western Amazon (Pärssinen, Schaan, and Ranzi 2009). These geometric earthworks are referred to as geoglyphs and expand

from Brazil to Bolivia, covering an area approximately of 1,000 km (Mann 2008). These geoglyphs are also found with other forms of earthworks (Mann 2008:1149). The location of these geoglyphs is believed to be strategic, as they are seen at the edges of plateaus above river valleys (Pärssinen, Schaan, and Ranzi 2009:1089). The geometric shape of these geoglyphs indicates their symbolic nature. Pärssinnen, Schaan and Ranzi (2009: 1094) argue that the symbolic significance can be indicated by the accuracy of the shapes.

In Brazil, 360 enclosure sites have been recorded throughout various regions (Saunaluoma and Schaan 2012: 1). Through satellite imagery, these various earthworks could be seen and revealed sites that were not noticed before (Saunaluoma and Schaan 2012:1). Ceramics and other archaeological materials were found among these earthworks, with common attributes across the sites. The layout of the earthworks did not change drastically throughout their use, although there was variation in the forms at the sites. However, these sites did not show any domestic layers, suggesting sporadic, periodic use (Saunaluoma and Schann 2012:8). Saunaluoma and Schaan (2012:8-9) suggest that these sites had ritual or ceremonial purposes. Several of the sites suggest a ritual context due to the scattered utilitarian wares, potentially used for communal consumption, in the ceramic assemblages (Saunaluoma and Schaan 2012: 8).

Ditches and canals are other earthworks found throughout Amazonia. In the Guianas, ditches were made for water control and enclose groups of raised fields, while canals were used for drainage and could even serve for canoe travel (Rostain 2010). Mounds are also found in the Guianas, along with causeways. Rostain (2010:341-342) details that mounds found in this region are associated with raised fields, with the raised fields being built in between the mounds. Canals can be found between mounds, making them pathways during the wet and dry seasons. These

mounds were artificial and functioned as habitation sites. Further, causeways in the Guianas are oriented north-south and cut through swamps (Rostain 2010:343). During colonial periods, it seems that earthworks for agricultural purposes were still utilized in this region. However, in the Bolivian Amazon, it seems that similar earthworks to those discussed above, along with others, were utilized in precolumbian times.

Archaeology of the Bolivian Amazon

In this region of Amazonia, earthworks have been investigated by various archaeologists. These earthworks include forest islands, mounds, raised fields, causeways, canals, and ring ditches, which will be discussed through various examples below (Figure 2-4). Nordenskiöld’s extensive excavation were for decades the best known in Mojos (Denevan 1966b). Work by Nordenskiöld in the early 1900s provided descriptions of canals, causeways, and mounds (Nordenskiöld and Denevan 2009). These excavations are of three mounds in southeast Mojos to the east of the Río Mamoré (Figure 2-5). These excavations provided information on potential craft specialization in Mojos, as well as interpretations on how the flooding may have affected the construction of these mounds (Denevan 1966b:20-21). These reports and investigations provided a basis for future investigation in Mojos.

Saunaluoma (2010) presents research on earthworks, including ditches, enclosures, and roads, in the region of Riberalta in the NW Bolivian Amazon. This region is part of the Beni and Pando departments. Various interpretations are provided for these earthworks, including the possibility of a protected area of occupation, defensive moats, ritual spaces or special gardens, and potential ceremonial centers or meeting places. Saunaluoma (2010) discusses that the ditches

and canals found in this region were used for water management, similar to ditches and canals in Mojos. Also, Saunaluoma (2010:138) argues that these earthworks had the purpose of delimiting the area of occupation, but yet they could have been symbolic in nature as well. These earthworks were intentional and planned, altering the environment (Saunaluoma 2010: 131).

In the Baures region of Bolivia (Figure 2-6), causeways and canals can be found in dense concentrations (Erickson 2006). Most of these causeways and canals are straight and cover several kilometers. These causeways and canals are intentional in nature due to the fact that maintaining straightness throughout their entire length seems to be important to the builders (Erickson 2006:255). It is suggested that these earthworks may have ceremonial functions, either in regards to rituals or political events (Erickson 2006:255). However, in other areas in Mojos, causeways and canals may have had other functions as well. Along the Apere River in Mojos (Figure 2-7), the purpose of movement and communication was more important than the function of water management in the establishment of these causeways and canals (Erickson and Walker 2009:250). Some of these causeways were not just for water management, but were also a means of transportation and communication (Erickson and Walker 2009: 249). Additionally, causeways and canals found within this area are also argued to have hydraulic purposes, such as diverting and isolating the flow of water and channel runoff during the wet season (Erickson and Walker 2009:246).

Ring ditches are also found in the Bolivian Amazon, with areas ranging from 1 hectare to 5 hectares (Erickson 2006: 258). The depth and width of these earthworks also vary, reaching up to about 4 meters deep and 10 meters wide (Erickson 2006: 258). The form of these ditches varies, including round, oval or square forms (Erickson 2006: 259). Some of these ring ditches

are believed to have been used for palisades, as detailed by early explorers (Erickson 2008). Many large ring ditches, specifically in the Baures region, are part of networks of causeways and canals (Erickson 2006).

In northeast Bolivia, extensive networks of ring ditches can be found, ranging in form and size in the Iténez province (Carson et. al 2014). The construction of these earthworks along with agricultural activity occurred in the open savanna, maintained throughout the years of use (Carson et. al 2014). Further investigations in the Iténez province of Bolivia have presented information on ring ditches associated with causeways (Prümers, Betancourt, and Martinez 2006). Around the site of Bella Vista, there are several ring ditches, varying in size and shape (Prümers, Betancourt, and Martinez 2006:253). It is believed that these ring ditches may have had defensive purposes, some having palisades in the past according to historical accounts (Prümers, Betancourt, and Martinez 2006:254). However, the material from which palisades might have been created have not been found in the archaeological record.

Ring ditches in the Bolivian Amazon are similar to those found in other areas of Amazonia, such as Riberalta, Acre, and the Upper Xingu (Erickson 2006, 2008). A recent review of excavations of ring ditches in Mojos, specifically along the Yacuma and Rapulo Rivers, has provided further information on ring ditches in the region (Walker 2008b). The ring ditches discussed in this study were found on four forest islands in the study area. Ring ditches are earthworks that have been associated with Arawak speakers, but through this study it seems that the association of ring ditches with a specific linguistic group is difficult because they are found in areas with great linguistic diversity (Walker 2008b).

Forest islands can be found throughout the Bolivian Amazon, specifically in the savannas. These forest islands are believed to be anthropogenic, being prime areas for settlement (Erickson 2006). Forest islands are defined as isolated units of forest found in the open landscape (Langstroth 1996). These forest islands, also referred to as *islas*, are slightly elevated. These forest islands are often surrounded by raised fields, canals, and causeways. The height for most of these forest islands is less than one meter (Erickson 2008). Forest islands were occupied during precolumbian times, as indicated by excavations and shovel tests of forest islands in Mojos (Walker 2004). A distinct settlement pattern is noted among forest islands, as well as long-term occupation due to the depth of cultural material and human effects in the soil. It is a possibility that forest islands could have been a convenient location for habitation during the wet season or rest stops for over land travels. Seasonality seems to play a role in the habitation of forest islands.

In the area near the city of Trinidad, in SE Mojos, monumental mounds have been found; many situated on levees and were modified and built upon along with being used (Prümers 2007; Whitney et. al 2013). These habitation mounds are part of a complex that includes canals, causeways, and various other earthworks (Whitney et. al 2013). Platforms within mound complexes, such as what is seen at Loma Salvatierra approximately 50 km from Trinidad, can be found in “U” shapes, enclosing a plaza (Prümers 2007). Excavations conducted by Heiko Prümers and his colleagues (Prümers 2007:104) of two habitation mounds at Loma Salvatierra have presented data that contrasts colonial accounts to the archaeology in the understanding of cultures in Mojos. The correlation between the orientation and plan of these mounds and the

cardinal directions potentially gave insight to the world view of the prehispanic occupants (Prümers 2007:104). Burials were also found at Loma Salvatierra, within the mounds.

Research on occupation patterns has presented new suggestions for the settlement pattern of precolumbian groups. A study conducted by Lombardo and Prümers in the area east of the city of Trinidad presented ideas on settlement patterns by analyzing forest islands and mounds at varying scales. The authors utilized remote sensing techniques and GIS. Canals were also found in the study area, but were not connected to the mounds. Lombardo and Prümers (2010) argue that the forest islands and mounds were likely man-made, including the fact that they were organized in strategic clusters and most were surrounded by circular depressions that were more than likely man-made. However, raised fields were not found in this study area.

Raised Fields

In the Americas, many precolumbian agricultural earthworks can be found and are the focus of archaeological studies. Within Amazonia, raised fields are part of the cultivated landscape created and maintained by the diverse groups in the region. Raised field agriculture, defined as elevated planting surfaces, was a form of landscape modification the native populations found sustainable (Erickson 2006:251-253). Raised fields are found in savanna habitats, as well as the highland regions of several countries in South America (Denevan 2001). The savanna soils are heavy in clay and make agriculture difficult, yet precolumbian groups were able to create raised fields and manage them. Rostain (2010:348) argues that the ability to intensively use the land makes raised fields the best method for agricultural purposes when populations rose. Within Amazonia, the largest savannas are found in the Llanos de Mojos,

Bolivia, Orinoco Llanos, Venezuela, Panal in Western Mato Grossa, Brazil, and the Atlantic coast of Guyana (Denevan 2001). Most of these raised fields date between 1,000 BCE and the first millennium CE (Rostain 2010).

The extent of the various constructions of raised fields suggests that dense populations were being supported by these fields (Renard et. al 2012). These dense, larger populations can be associated with intensive agriculture, which is interpreted though the extensive raised field system (Walker 2004). These fields are found in diverse environments, throughout the world and in South America. Contemporary raised field systems are not exact analogues of the prehistoric systems studied by scholars, but provide some insight to raised field agriculture (Renard et. al 2012). The diversity in raised fields can be seen in their size, shape, orientation and location (Denevan 2001).

Precolumbian Raised fields throughout South America

Raised fields are defined as land that has been transferred and elevated above the natural surface to improve cultivation (Denevan and Turner 1974). According to Denevan (2001:220), the term raised field is a general term, referring to any artificially elevated field. Within South America, raised fields are found in seasonally flooded or near permanent standing waters, where managing drainage has been interpreted as an important function of these fields (Denevan 2001:220). These precolumbian fields come in a vast range of sizes, forms, and patterns. Raised fields can be found in countries such as Ecuador and Colombia, as well as along the Guianas coast. The discussion of raised fields throughout South America will begin with fields found in Ecuador and move east towards fields that are found in the Guianas and Suriname. Lastly, fields

found throughout Bolivia will be discussed. Descriptions presented of raised fields found throughout these various locations is primarily based on Denevan (2001), in which he details raised fields and other earthworks throughout Amazonia.

Within Ecuador, raised fields have been found both in the coastal region and the northern highlands. In coastal Ecuador, raised fields are found in the periodically flooded savannas of the Río Guayas Valley (Parsons 1969). The fields found in this region are associated with other types of earthworks, both being destroyed over time (Denevan 2001:228). Air photographs have revealed the area of fields (Parsons 1969). Within the highlands of Ecuador, some fields have been buried by volcanic ash, preserving them. The large fields have dates as far back as CE 600, while the smaller fields have dates as far back to at least 300 BCE (Denevan 2001:234). These fields found in the highlands of Ecuador are associated with large mounds with ramps. Raised fields in Ecuador were no longer in use at the time of European contact, similar to those in Colombia and Bolivia (Parsons 1969). In coastal Peru, raised fields have been found as well, located near the Casma River in an area that overflows. The fields were constructed during the period of the Chimú culture, dating from CE 1300-1470 (Denevan 2001:234).

In Colombia, these precolumbian fields are found in the seasonally flooded Mompos Depression (Parsons and Bowen 1966). Precolumbian mounds are found in the area as well, some including burials (Parsons and Bowen 1966). Canals between the raised fields have provided dates as far back as 810 BCE and 330 BCE (Denevan 2001:222). Raised fields are also found in the elevated region near Bogotá, in which the area is poorly drained. From the ground the fields are not easy to see and may go unrecognized (Parsons and Bowen 1966:319). In the Venezuelan Llanos, the raised fields can be found between the gallery forests and the natural

levees of rivers. No adjacent settlement sites were discovered that are associated with these raised fields (Denevan 2001:224). These raised fields are mostly found in pairs with a ditch and with open savanna in between. Additionally, located in the western Venezuelan Llanos is an area of precolumbian drained fields system that encompasses about 35 hectares (Spencer and Redmond 1992:150). This field system potentially served as a means to minimize crop loss and to extend the growing season (Spencer, Redmond, and Rinaldi 1994:130-131).

Raised fields on the Guianas coast are found in both Suriname and French Guiana, accompanied by ditches, ponds, and causeways (Rostain 2008). In Suriname, the fields are described as almost square along with rectangular fields (Denevan 2001:226-227). Four types are categorized in the Guianas: ridged fields, large raised fields, medium-sized fields, and small-rounded fields (Rostain 2010). A specific cluster of fields that Denevan (2001:227) discusses is found around a large artificial mound with a date of about CE 700. This mound and surrounding fields are found near Caroni. Within French Guiana, there are numerous areas with both fields and mounds, found in coastal savannas (Denevan 2001:227). Among these fields, the earliest date to about CE 200.

The major influence for the location of these fields is water, which has a role in where fields were constructed, demonstrating the intentionality of these fields (Rostain 2008:222). Raised fields found in French Guiana were used after the conquest as well, demonstrating their ongoing significance (Denevan 2001: 227). Fields in French Guiana have also been found in highly organized fashions and often in square grid arrangements; however, not all are equally conserved (Mckey et. al 2010). The round shaped raised fields in the Guianas, majority concentrated in French Guiana, make them distinct (Rostain 2010). However, local variations,

varying from west to east, can be seen within this region, which can be indicative of cultural or chronological differences (Rostain 2008: 222; 2010:340).

Within Bolivia, raised fields are found in both open savannas of the Bolivian Amazon and in the Lake Titicaca Basin. Within the southern Lake Titicaca Basin, raised fields have been found buried since their abandonment (Janusek and Kolata 2004). Janusek and Kolata (2004:419) note that these fields were mostly built during single construction events, with a few having evidence of multiple periods of construction. Raised fields in this area were managed along with the various other resources available, making these fields part of a very diverse economy (Janusek and Kolata 2004:413). Raised fields in this region had a variety of sizes. The local villages are believed to have had the task of maintaining and building the local fields during the Tiwanaku period (Janusek and Kolata 2004:422). These raised fields are understood to have come from “knowledge and practice of local groups,” prior to state emergence (Janusek and Kolata 2004:425).

In the Lake Titicaca Basin, raised fields have also been investigated and studied by Clark Erickson (1988, 1993). The raised fields found in these investigations range in size and form (Erickson 1988:9). Habitation mounds have also been found associated with these raised fields, presenting evidence for a dense population (Erickson 1988:12). The development of these raised fields occurred earlier than the development of state organization and continued during the rise of state in the Lake Titicaca Basin (Erickson 1993:389). In this region, communal and cooperative labor is the traditional organization of labor (Erickson 1988:15). Erickson (1993:391) has also argued that the patterned division of the raised fields of this region could reflect the Andean structure and organization of families and communities. He supports this by

explaining that raised fields were developed and maintained by the local communities organized by farmers (Erickson 1993: 413). Through the building and maintenance of experimental raised fields, Erickson and his team was able to support the idea of communal labor and the maintenance of raised fields at the local level (Erickson 1993:402). These raised fields provide a comparison for fields found in Mojos.

Raised Fields in Mojos

The largest area of surviving precolumbian fields is in Mojos in the Bolivian Amazon (Denevan 2001:72). There are four types of raised fields found in Mojos, outlined by Denevan (2001:241) with examples of each. The four types include platform fields, narrow, ridged fields, mound fields, and gridiron fields. Denevan (2001:241) notes that generally these types of fields do not occur in the same area, but they do all occur throughout the region. Raised fields stand out from the air, but are difficult to see on the ground (Figure 2-8). Platform fields are found in the pampa (grasslands), as well as mound fields. Ridged fields are found in association with causeways, artificial mounds, and other types of fields. Mound fields are mostly circular and are regularly spaced, while gridiron fields are enclosed on three or four sides by ditches.

In Mojos, it is argued that raised fields seem to occur predominantly on the west side of the major river in the area, the Mamoré River (Lombardo 2010:3). Raised fields in Mojos are the largest surviving clusters of raised fields in Amazonia (Denevan 2001:72). Most of these raised fields are found in the pampa and can be seen from the air (Denevan 1966b). Erickson (2006:252) asserts that the patterning of raised fields in certain areas is structured, while in others it is informally organized. An understanding of the labor required and necessary maintenance to

make raised fields productive and sustainable implies that a large population could have been supported by these earthworks (Erickson 2006:253).

The understanding of how raised fields were created, utilized, and maintained contributes to the link between social and spatial organization in Mojos (Walker 2004). Walker (2001) presents information on large raised fields found along the Iruyañez River in the Llanos de Mojos. These raised fields remain dry due to their location and are associated with forested high ground. These fields seem to also not have been monocropped and had variation within field groups (Whitney et. al 2014). Walker (2001) argues that work parties were building these raised fields. Evidence of these work parties can be seen in the ethnohistorical record. Small communities pooling together to perform tasks to build and maintain these fields demonstrates the necessary social organization in the area. Coordination between groups of farmers was necessary to ensure there was sufficient space between fields for other use (Walker 2011a:289). Walker (2001) also details that no other large agricultural infrastructure, such as canals or causeways, are found in the study area. Analysis of the fields also presents evidence that suggests the fields were built individually and could potentially have been organized into groups. This study shows that large groups of people were not needed to maintain these fields, yet the amount of fields found in the region is very high. Studies of the spatial distribution of raised fields also provided insight to their construction and maintenance.

Recent research on raised fields has been done by several scholars, including Walker (2004, 2011b), Lombardo (2010), and Boothby (2012), each providing insight to how these landscape modifications may represent the relationship between precolumbian groups and the environment. These specific studies included the use of GIS for spatial analyses. The Proyecto

Sistemas de Información Geográfica-Arqueológica del Beni (PROSIGAB) is an ongoing project, to which this study will contribute, that includes research on raised fields, forest islands, and ring ditches. Throughout the PROSIGAB project, several excavations of sites have been conducted that have revealed information of precolumbian groups in Mojos. Recent excavations at Isla Estancita and Isla San Francisco have provided information on ceramic styles and use at the sites (Walker 2012; 2013). Further analysis of some ceramic assemblages has also been presented in separate studies (Walker 2011a; 2011b).

In the research conducted by Walker (2004), several questions were addressed including intensity of cultivation and population density. Remote sensing resources, such as aerial photos, were utilized to conduct this research. Field survey was also done to provide "ground truth" for the aerial photos (Walker 2004). Individual fields were measured for analysis through the use of aerial photos. Through this analysis three trends were noted, which include limited range in variation in width of the fields, there was a maximum length of the individual fields, and there was variation in raised field orientation, following the cardinal directions (Walker 2004:41). These raised fields could also be categorized into groups, based on orientation and the size of the neighboring individual raised fields. These groups could possibly reflect different social groups that are building these raised fields (Walker 2004:49).

Walker (2011b) conducted a spatial analysis of raised fields along the Iruyañez and Apere Rivers. Earthworks were georeferenced from aerial photographs, while other features were digitized through Google Earth imagery. Four patterns were found among the earthworks along the Iruyañez, while seven patterns were found along the Apere (Walker 2011b:281). The patterns along the Iruyañez were categorized into platforms, platform groups, platform

neighborhoods, and platform divisions. The patterns along the Apere were categorized as well. These categories included: blocks, block neighborhoods, block divisions, causeways, and an integrations of blocks and causeways. The labor required to build the landscapes in both areas was very similar (Walker 2011b:287). Walker (2011b:292) notes that these areas could have been occupied by different groups contemporaneously, including different linguistic and ethnic groups. The production and maintenance of this type of agricultural system did not require centralized authority, giving farmers the opportunity to maintain their own social and political lives through the landscape (Walker 2011b:292).

A GIS based analysis conducted by Lombardo (2010) provides further information on raised fields north of Santa Ana. QuickBird images were used in this study along with the ArcGIS 9.2 program. Lombardo (2010:7) found that there was great variability in length among the raised fields, but a smaller variation in width. The raised fields were categorized into groups based on the groups defined by the researcher. There was a positive relation between the group size and field length. Also, there was greater variability in orientation of fields that did not belong to a group than the ones that belonged to the larger groups, which had the least variability (Lombardo 2010:11). Lombardo (2010:12) noted that the directional means of the fields were rotated counter-clockwise, similar to those studied by Walker (2004). A hypothesis that Lombardo (2010:14) presents as a possible explanation for the separate grouping of fields is that they may be separated to go with different cycles for crop and fallow periods.

Boothby (2012) conducted a GIS-based analysis of Mojos, focusing on precolumbian earthworks, including raised fields and ring ditches, as well as landscape features including rivers and forest islands. Google Earth imagery was used for the digitization of the features and

imported into ArcGIS. The perimeter of Boothby's (2012:32-33) study area was not determined based on the geographical features in the region, but was delineated based on longitudinal lines and measured boundaries for consistency. The major focus was the raised fields within the area. The orientations of the fields seem to have been influenced by the water resources in the area (Boothby 2012:63). Intentionality could also be interpreted from the location of the fields, being that they were mostly located along the waterways (Boothby 2012:63). Boothby (2012:69) also observed any correlations between forest islands and raised fields in the study area. Intersections were found between raised fields and forest islands, leading to the interpretations that perhaps the islands were forest vegetation growing on sections of raised fields or the fields were constructed up to where settlements were located (Boothby 2012:69). Spatial analyses, such as those conducted by Boothby, contribute to the understanding of the spatial distribution of precolumbian earthworks in Mojos.

Summary

The growth of Amazonian archaeology throughout recent years has shed light on the complexity that was present in this vast region. With continuous investigations of earthworks in the Amazon and further analysis of the correlation between these earthworks and what they may represent, scholars have gained further understanding of how interactive networks and communities developed in Amazonia. The modifications of the landscape of Amazonia gives scholars the opportunity to interpret and understand the impact of precolumbian groups on the environment. The connection between nature and culture present in landscape modification also

provides insight to how precolumbian groups may have related to and interpreted the environment.

The numerous types of earthworks, such as geoglpyhs, ring ditches, mounds, and raised fields found throughout Amazonia demonstrates the various ways that diverse groups shaped their landscape. The distribution of these earthworks throughout various geographic locations demonstrates the movement and communication that could have occurred during the precolumbian era. The interactive networks that existed during the precolumbian era of Amazonia may have allowed for this movement and communication. Through this interaction among diverse linguistic and ethnic groups, cultural characteristics, including earthworks, were diffused throughout Amazonia. An example of a large, interactive network characterized by various cultural elements is the Arawak exchange network. While it has been argued that earthworks are directly associated with Arawak speakers, this is a more complex issue. In Mojos, while there are Arawak speakers, earthworks at a large scale are found in areas that are not associated with Arawak speakers. These earthworks include, but are not limited to, agricultural raised fields.

Research conducted on raised fields in Mojos provides a foundation for future research on how this agricultural system can be linked to social organization and identity. Groups that created these earthworks may have reflected their social organization into the organization of the individual fields, and further the groups of fields, as seen in the fields found in the Lake Titicaca basin. The construction and maintenance of the Lake Titicaca basin was at a local level and was a communal effort. The building and maintenance of these fields could provide insight to the relationship between precolumbian populations and the landscape. The interaction among

precolumbian groups in Amazonia could have contributed to the distribution of diverse earthworks in the region through movement and communication.

This project observes and analyzes the distribution of both raised fields and forest islands along two sets of rivers in Mojos. This project utilizes GIS analysis, similar to those discussed above. The past studies in Mojos that utilized GIS programs for spatial analysis provide a basis for methods and interpretations of the spatial distributions found within the landscape. An analysis of the spatial patterns in the landscape of Mojos provides a foundation to understand the interaction and movement of groups in the study area and their potential connection with the overall larger network in Mojos along the major river systems and tributaries. The distribution and density of raised fields in this analysis provides support for the argument that earthworks, such as fields, were not solely built and used by Arawak speakers.

CHAPTER THREE: MATERIAL AND METHODS

Throughout the tropics, and specifically lowland South America, investigations of archaeological features are difficult. Limitations such as preservation factors, problems of field logistics, and visibility make archaeological study difficult in lowland South America (Erickson 1995). Within the Llanos de Mojos, various methods and techniques have been used to investigate the various landscape modifications that are found in the region. These methods include remote sensing analysis, reconnaissance from aircraft, ground surveys, mapping and excavation, and agricultural experimentation (Erickson 1995). The methods and techniques utilized to investigate landscape modifications in Amazonia have developed and improved throughout the last few decades.

Increasing access to resources, such as satellite imagery and improved computer software, is beneficial for archaeologists and other scholars. Public access to satellite imagery can provide further information on the landscape that can later be explored by researchers. Programs such as Google Earth™ and GIS software provide avenues for scholars to conduct spatial analyses of areas that may be difficult to see on the ground or would be tremendously time consuming. As mentioned in the previous chapter, the Proyecto Sistemas de Información Geográfica-Arqueológica del Beni (PROSIGAB) utilizes both programs for analyses and supplementary sources for excavations and surveys in Mojos. PROSIGAB conducts GIS-based spatial analyses of Amazonian precolumbian earthworks, including raised fields, in Mojos to gain further understanding of the social organization of the region (Walker 2010). Raised fields, along with other features, that have been digitized are a basis for the data utilized in the PROSIGAB project.

A recent study that utilized Google Earth and the ArcGIS program for spatial analysis is the thesis work of Stephanie Boothby (2012). In this study, Google Earth was utilized to digitize data that were then imported into the ArcGIS program. Boothby (2012:34) mapped precolumbian features, which included ring ditches and raised fields, as well as the landscape, which included rivers and forest islands. The perimeter of her study area included archaeological excavations in the region and was delineated by latitudinal and longitudinal lines (Boothby 2012:32-33). Google Earth provides digitizing tools, but does not have the necessary tools to conduct a spatial analysis. To conduct a spatial analysis, GIS programs, such as ArcGIS, can be used.

Boothby (2012:54) used ArcGIS to conduct a spatial analysis of the digitized data from Google Earth. She used several tools in ArcGIS, including the clip, select by location, intersect, and buffer tools. The tools chosen for the spatial analysis were used to determine correlations and patterns among the mapped features attained from Google Earth. The data Boothby used in her thesis work was digitized through the PROSIGAB project. This current thesis project will use similar methods and will also use data from the PROSIGAB project. The digitized data of PROSIGAB has continuously been updated since the work by Boothby. ArcGIS, will also be used for spatial analysis.

The focus of this thesis project is data that was digitized to represent raised fields and other features, and its spatial distribution throughout Mojos. Spatial patterns distinguished in the analysis were analyzed and interpreted to understand the relationship between raised fields, forest islands and the two river systems within a portion of Mojos. These patterns were divided between the northern and southern sections of the study area as a means of comparison. The

northern and southern sections in the study area can then be correlated and identified with two linguistic groups in the region, the Cayuvava and Movima. Information on these groups and their distribution is based on ethnohistorical accounts and work by previous scholars (Métraux 1948; Denevan 1966b; Block 1994). This analysis provided information on the distribution of these features in relation to the rivers and linguistic groups.

Study Area

The study area is found in Mojos, Beni, Bolivia, which is part of the Amazonian basin. Various earthworks are found in Mojos, such as canals, causeways, ring ditches, raised fields, and forest islands. The earthworks analyzed are raised fields and forest islands. These will be compared in relation to river systems in the area. Mojos covers approximately 110,000 km^2 within Bolivia, therefore it was necessary to narrow down the study area for the scope of this thesis. Overall, the study area for this project covers 8,992.336 km^2. The study area of this thesis was distinguished by creating a polygon outlining the overall distribution of raised fields (Figure 3-1). This area was then clipped to include forest islands found in the area.

The western boundary of the study area is the Mamoré River and it includes two sets of rivers within this boundary: the Iruyañez, Omi, Yacuma, and Rapulo Rivers (Figure 3-2). This study area is further divided into a northern and southern region. The northern area of the study refers to the Iruyañez and Omi river system, which is associated with the Cayuvava ethnohistorically (Figure 3-3). The southern area of the study refers to the Yacuma and Rapulo river system, which is associated with the Movima ethnohistorically (Figure 3-4). A part of the Omi River is found within both linguistic group areas. Between the two river systems, there is a

wetland area in which forest islands and raised fields are found. This region falls into the Movima region on the map provided by Denevan (1966b:41), but north of it the "boundary" of the two groups can be found (Figure 3-5). High quality imagery for the area is available on Google Earth.

Public Domain Data

Google Earth™ is a public source providing imagery of locations around the world. Through this, archaeologists and the public are able to find features of interest and digitize them for spatial analysis. Access to this program is granted through free licensing and downloads for the program. The software was used at the University of Central Florida (UCF), and also on a personal laptop. Google Earth includes tools that can be used to digitize and map features. These are the polygon, path, and placemark tools. The polygon tool allows individuals to outline and map features, such as raised fields or forest islands. The path tool can be used to delineate features such as rivers. The placemark tool can be used to mark a point of interest. Similar to previous research, the polygon and path tools were used to map raised fields, forest islands, and rivers. The digitized features utilized for this thesis were mapped as part of the PROSIGAB project and were continuously updated throughout the Spring 2014 and Fall 2014 semesters. Mapping of these fields, as well as the mapping of forest islands, has been conducted by a group of undergraduate mappers, Siskin Serebriany, Andre Oliveira, Sabine Macmahon, Saran Allaun, Danielle Young, Kasey Moore, and Thomas Lee; with later contribution by the author at UCF through Google Earth. The continuous hardwork of the mappers was continuous throughout the semesters as imagery was updated and became available through Google Earth. The satellite

imagery utilized in this project is provided through Spot Image, LANDSAT imagery, and Digital Globe imagery (Google Earth 2013).

Distinguishing raised fields on the ground is quite difficult, making satellite imagery a valuable source for surveys and analysis. As experienced by the author in the summer of 2014, raised fields are difficult to distinguish on the ground due to potential vegetative overgrowth and erosion. However, distinguishing features throughout satellite imagery can be also difficult, depending on various factors such as the clarity of the imagery and the preservation of the fields. For example, distinguishing raised fields can vary depending on the visibility of the fields. Raised fields seen on satellite imagery can be distinguished by lighter coloring in comparison to the surrounding vegetation (Figure 3-6). Similarly, forest islands can also be distinguished on satellite imagery. Forest islands are seen as dense areas of vegetation, normally in a circular or round formation (Figure 3-7). The color of these forest islands is normally a darker green compared to the surrounding vegetation. Lastly, rivers seen on satellite imagery may be the easiest to distinguish. They are normally distinguished by the darker, dense vegetation that run along the banks of the rivers (Figure 3-8). The width of the rivers can also be seen when zooming in to the images. Old river courses can also be seen in the imagery. These are distinguished by dark marks running off or near the current course of the rivers.

The distinction and mapping of these features depends on the individual digitizing. The raised fields utilized in this analysis were digitized and mapped by several individuals, providing different versions of fields (Figure 3-9). The fields are usually rectangular in shape, either elongated or short in size. Raised fields can be found either in large clusters in varying orientations or at times isolated. Forest islands vary in size, leading to variation in how they are

mapped as well (Figure 3-10). The circumference and width of forest islands can vary based on the individual who is digitizing and mapping the feature. Around some of the forest islands there can be lighter coloring that can at times be seen as the boundary of the forest islands. Lastly, how rivers are digitized can vary as well. Some may map rivers just as a path through the center of the river, while others may map it as a polygon, demonstrating the width of the river along with the path or curvature of the river (Figure 3-11). These features were digitized by various individuals and discussed at weekly meetings.

As these features were being digitized, they were combined and separated into files categorized by type. All files related to the raised fields were combined into one large file. A total of 41,931 polygons were digitized and collected into this file, these polygons were then categorized into neighborhoods by using a 10 m buffer due to the uncertainty of the exact outline of each field and the multiple representations of one potential field (Figure 3-12). The same was done for all files of forest islands and rivers. A total of 656 polygons were digitized and collected into the file of forest islands (Figure 3-13). This ensured that all digitized data by the individuals that are a part of PROSIGAB are organized. Separating files and categorizing them had to be done prior to converting them into layers for the ArcGIS program to ensure that the correct data is included in each respective layer. Using Google Earth to map the fields, islands, and rivers provides an organized, specific file to import into ArcGIS.

In addition to the geographic data, data from historical accounts and previously mapped areas of the linguistic and ethnic groups were used (Figure 3-14). The map of linguistic and ethnic groups is based on the information provided by Denevan (1966b:41). The boundaries of these groups are as interpreted by Denevan (1966b) based on ethnohistorical accounts provided

by Jesuits and early explorers of Mojos. Two major missions found within the study area are Santa Ana and Exaltación. These missions are associated with the Movima and Cayuvava, respectively. The representation of the boundaries and extent of these groups were drawn as polygons on Google Earth. The groups within the study area are the Cayuvava and Movima. These linguistic group polygons, along with the digitized data of raised fields, forest islands, and rivers were imported into ArcGIS for further analysis.

ArcGIS 10.1

The spatial analysis for this project was conducted through the use of the ArcGIS program. Access to this program was granted through the site license of UCF. Through this program, various tools can be used to conduct spatial analyses. This program provides various tools that scholars can utilize and share with the public domain and their colleagues. For this project, several tools were used to first create the layers that will be the basis for the analysis, and then to conduct the actual analysis. These tools include the conversion tool, buffer tool, select by location, and the dissolve tool. The several layers created by these tools from the Google Earth data were the basis for the analysis.

To first create the layers that are the basis of the analysis, the files from Google Earth are saved and converted into layers through the ArcGIS conversion tool. This conversion tool converts KML files to layers within ArcGIS. The three layers include the raised fields, forest islands, and rivers layer, each containing the respective digitized data. A final layer that was utilized in the analysis is the linguistic groups, based on the linguistic group distribution map provided by Denevan (1966b:41). The distribution of the linguistic groups presents the areas

which the groups were believed to have occupied, based on ethnohistorical accounts. These areas will be used to compare patterns among the spatial distribution of raised fields and forest islands.

Through selections and buffers, the patterns found among the distribution of the features in the study area can be distinguished at various threshold distances. Determining a threshold distance for travel in regards to agricultural practices was based on threshold distances found in the literature. For the analysis, the threshold distances of 700 meters and 1,000 meters, which were chosen based on previous agricultural theories in regards to movement minimization and travel time. These theories include the idea that social factors affect land use and distance to this land (Stone 1991). Through studies conducted in agricultural settlements, Stone (1991:347) argues that a threshold distance for trips related to agriculture is 700 meters. The number of trips to fields, or any other agricultural land, increase up to this distance and then the number of trips drops off sharply when the distance is increased beyond 700 meters (Stone 1991:347). Stone (1991:349) notes that the travel for intensive and extensive farming differs in the way that it is short and frequent when intensive and infrequent and long when extensive. An alternative distance is presented by Chisholm (2007), who notes that the distance of 1,000 m is significant. Through various studies, Chisholm demonstrates that up to 1,000 m or 1 km, little time and adjustment is needed. Beyond 1 km the costs of movement would be so great that the community would have to respond through their social organization (Chisholm 2007:148)

For the analysis, neighborhoods of raised fields were created due to the issue of multiple digitized polygons that could potentially be representative of one field. These neighborhoods were created by 10 m buffers around fields, which were then dissolved to included larger groups of fields. Each dissolved buffer created an area of fields that overlapped within the 10 m buffers,

which are referred to as neighborhoods (Figure 3-15). The 10 m buffer was chosen because of the uncertainty of the exact outline of each field. Also, it is possible that the earth moved to create the fields could have been from about 10 m around each field. The neighborhoods created through these buffers were then the basis of the analysis to understand the correlation between the raised fields and the other features.

The select by location tool was used to select various features. Each selection was “saved as” separately, labeled according to what it demonstrated, such as if they were raised fields within 700 m from the rivers or forest islands within 1,000 m from the rivers. The first set of selections were conducted at a threshold distance of 700 meters. Raised field neighborhoods were selected at this threshold distance from forest islands and rivers. Additionally, they were selected at the 700 threshold distance simultaneously from both forest islands and rivers as a means of comparison. This selection demonstrates the relationship of raised field neighborhoods with forest islands and rivers simultaneously. Overall, these selections provided information on the percentage of raised fields and forest islands within the 700 m threshold distance of the rivers, as well as the relationship between forest islands and raised fields.

The analysis was repeated with a threshold distance of 1,000 meters. Neighborhoods within 1,000 m of rivers were selected, followed by a selection of neighborhoods at this threshold distance from forest islands. Similar to the selections discussed above, raised field neighborhoods found within 1,000 m from forest islands and rivers were chosen, to demonstrate the relationship between neighborhoods and these two features simultaneously. Through these selections, the data was able to demonstrate the spatial distribution of features at the two threshold distances and in relation to each other.

The selection of features and buffers provide a visual of the spatial distribution of these precolumbian earthworks. These tools were used to observe the distances and relationships between raised field neighborhoods and forest islands, as well as these two features and the rivers in the area. The overall distribution of the raised fields included a total of 41,931 polygons, associated into 6,639 neighborhoods. The overall distribution of forest islands included a total of 656 polygons, however these features were then clipped to be included in the chosen study area. Therefore, a total of 574 islands were used in the study. Through each selection and buffer, these numbers were narrowed down and provided distinct distributions of each feature. The visual of the spatial distribution of the dataset in relation to the rivers at the threshold distances demonstrates how the landscape was modified at each respective distance. The percentages and exact amount of polygons found within each selection and buffer provided a statistical representation of the spatial pattern. Though the selections and buffers were the bulk of the spatial analysis, an overlay of the linguistic groups found in the study area was also incorporated.

The layer of linguistic groups based on work by Denevan (1996b:41) is also an important part of this spatial analysis. In order to determine a relationship between the spatial distribution of the geographic features and the linguistic groups, the linguistic group layer was overlaid each layer of the analysis. The linguistic groups also were identified with the northern and southern areas of the study area. Similarities and differences within the northern and southern areas of the study area were observed and noted. The relationship between the spatial distribution of the landscape and linguistic groups of the study area is just a piece of the overall network of Mojos.

Summary

The distribution of raised fields and forest islands along the two river systems chosen for this analysis has demonstrated distinct spatial patterns within the landscape of Mojos. The spatial patterns found throughout the study area, specifically within the linguistic groups, contribute to the argument of an interactive network in the region. These features are part of the vast landscape management attribute that was diffused through the region. The spatial distribution of raised fields and forest islands along this selected piece of the river network in Mojos in relation to the distribution of linguistic and ethnic groups could also provide insight to how landscape management may have been similar or different between groups. Landscape modification was an important cultural feature of Amazonian groups, being seen throughout the region in various forms. The results of this analysis and possible interpretations are detailed in the following section.

CHAPTER FOUR: RESULTS AND ANALYSIS

Results

The spatial analysis includes raised fields and forest islands, as well as two river systems. The focus of the analysis is the relationships between spatial distributions of these features across the study area. The spatial distributions of the raised fields and forest islands along the river systems are analyzed and compared by northern and southern regions. These sections of the study area were later discussed in relation to the two linguistics areas, the Cayuvava and the Movima, which are both linguistic isolates. These patterns are based on where the raised fields and forest islands are located in relation to the rivers, which possibly served as a network of movement and communication in the region.

Forest islands are were occupied by precolumbian groups, supported by evidence from excavations and previous work from several scholars (Denevan 1966b:70-72; Langstroth 1996; Walker 2004). If fields are constructed close to forest islands, could that mean that these fields belonged specifically to the groups found at these islands? While this is a possibility, it is difficult to associate neighborhoods of fields with specific groups that occupied the forest islands. The extent of neighborhoods of fields and their proximity to forest islands in Mojos contribute to the difficulty in associating fields with islands. Additionally, throughout the study area, several forest islands can be found in close proximity to each other, making it difficult to assess which neighborhoods of fields may belong to each specific island.

The distribution of each feature was essential to this analysis. The analysis began by observing the overall distribution of raised fields and forest islands as they correlate with the river systems in the area. As previously discussed, the raised fields used in the analysis were

categorized into neighborhoods of fields, minimizing potential error in the exact amount of fields found at the threshold distances. The distribution of these neighborhoods spans the extent of the study area (Figure 4-1). Additionally, the overall distribution of forest islands in the region was clipped to include the forest islands that can be found in the delineated study area (Figure 4-2). Lastly, the distribution of both features were analyzed together to further understand the relationship between raised field neighborhoods and forest islands in the study area (Figure 4-3). The spatial analysis of the raised field neighborhoods and forest islands included the selections of these features accessible within the threshold distances of 700 m and 1,000 meters (Stone 1991; Chisholm 2007). A summary of the analysis including the results of neighborhoods and forest islands found within each distance are presented in Tables 1 and 2, as well as those found at a greater distance presented in Tables 3 and 4. Additionally, the areas of each selection according to the threshold distance for the raised field neighborhoods can be found in Table 5. To begin, the results that include forest islands will be presented, followed by the results including raised fields.

Forest Islands

The analysis includes a total of 574 polygons representing forest islands. These features were represented in green with a black outline. Statistics for the forest islands can be seen in Table 3, including how many fields were found within each distance, as well as how many were found farther than 700 m or 1,000 meters. Overall, the forest islands covers approximately 29.29 km^2 of the study area, or 0.33%. The spatial distribution of forest islands in relation to the rivers in the study area was shown through selections of features by location. A total of 52 forest

islands, approximately 9.05%, were found within 700 m of rivers (Figure 4-4). Within the threshold distance of 1,000 m of rivers, a total of 78 forest islands, approximately 13.58%, were found (Figure 4-5). The relation found within the spatial distribution of forest islands and raised fields will be discussed in the following section.

Raised Fields

The analysis included a total of 41,931 polygons representing raised fields that were then buffered and dissolved to create neighborhoods of fields. A total of 6,639 neighborhoods were created and all were utilized in the analysis. These features were represented in purple. Statistics for the neighborhoods can be seen in Table 4. Overall, the raised field neighborhoods cover approximately 192.155 km^2 of the study area, or 2.14%. The spatial distribution of raised fields in relation to the rivers and forest islands was shown through a selection of features by location. A total of 583 neighborhoods of fields, approximately 8.78%, were found within 700 m of rivers (Figure 4-6). A total of 1,026 neighborhoods of fields, approximately 15.45%, were found within 700 m of forest islands (Figure 4-7). Within this selection, it was narrowed down to neighborhoods that are found within 700 m of both forest islands and rivers. This resulted in a total of 104 neighborhoods of fields, approximately 1.56% (Figure 4-8).

The analysis was repeated for a threshold distance of 1,000 meters. A total of 887 neighborhoods of fields, approximately 13.36%, were found within 1,000 m of rivers (Figure 4-9). A total of 1,393 neighborhoods of fields, approximately 20.98%, were found within 1000 m of forest islands (Figure 4-10). Within this selection, it was narrowed down to neighborhoods within 1,000 m of forest islands and rivers. A total of 201 neighborhoods of fields were selected,

approximately 3.02% (Figure 4-11). The spatial distribution of both raised field neighborhoods and forest islands also shows patterns that differ across the study area, each covering 192,155 km^2 and 29.29 km^2 respectively. The differences found within the spatial distribution of the raised fields, as well as the forest islands, poses further questions and interpretations that will be addressed below.

Spatial Patterns

Within the analysis, several patterns were observed. Similar patterns were observed among the neighborhoods of raised fields and forest islands at both the 700 m and 1,000 m threshold distances. A difference between the spatial distribution of neighborhoods and forest islands at 700 m and 1,000 m is the increase in features found when the distance increased. The increase is not drastic, but it is notable. An example of this is that the percentage of forest islands found within 700 m from rivers is approximately 9.05%, which then increases to approximately 13.58% at 1,000 meters. A similar increase is seen in the neighborhoods of fields. Within 700 m from rivers approximately 8.78% of the total neighborhoods are found, while at 1,000 m it increases to approximately 13.36%. The amount of neighborhoods found within distance of forest islands also showed an increase when comparing the percentages at 700 m and 1,000 meters. At 700 m, approximately 15.45% of neighborhoods were found, while at 1,000 m approximately 20.98% are found. The increase found between the distances leads to the question of at what distance are majority of these features found?

The spatial patterns found among the forest islands distribution was similar at 700 m and 1,000 meters. Within 700 m of the rivers, forest islands seem to have a distinct pattern, covering

approximately 2.881 km². Along the Iruyañez and Omi Rivers, forest islands were found closer to the mouth of the river system, while along the Yacuma and Rapulo Rivers, forest islands at this distance were found further upstream, with a higher amount found along the Rapulo River (Figure 4-4). However, the majority of the forest islands found within 700 m of the rivers were concentrated along the Iruyañez-Omi River system. A noted difference among the distribution of the forest islands throughout the study area is that while the majority are accessible within each threshold distance along the Yacuma and Rapulo Rivers, the forest islands tend to be represented by larger polygons further north. Similar patterns were found at the distance of 1,000 meters. Forest islands found within this threshold distance of rivers were found near the mouth of the Iruyañez and Omi Rivers, and upstream on the Yacuma and Rapulo Rivers, covering approximately 4.515 km² (Figure 4-5). At this distance, a higher number of forest islands were found along the Yacuma and Rapulo Rivers. Forest islands were found throughout the entire study area, with islands concentrated at the mouth of the Iruyañez and Omi Rivers, upstream on the Yacuma and Rapulo Rivers, and in the wetland area found between the two river systems.

The spatial distribution of neighborhoods presented similar spatial patterns at both 700 m and 1,000 meters. Raised field neighborhoods at 700 m from rivers presented a continuous distribution along the Iruyañez and Omi Rivers, beginning at the mouth of the rivers and continuing upstream, covering approximately 33.272 km² (Figure 4-6). This portion of the distribution of neighborhoods could be seen as the majority, since the clusters were dense and continuous along the rivers. Along the Yacuma and Rapulo Rivers, the distribution of neighborhoods was more sporadic and scattered along the rivers. The distribution began at the

mouth of the river and continued upstream, similar to that of the neighborhoods found along the Iruyañez and Omi.

The distribution of raised field neighborhoods in relation to the forest islands presented patterns of its own. Neighborhoods within 700 m of forest islands seem to follow a distinct pattern, covering approximately 57.958 km² (Figure 4-7). Along the Iruyañez and Omi Rivers, neighborhoods found within 700 m of forest islands were concentrated near and at the mouth of the river system, with a small cluster found further upstream the Omi River. There was also a dense cluster found in the wetland area between the two river systems. Along the Yacuma and Rapulo Rivers, the neighborhoods within distance of forest islands were found upstream on both rivers. From within these neighborhoods, they were narrowed down to neighborhoods that are found within 700 m of forest islands and rivers, covering approximately 15.360 km² (Figure 4-8). These neighborhoods of fields were found along the mouth of the Iruyañez and Omi Rivers, in a continuous pattern, while along the Yacuma and Rapulo Rivers they are found upstream, in a sporadic pattern, with a lower density.

Similar patterns were found at 1,000 meters. Raised field neighborhoods found within 1,000 m of rivers were continuous along the Iruyañez and Omi, while sporadic and scattered along the Yacuma and Rapulo, both starting at the mouth of the rivers and continuing upstream, covering approximately 46.135 km² (Figure 4-9). These neighborhoods were found along both banks of each river. Neighborhoods found within 1,000 m of forest islands were found concentrated near or in range of the mouth of the Iruyañez-Omi river system, as well as in a small cluster farther upstream the Omi, covering approximately 71.888 km² (Figure 4-10). Along the Yacuma and Rapulo Rivers, they were found upstream in small clusters. A dense cluster was

found in the wetland between the river systems. The distribution of raised field neighborhoods within 1,000 m of forest islands was narrowed down to include those found within 1,000 m of forest islands and rivers, covering approximately 24.825 km^2 (Figure 4-11). These neighborhoods were concentrated along the Iruyañez and Omi Rivers in a dense, continuous pattern, while along the Yacuma and Rapulo Rivers they were found upstream in small clusters. These patterns were identified with the linguistic groups, which is further discussed below.

North vs. South: Spatial Pattern Comparisons

Within the study area, two areas were distinguished, the northern section, which includes the Iruyañez and Omi Rivers, and the southern section, which includes the Yacuma and Rapulo Rivers. Additionally, two linguistic groups, discussed in ethnohistorical accounts and in research of several scholars, are found throughout the study area. The boundaries and extent of these groups is based on work by Denevan (1966b:41). The spatial distribution of these groups was identified with the distribution of the features focused on in this study. However, the spatial patterns found in the northern and southern regions were compared to describe the similarities and differences along these two river systems.

The overall distribution of raised field neighborhoods demonstrates a dense concentration of fields found in the northern region of the study area (Figure 4-12). Within the southern region of the study area, raised field neighborhoods can be seen scattered throughout the region, with the majority found in the wetland area and along the Omi, which is closer to the boundary between the two groups. The overall distribution of forest islands presented a wider distribution of these features in the southern area, with forest islands found near both rivers and upstream the

Omi (Figure 4-13). A cluster is also found in the wetland area. In the northern area, forest islands are found mainly in range of the mouth of the river system and continuing upstream the Omi.

The spatial distribution of both features identified with the linguistic groups demonstrates the dense concentration of features in the northern area, which is focused around the mouth of the river system (Figure 4-14). The distribution of features continues upstream the Omi into the southern area, with a wider, scattered distribution found in this area. A noted difference between the two areas is that a greater number of forest islands, while at smaller sizes, are found in the southern area, while a greater number of raised field neighborhoods are found in the northern area in dense, concentrated groups.

Spatial patterns were also noted within the northern and southern sections at each threshold distance. The spatial patterns found at 700 m and 1,000 m were compared between the northern and southern section of the study area, as well as identified with the linguistic groups. The forest islands found within 700 m of rivers when identified with the linguistic groups demonstrates that the majority of these islands are found in the northern area (Figure 4-15). This pattern is similar among the forest islands found within 1,000 m of rivers, even though the amount of islands found in the southern area increases along the Yacuma River (Figure 4-16). Additionally, it is noted that no forest islands are found within the wetland area at either distance threshold.

The spatial patterns of raised field neighborhoods were also compared between the northern and southern section of the study area, as well as identified with the linguistic groups. Raised field neighborhoods found within 700 m of rivers demonstrated a continuous distribution from where the Iruyañez River meets the Mamoré going upstream throughout the northern area

(Figure 4-17). The distribution of neighborhoods found on the Omi at this distance continues into the southern area. Within the southern area, the neighborhoods are found in a sporadic, scattered distribution along the Yacuma and Rapulo Rivers. Raised field neighborhoods found within 700 m of forest islands were found in a dense cluster in the northern area, concentrated at the mouth of the river system, while in the southern area they are found in the wetland area, upstream the river system and along the Omi (Figure 4-18). While the neighborhoods found within 700 m of forest islands were distributed throughout both groups, the neighborhoods found within 700 m of both forest islands and rivers were mainly found in the northern region (Figure 4-19).

Similar patterns were found within the northern and southern regions at 1,000 m distances. Raised field neighborhoods found within 1,000 m of rivers demonstrated a continuous distribution that included the majority of the neighborhoods in the northern area, similar to that of the 700 m distribution (Figure 4-20). Within the southern area, the distribution was sporadic along the rivers. Raised field neighborhoods found within 1,000 m of forest islands were found in a dense cluster in the northern area, concentrated at the mouth of the river system (Figure 4-21). In the southern area, these neighborhoods were found in a sporadic, scattered distribution ranging from the wetland area to upstream the rivers. The distribution of raised field neighborhoods found within 1,000 m of both forest islands and rivers presented a pattern similar to that found at 700 m when compared in each region (Figure 4-22). These neighborhoods were found in dense clusters at the mouth of the river system in the northern area, continuing upstream along both rivers. In the southern area, a small cluster of fields is found along the Omi and upstream the two rivers in the area.

Essential to the understanding of the distribution and extent of the linguistic groups is the ethnohistorical accounts provided by the Jesuit missionaries which occupied the area during the 17th and 18th centuries. Ethnohistorical accounts from this time period provide brief information on the Cayuvava and Movima. In regards to agriculture, scholars note that the Cayuvava traded peanuts, maize, and manioc with travelers; these products potentially cultivated by the Cayuvava (Denevan 1966b:50). Also, the Movima were described by travelers to be farmers and fishermen (Denevan 196b:52). Specifically in study area, there are two missions that are associated with the Cayuvava and Movima linguistic groups. These missions are Mission Santa Ana, located at the mouth of the Yacuma and Rapulo Rivers, and Mission Exaltación, located along the Mamoré River further north and in close proximity to the Iruyañez and Omi Rivers (Figure 4-23). Historically, as well as today, these missions have been associated with each of these linguistic groups, Exaltación with the Cayuvava and Santa Ana with the Movima. As seen in Figure 4-24, these missions can be found within the designated extent of each linguistic group respectively. These missions were located in proximity to the major rivers as a means to be able to move upstream and reach groups found along the rivers and into the savanna.

Overall, a pattern that is prominent among the distribution of raised field neighborhoods and forest islands is that as the distance increases, the amount of features, both neighborhoods and forest islands, found in the southern area increases. Yet, the overall density of the neighborhoods is greatest in the northern region of the study area. Additionally, the distribution of forest islands within the southern section, as well as in the wetland in between the two river systems, has the majority of the distribution of forest islands in the chosen study area. These spatial patterns and their relation to the linguistic groups pose several questions.

Summary

The spatial analysis conducted in this project presents a spatial distribution of precolumbian features and several of the spatial patterns of these features. The relationship between raised field neighborhoods, forest islands, and linguistic groups in the study area show spatial patterns that are consistent at the two threshold distances of 700 m and 1,000 meters. However, the number of features found at these distances is just a fraction of the overall amount of features utilized in the analysis. Would similar patterns be seen at a greater distance? An increase of features found at greater distances could present different spatial patterns. Within the study area, there are other water sources, such as lakes and creeks, which are not taken into consideration. If all navigable water sources were taken into consideration it is possible that the patterns may shift and the number of features included in each portion of the analysis may increase.

The distribution of raised field neighborhoods in the study area presented consistent spatial patterns. The majority of neighborhoods in the data set were concentrated in the northern region of the study area, distinguished by the Iruyañez and Omi River system. This area is also associated with the Cayuvava linguistic group. The dense clusters of raised fields in this region were distinct in comparison to the sporadic and scattered distribution seen in the southern area along the Yacuma and Rapulo Rivers, which is associated with the Movima linguistic group. While it seems that the construction and use of raised fields was being conducted in both areas, neighborhoods of fields were found in a greater density in the northern area in concentrated clusters.

The concentrations of these neighborhoods are also found close to where the Iruyañez meets the Mamoré, the major river that runs throughout Mojos. The Mamoré is the center river network in Mojos, running throughout the entire region, providing a means of transportation and communication for the various groups in the region. The distribution of raised field neighborhoods in the region shows that these features are found continuously upstream along the Iruyañez and Omi Rivers into the southern area, along the Yacuma and Rapulo Rivers, decreasing in number. Could raised field agriculture have moved southwest from the Mamoré into the area of these two linguistic groups?

While the major focus of the analysis was the relation of raised fields to rivers and forest islands in the area, forest islands are also important for an understanding of the spatial distribution of precolumbian groups. The majority of forest islands are concentrated in the southern area, associated with the Movima, within the wetland and along or between the rivers. Excavations on forest islands in the study area have shown that precolumbian groups occupied them in the past (Walker 2004). A pattern seen in excavations is that large islands consistently showed signs of human occupation, such as ceramic sherds and anthrosols (Walker 2004:109). Small islands that were excavated also showed signs of human occupation, but not as consistently (Walker 2004:109). Could this pattern of human occupation be applied to the forest islands incorporated in the data set of this study? If so, it could be used to interpret whether precolumbian groups were living in relation to the rivers in the study area. Based on the patterns presented in this analysis, precolumbian groups were potentially living near rivers, but the majority were found at greater distances than the ones chosen for this analysis. With a small percentage of the forest islands found within 700 m and 1,000 m from rivers, an informative

comparison would be to explore further outside of these distances to determine what the average distance from rivers would be.

The spatial patterns found among raised field neighborhoods and forest islands in relation to each other, as well as to rivers, in the study area have demonstrated that despite numerous field neighborhoods and islands being found near the rivers, the majority are found at greater distances. This poses the question of what does this mean for the larger, overall network in the region? Are various linguistic groups connected through these two river systems and the Mamoré or are they concentrating in areas far from the rivers? The spatial distribution and patterns seen in this analysis show that groups may have been living and farming within distance of rivers, connecting them to this larger network. The spatial distribution of raised fields and forest islands also shows that while groups are potentially interacting, they are also found in areas far from rivers.

The satellite imagery utilized for the digitizing of the data used in this analysis shows the landscape during the dry season. The patterns that are found therefore can be seen as representative of the distances of forest islands and raised fields as they are accessible and seen during the dry season. Movement and communication during the dry season may change during the wet season. The flooding during the wet season could influence the distance and location of forest islands and raised fields in relation to rivers in terms of accessibility during this time period. Also, the visibility on the imagery utilized in this analysis varies, which may then not reveal all features that are present in the study area. With the increasing number of raised fields that are found in the area as imagery is updated, it is possible that more raised fields can be included in future analyses. An increase of raised fields becoming visible in the area with

updated imagery could provide opportunities for further research on the spatial distribution of raised fields, as well as forest islands, in relation to the river systems in the area.

CHAPTER FIVE: CONCLUSIONS

This project proposed several hypotheses in regards to the spatial distribution of raised fields and their relationship with forest islands and river systems in Mojos. These included an interpretation of the travel distance between raised fields and forest islands, as well as from the river systems, potentially demonstrating the importance of the larger networks in the area. Additionally, it was hypothesized that based on the spatial distribution of the raised fields and forest islands in the study area, a difference between the northern and southern sections will not be significant, suggesting interaction between these groups. While further questions arose from this analysis, several spatial patterns were distinguished among the distribution of raised fields and forest islands, as well as their relationship with the two river systems in the study area.

The spatial patterns found among raised fields, forest islands, and rivers in the study area present several similarities and differences when compared across the northern and southern sections. The spatial distribution of these features demonstrates how the landscape was modified in this area of Mojos. Raised field neighborhoods and forest islands are found in both the northern and southern regions of the study area. Overall, the distribution of raised field neighborhoods in the study area covers approximately 192.155 km^2. The distribution of raised fields appears in dense clusters in the northern section of the study area along the rivers; however their density decreases upstream along the rivers. Between the dense, concentrated clusters of the northern section and the scattered, sporadic distribution seen in the southern section of the study area, a distinction in the construction of raised fields exists. The dense, concentrated clusters of fields consists of high numbers of fields found within close proximity to each other, while the scattered, sporadic distributions seem to have fewer fields within distance of each other.

However, this spatial analysis focuses on large raised fields in the region and does not take into account different forms of earthworks that can be found along with these fields, as well as with forest islands.

Interpretations of the spatial distribution of forest islands is vital to furthering the understanding of the spatial distribution of precolumbian groups and where they are potentially living. Overall, the distribution of forest islands covers approximately 29.29 km^2 of the study area. The distribution of forest islands in the study area shows that more forest islands are found in the southern section. As detailed in the previous chapters, evidence for human occupation has been found on forest islands throughout Mojos. Raised fields found near forest islands may suggest that groups that may have occupied forest islands could possibly be farming those fields. The location of forest islands in relation to the rivers demonstrates that the river systems in the study were important to the connection of groups and the larger network of Mojos. However, a majority of the forest islands, approximately 86%, were found at a distance greater than 1,000 m of rivers. Also, the spatial relationship of forest islands and raised fields demonstrates that the distance between where people are living and where they are farming varies. Overall, the raised field neighborhoods found within 700 m and 1,000 meters from forest islands covers approximately 57.958 km^2 and 71.888 km^2 of the study area, respectively. While a large number of raised field neighborhoods were found within both 700 m and 1,000 m of forest islands, the overall majority, approximately 85% and 79% respectively, of neighborhoods were found at greater distances.

The analysis also revealed that the spatial patterns of raised fields and forest islands in relation to the rivers in the study areas were consistent at the threshold distances of 700 m and

1,000 meters. Overall, the raised field neighborhoods cover approximately 33.272 km^2 within 700 m from rivers and 46.135 km^2 within 1,000 m from rivers. The distribution of features at 700 m provided spatial patterns such as the dense clusters of raised fields in the northern section and the larger number of forest islands found in the southern section. These patterns were similar at 1,000 m, yet the number of features found slightly increased. When comparing the amount of features found within 700 m of rivers and/or forest islands to the amount of features found within 1,000 m, a slight increase is observed. However, even with this increase at 1,000 m, the majority of features are not incorporated in the chosen distances. The distribution of these features at both distances remained constant, presenting patterns that were then identified with the linguistic groups of the area. While the extent of these areas may not have been as concrete in the past as they are presented, these spatial patterns still show a contrast that could contribute to the understanding of differences in the construction of raised fields between the groups. The spatial distribution of these features and the pattern they present could be interpreted as another "boundary" between groups that modified the landscape of Mojos.

The river systems found in the study area connect with the larger Mamoré River, which was central to movement and interaction between Mojos and the Andes, as noted during the mission period (Block 1994). The Jesuits that occupied the era during the 16th and 17th century noted that the river was utilized as a means of communication and movement throughout Mojos, influencing where missions were placed (Block 1994). Within this analysis, the river systems played an important role in understanding the distribution of raised fields and forest islands. The distribution of raised fields within the study area demonstrates the importance of the rivers in the movement of ideas on how to modify the landscape. Also, the distribution of forest islands

within the study area demonstrates where groups may have lived and their distance from this important network of communication and movement.

The distribution of raised fields within an area in which two non-Arawak linguistic groups are found can support the regional network that is believed to have traversed Amazonia during the precolumbian era. Both linguistic groups in the study area are not Arawak, yet raised fields are found throughout both areas. Arawak groups are found within Mojos and perhaps interacted with the groups found in the study area via the river network in Mojos. Further, the interaction between the Cayuvava and Movima linguistic groups is seen among the names of locations throughout the study area. Scholars have previously detailed that within the region correlated with the Cayuvava has Cayuvava place names, as well as Movima place names (Denevan 1966b:50). The range of locations in which places have names of both groups and the distribution of features can contribute to the idea that groups were interacting.

Interactive networks of movement and communication along river systems specifically in Mojos, as well as Amazonia as a whole, provided groups of different linguistic backgrounds the opportunity to share ideas on various ways to modify the landscape, such as the construction of raised fields. The diversity in both earthworks and linguistic groups can be reflected in the cultural landscape. This diversity can also be attributed to the diverse environments found in the Mojos, and Amazonia in its entirety. The spatial patterns found among the raised fields and forest islands in relation to the linguistic groups in the area demonstrate the fluidity between groups in the region. This analysis presents one kind of agricultural fields that are found in areas that are associated with two different languages. Insight to movement and communication in

Mojos can be understood through the interaction between linguistic groups and the distribution of archaeological features in the region.

Future Research

Google Earth and ArcGIS provide scholars the necessary tools to conduct spatial analyses as part of research projects. As satellite imagery is updated, further research and analysis of the distribution of earthworks across the landscape can be conducted. Features that were not seen in the past are now being exposed through both negative and positive factors, such as deforestation and improving remote sensing techniques, respectively. Denevan (2001:246) estimated that approximately 35,000 individual fields can be seen on aerial photos of Mojos, which he noted was a minimum estimate. With features being exposed, the estimated number of raised fields that are found in Mojos could increase. This can create opportunities for many other spatial analyses.

The chosen study area for this project covers an approximate area of 8,992.336 km^2, a fraction of the Llanos de Mojos region, with approximately 192.155 km^2 covered by these large raised field neighborhoods. The focus of this project was specifically raised fields and forest islands, but there are other earthworks found in the region that could be a focus for further studies, such as other types of fields and ring ditches. The distribution of these features and their relations to the river network could further the understanding of landscape management in Mojos. Research on the distribution of earthworks throughout other linguistic areas could provide a means of comparison for the distribution of earthworks of all types in Mojos and how they correlate with linguistic diversity at a larger scale.

Rivers were seen as a means of transport and communication, yet the majority of the features in the study area are not found within 700 or 1,000 meters of rivers. Expanding outside of river systems to include other navigable water features such as lakes or creeks, could further the understanding of where earthworks are being constructed and how they are distributed throughout the landscape. In this study, it is noted that majority of the features are found at greater distances than 1,000 m from rivers, yet the other navigable water features are not taken into account. For example, the swamp wetland area found in between the two river systems was not a focus of the analysis. A spatial analysis including all navigable water features could demonstrate if earthworks and other features that are found at greater distances from rivers are in close proximity to the other navigable water features. This could demonstrate how important rivers are or if other navigable water features were also important to precolumbian groups. Also, having imagery of raised fields and other earthworks during the wet season could demonstrate a different spatial pattern than that seen during the dry season. The proximity of certain features to rivers may shift during the wet season.

The study area of this project covered a region that was occupied by two linguistic groups, leading to a broad comparison of spatial patterns found between and within the two areas. Studies on the construction and use of raised fields over time or the length of occupation in each area could be a focus for future research. Further research could also focus in on a specific linguistic area, such as the Movima or Cayuvava individually, and conduct a spatial analysis of all earthworks found in the region and how they differ. Research within the specific linguistic areas can be beneficial for Pueblo Movima and Cayuvava groups living in Mojos today. By scholars working with these groups, histories of the area, specifically earthworks, passed through

generations can provide information for archaeological research. Alternatively, a study on the correlation of where missions in Mojos were settled and features such as forest islands and raised fields could provide information to complement ethnohistorical accounts. While it is understood that missions were settled near the major river systems as a means to move throughout the area and remain connected to the larger network, it would be beneficial to understand the relationship of precolumbian features and the missions. By further exploring the relationship between the Jesuit missions in Mojos and these features, the history of Mojos could be further understood.

APPENDIX A: IMAGES AND MAPS

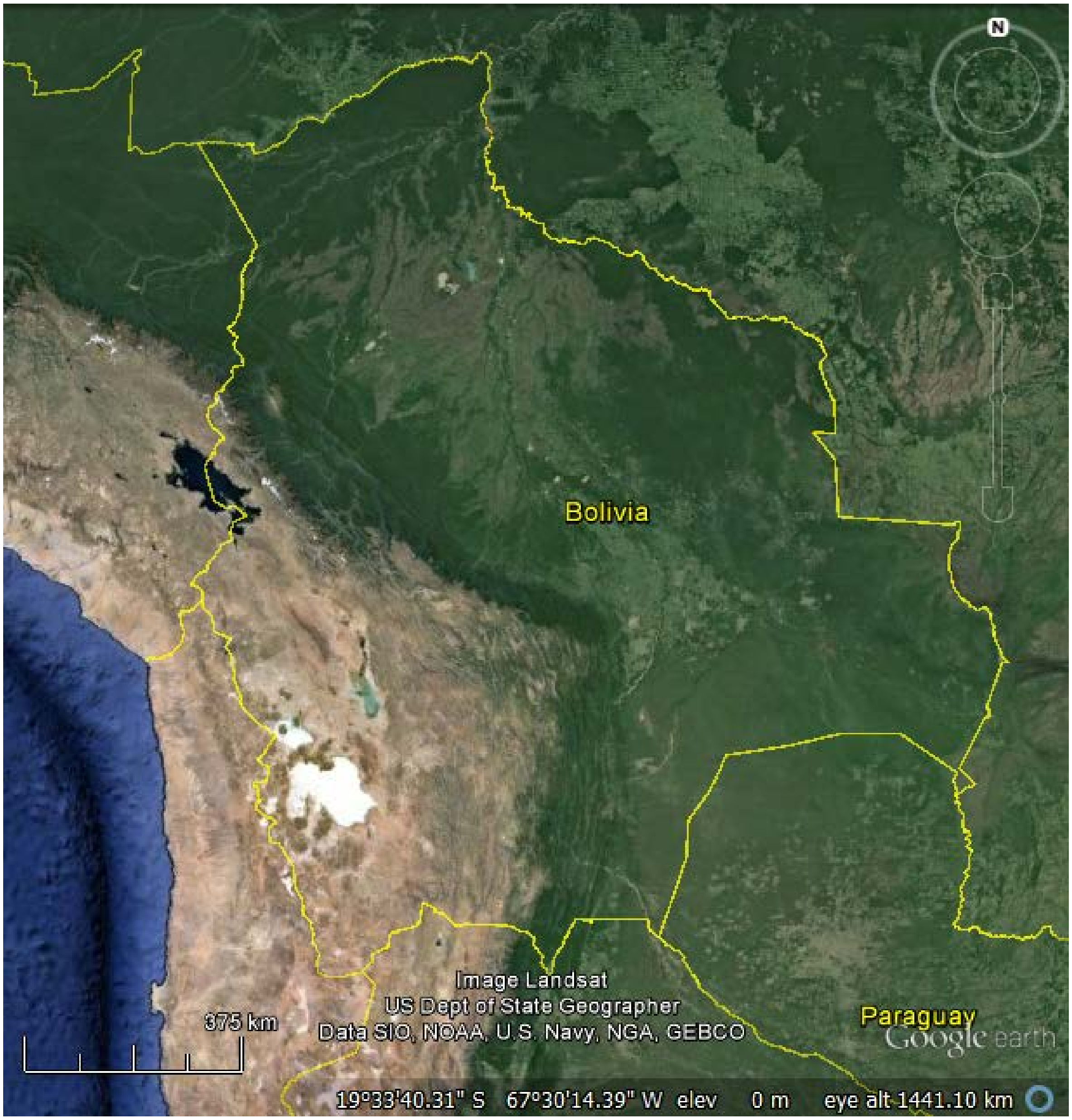

Figure 1- 1 The country of Bolivia as seen on Google Earth.

Figure 1- 2 The Beni Department of Bolivia, in which the Llanos de Mojos region is found.

Figure 2-1 The Llanos de Mojos (Mojos) region of Bolivia. This region is part of the southwest Amazon and is characterized as a large, tropical savanna, which is seasonally flooded.

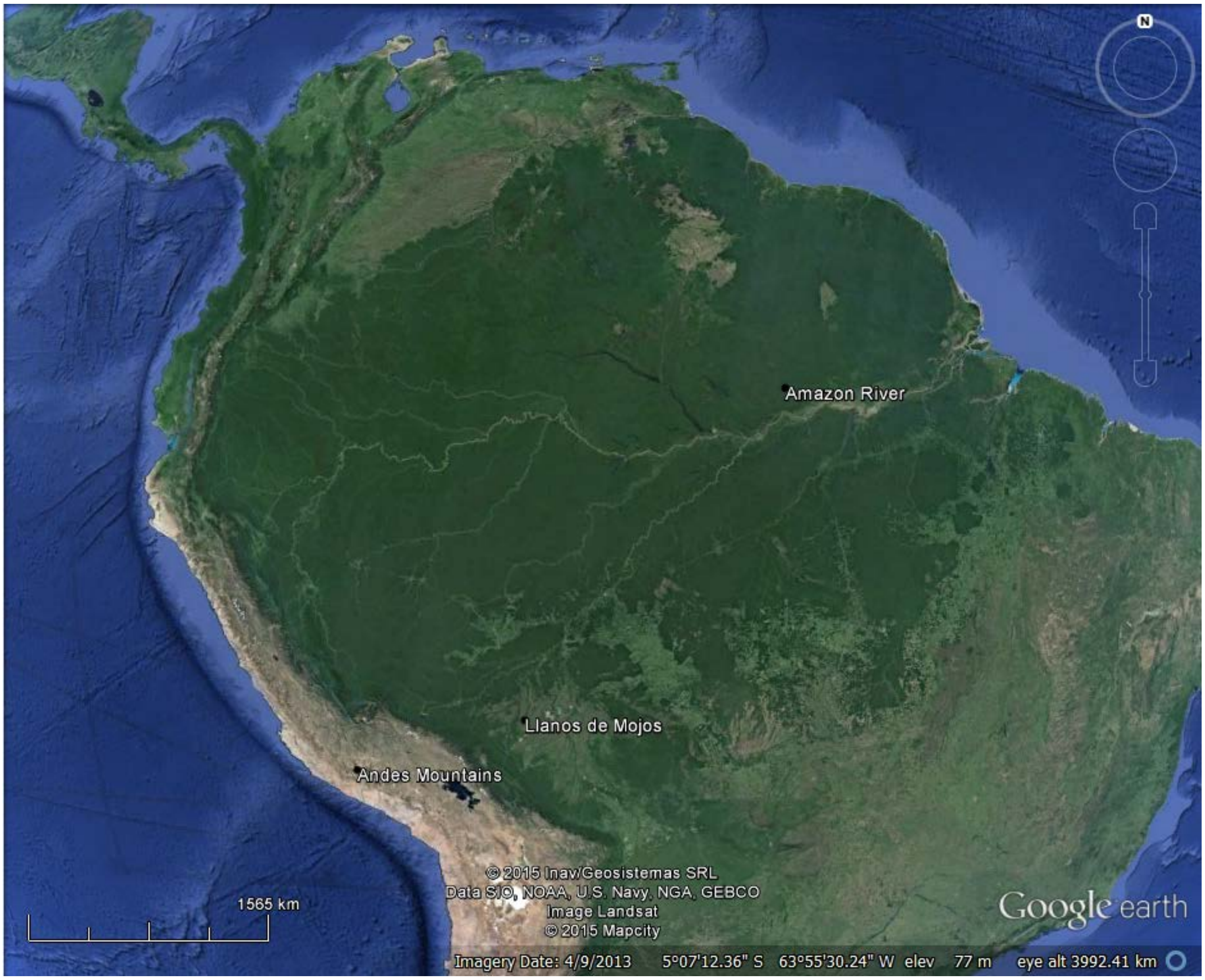

Figure 2-2 Northern South America including the Amazon River, Llanos de Mojos, and the Andes Mountains.

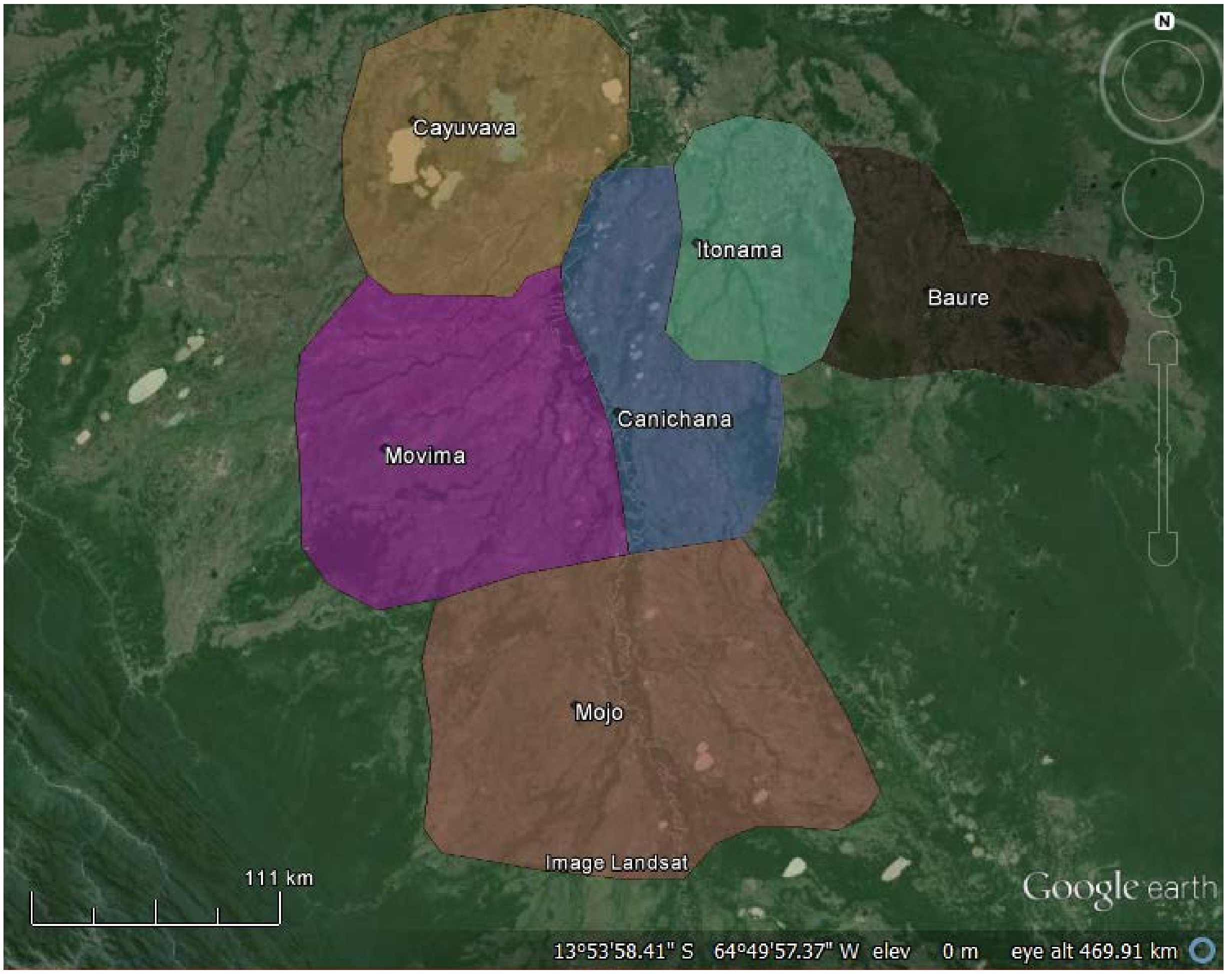

Figure 2-3 Linguistic groups of Mojos as mapped by Denevan (1966: 41). These groups were distinguished by Jesuit missionaries who occupied the region during the 17th and 18th centuries.

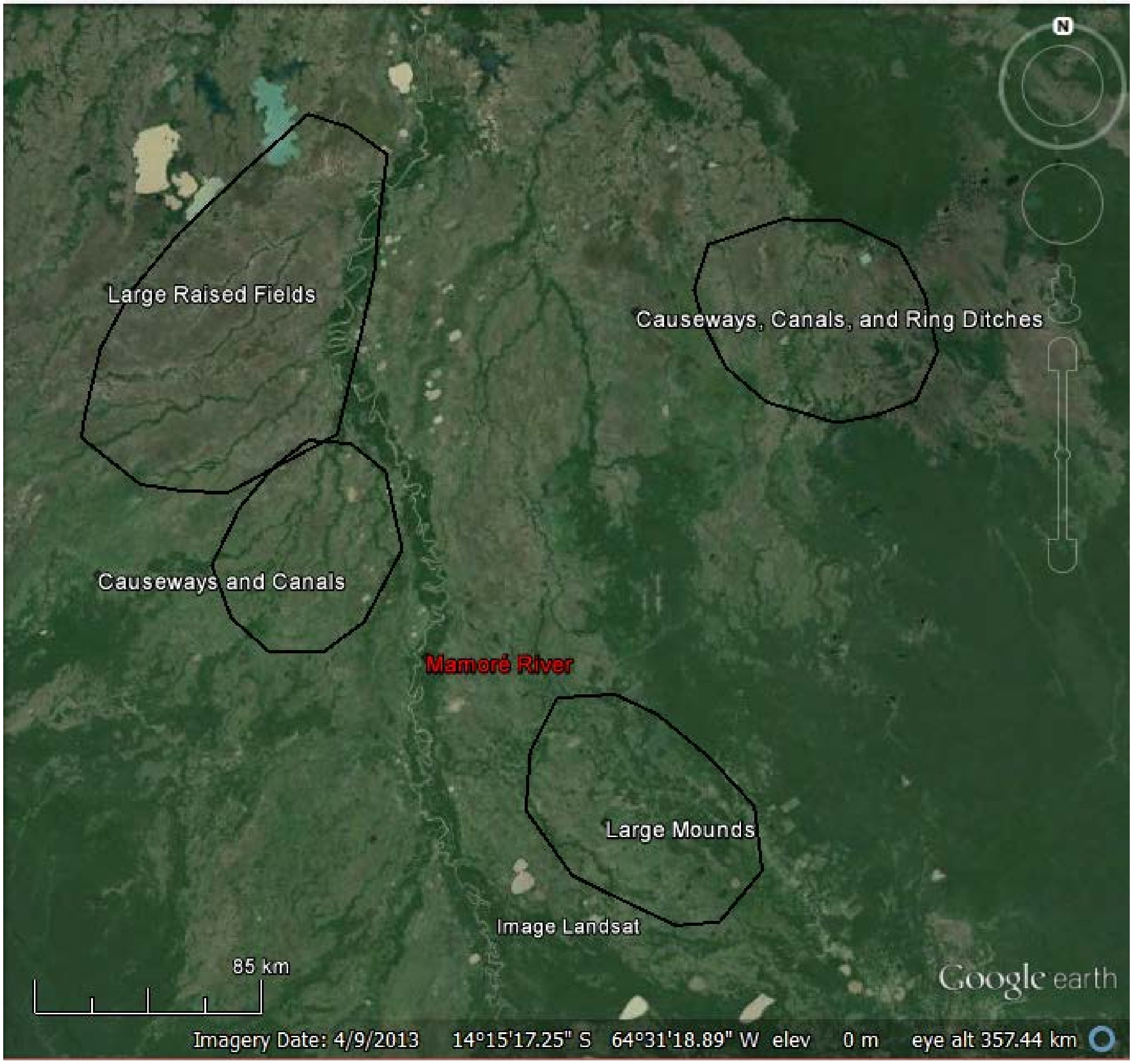

Figure 2-4 Several areas where earthworks are found in Mojos. Information on the earthworks investigated in these areas has been presented by various scholars.

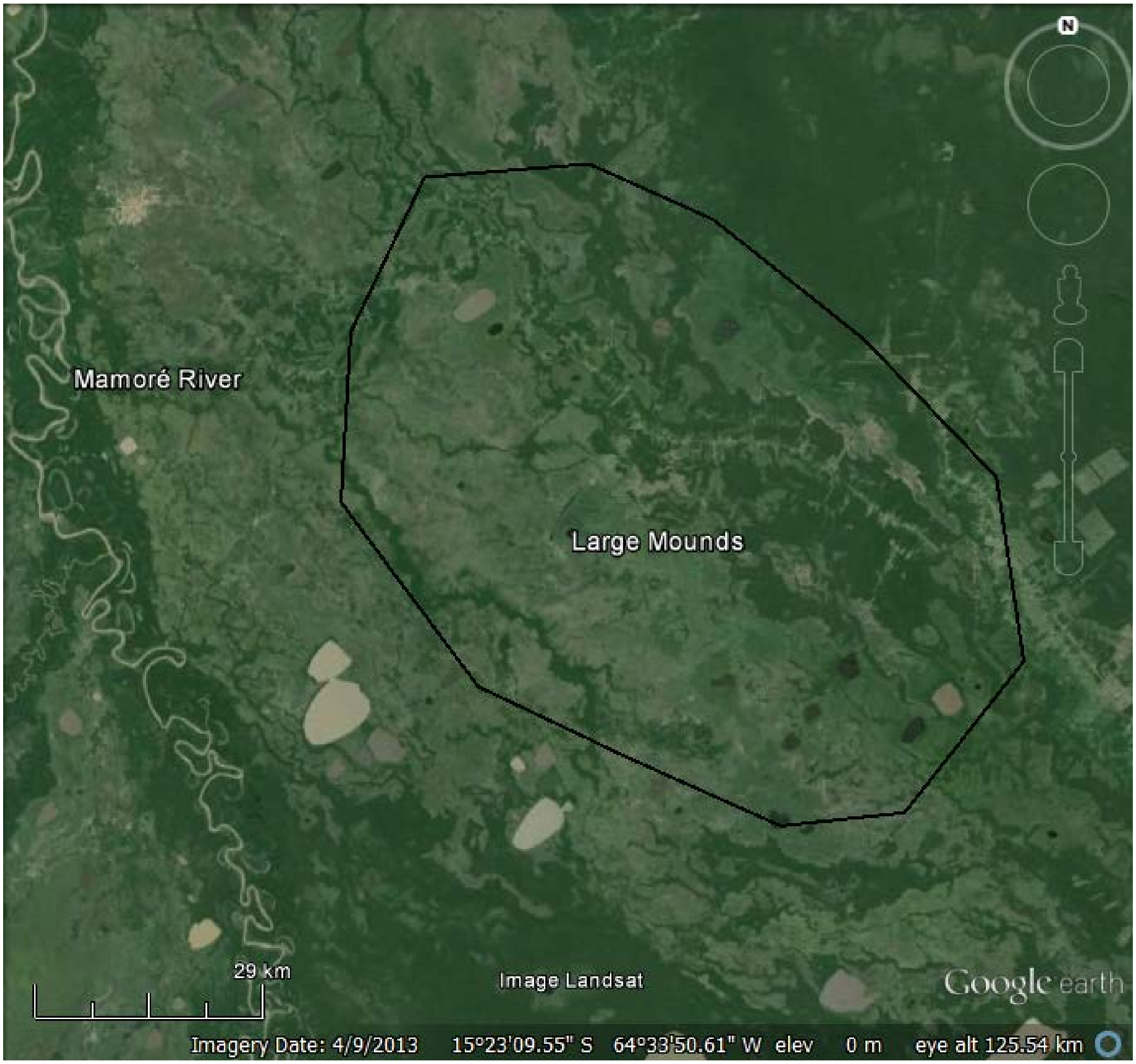

Figure 2-5 The approximate area of where the large mounds excavated by several scholars in southeast Mojos are located. These sites are found east of the Mamoré, although they are not visible in this image.

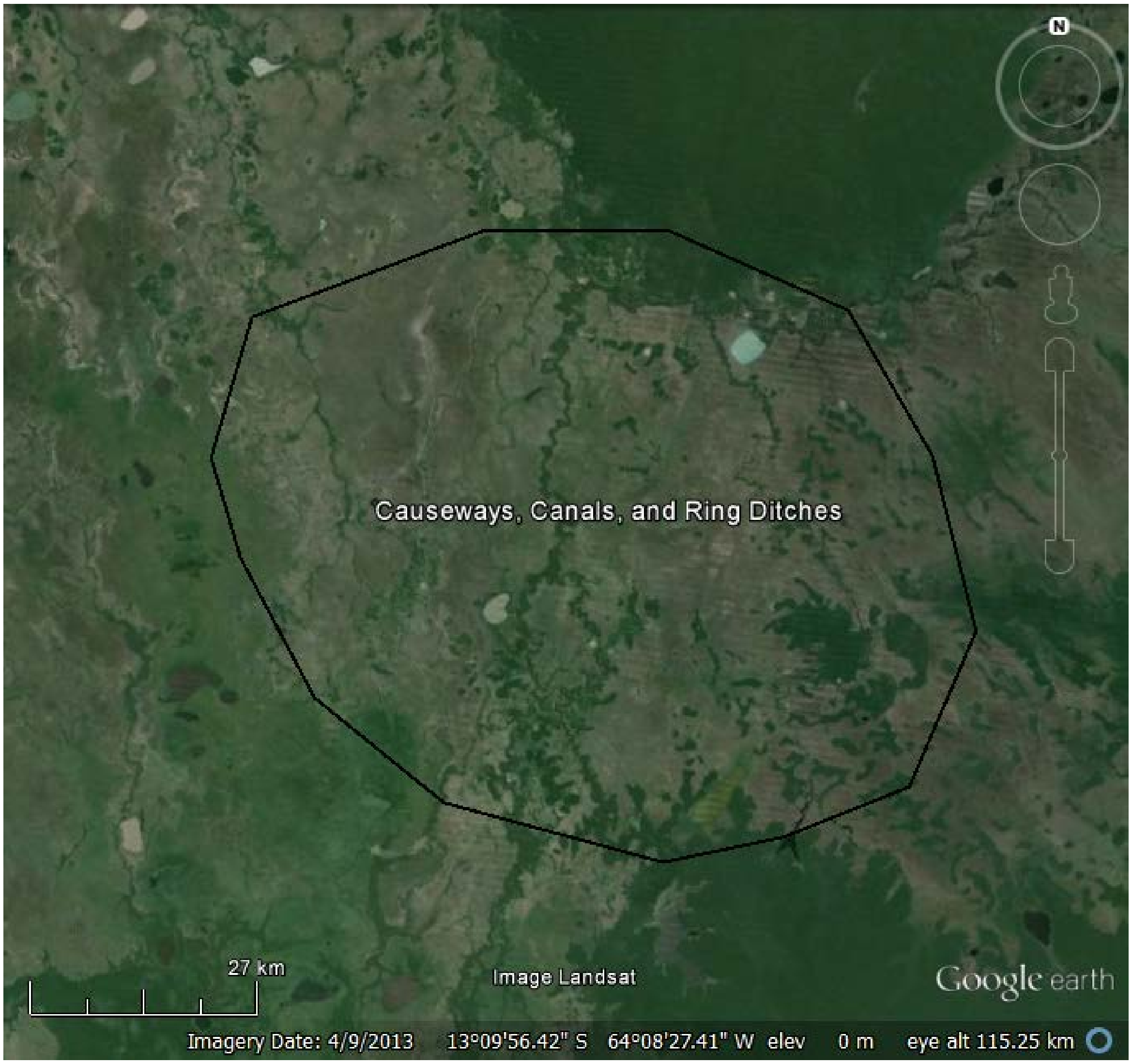

Figure 2-6 The approximate area in which causeways, canals, and ring ditches are noted by scholars in the region of Baures. This area is also found to the east of the Mamoré and is in NE Mojos.

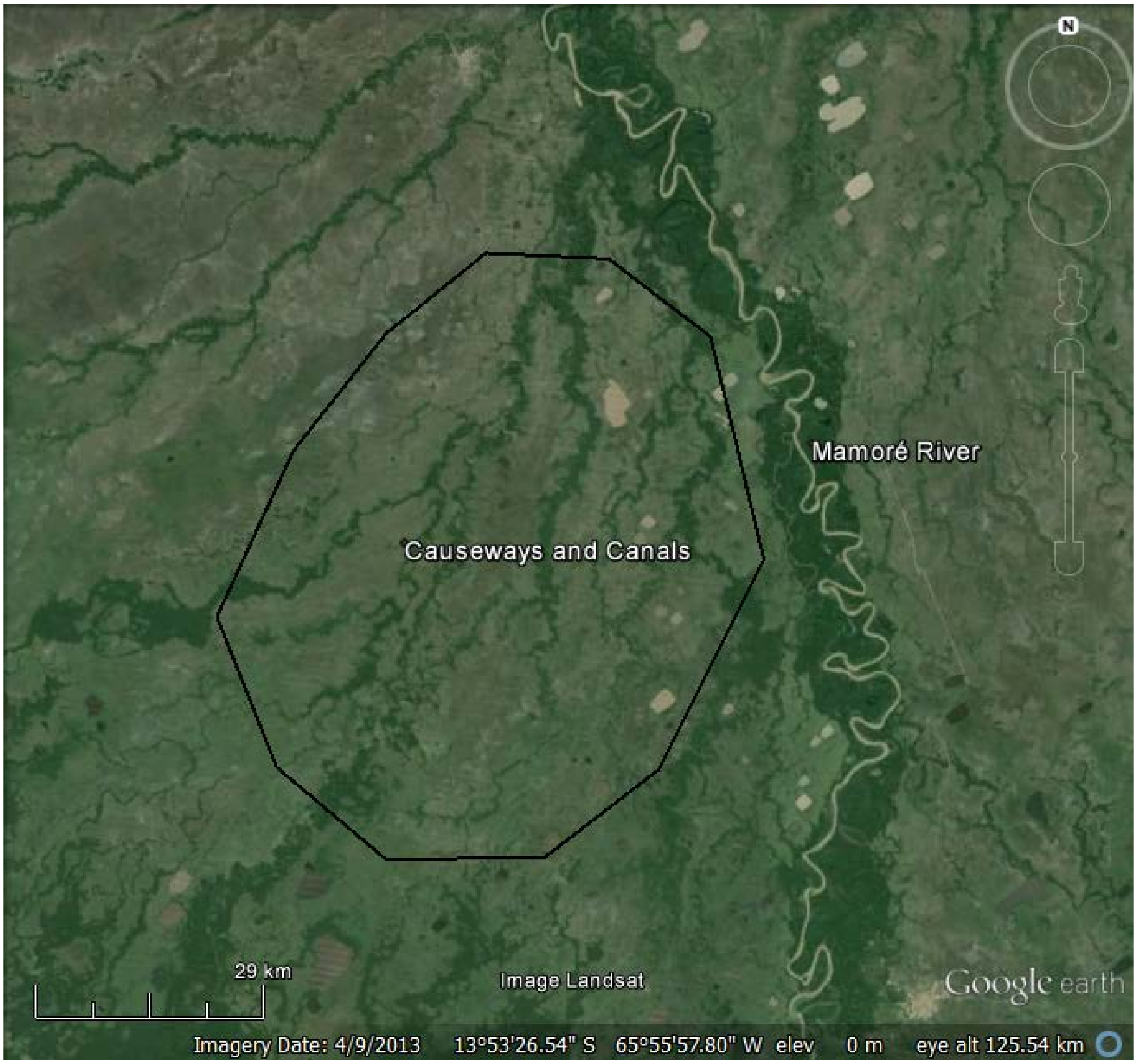

Figure 2-7 The approximate area in which causeways and canals are also found, specifically near the river system that includes the Apere River. This area is west of the Mamoré, south of the area in which large raised fields are found.

Figure 2-8 Raised fields as seen on the ground. Photography by the author, taken during the Summer 2014 field season.

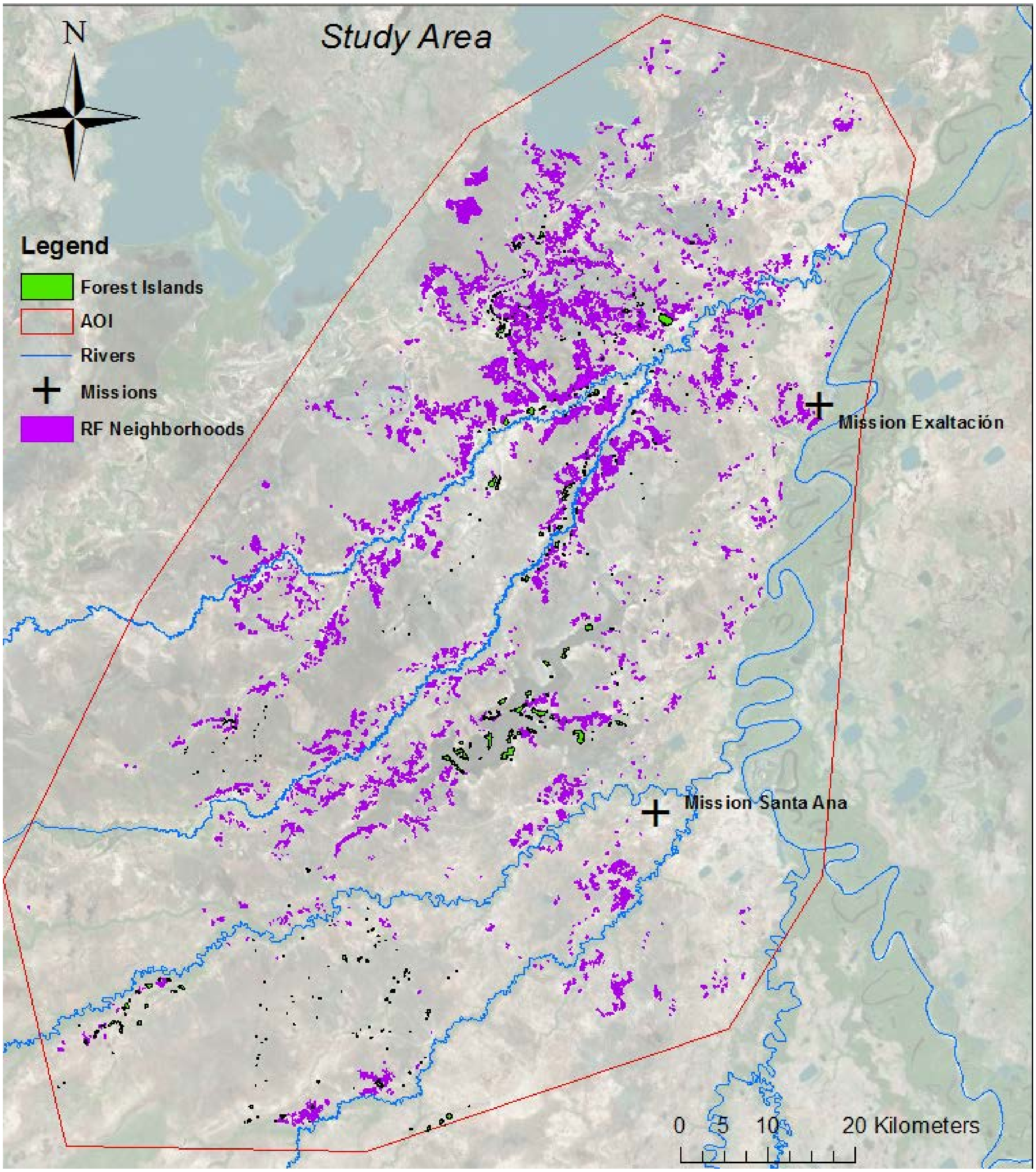

Figure 3-1 The study area as seen on ArcGIS. This image includes the neighborhoods of raised fields, forest islands, and rivers utilized in the analysis. Locations of the Jesuit Missions are indicated.

Figure 3-2 The two river systems focused on in this study, tributaries of the Mamoré. The Iruyañez and Omi Rivers are the northern river system and the Yacuma and Rapulo Rivers are the southern river system.

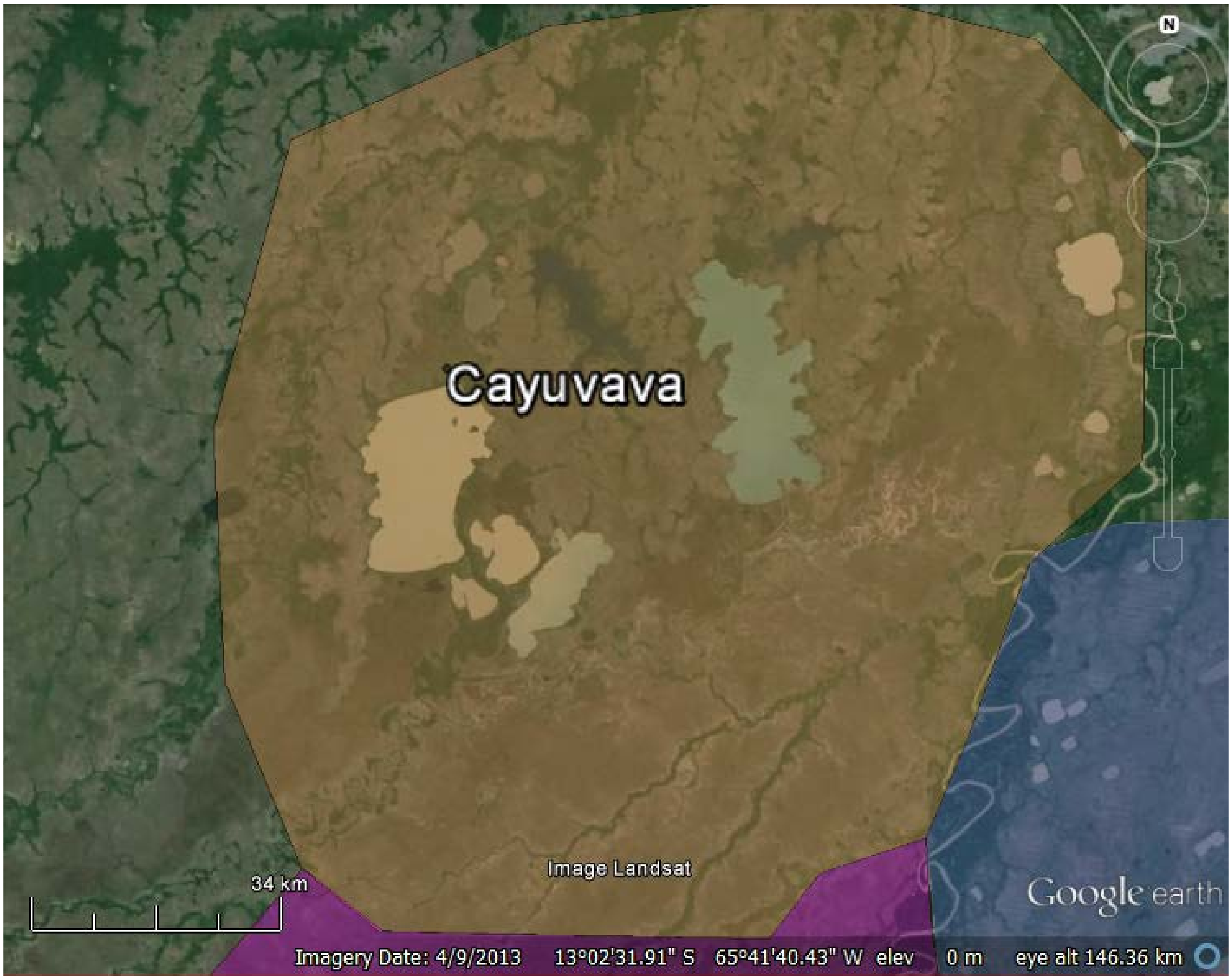

Figure 3-3 The northern section of the region, which is associated with the Cayuvava linguistic group in ethnohistoric documents. This region is also distinguished by the Iruyañez-Omi river system. (See Denevan 1966b:41)

Figure 3-4 The southern region of the study area, which is associated with the Movima linguistic group in ethnohistoric documents. This region is also distinguished by the Yacuma-Rapulo river system. (See Denevan 1966b:41)

Figure 3-5 The wetland area found in between the two river systems of the study area. Forest islands and raised fields are found in this region.

Figure 3-6 Raised Fields as seen on satellite imagery. These raised fields are found along the Yacuma River in the study area. This image demonstrates how raised fields can be distinguished on satellite imagery.

Figure 3-7 Forest Islands as seen on satellite imagery. This image demonstrates how forest islands can be distinguished on satellite imagery. Raised fields can also be seen on the eastern part of the image.

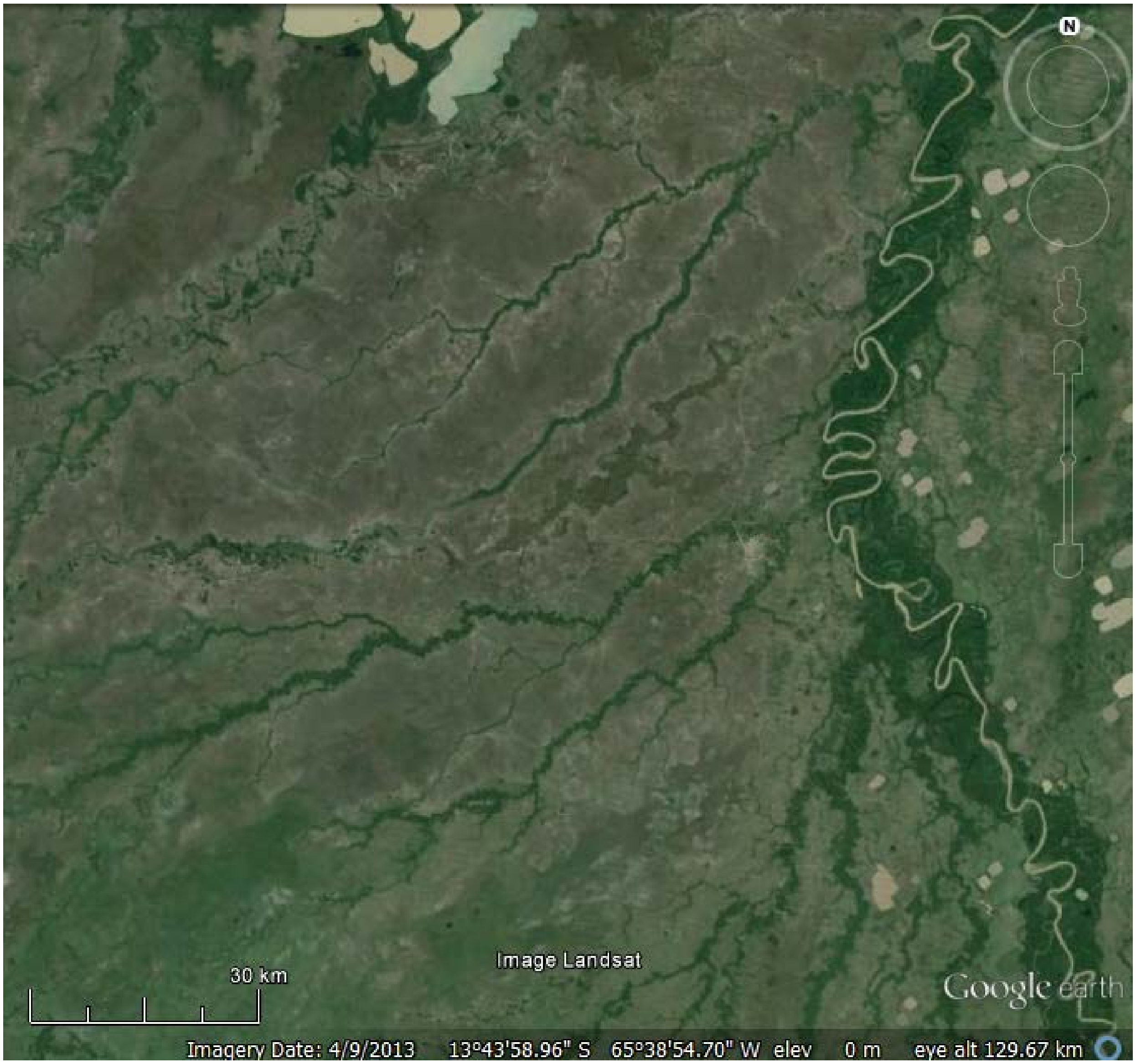

Figure 3-8 Rivers in Mojos as seen on satellite imagery. This image demonstrates how rivers can be distinguished on satellite imagery.

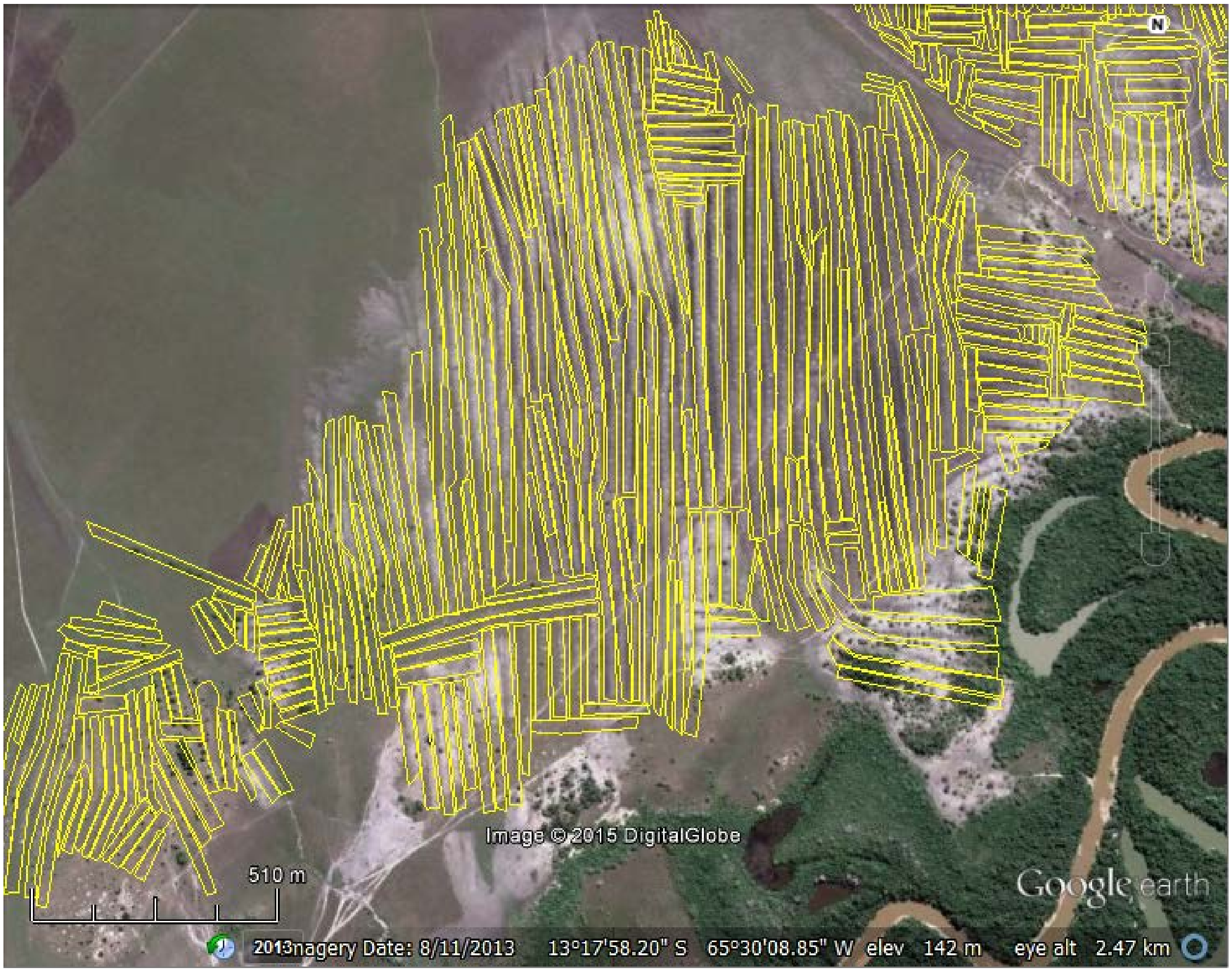

Figure 3-9 Raised fields digitized in the study area. These fields were digitized by individuals from the undergraduate mapping group.

Figure 3-10 Forest islands digitized on satellite imagery. These islands were digitized by individuals in the undergraduate mapping group.

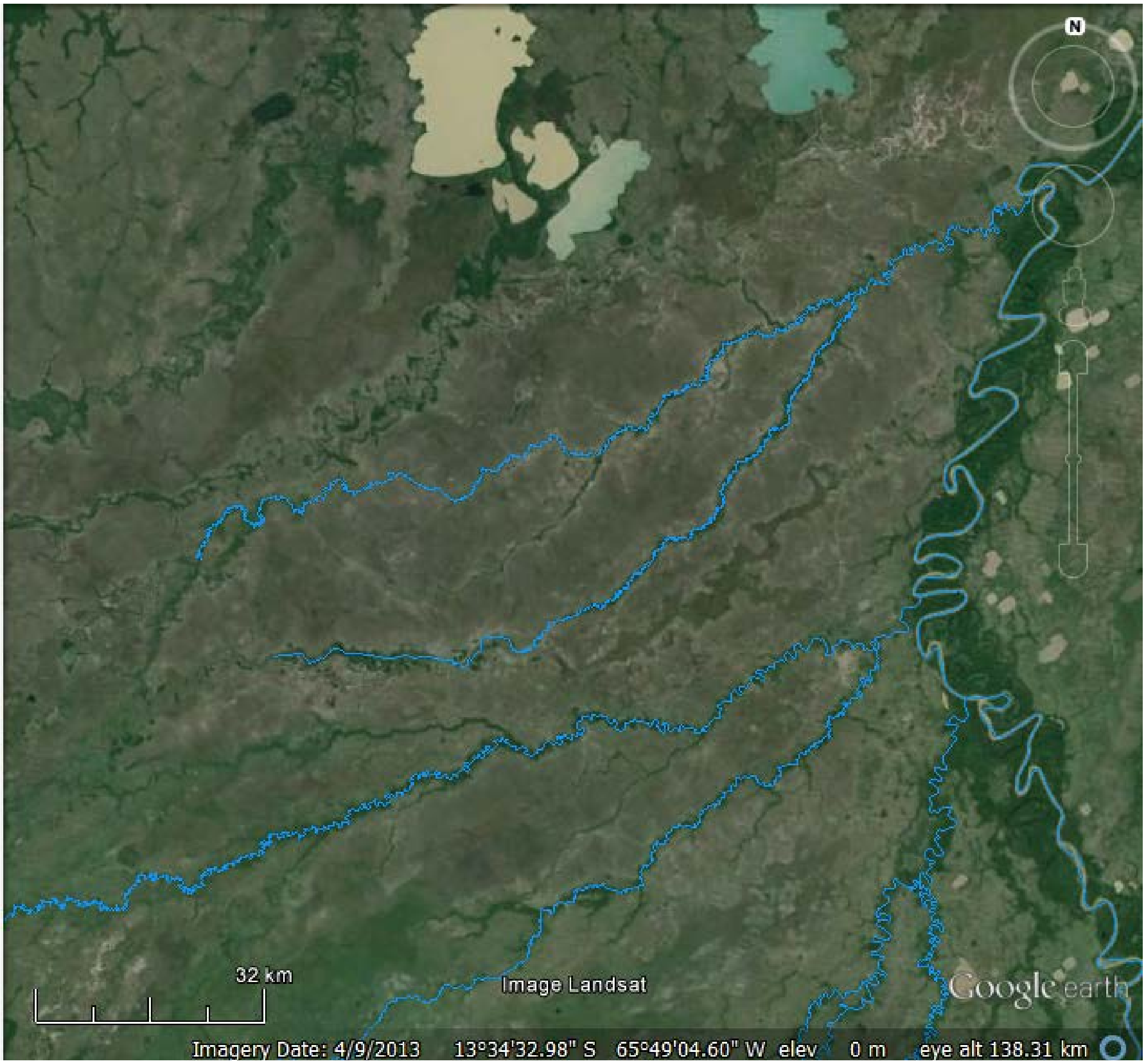

Figure 3-11 Rivers digitized on satellite imagery. These rivers are a combination of past digitization by several individuals.

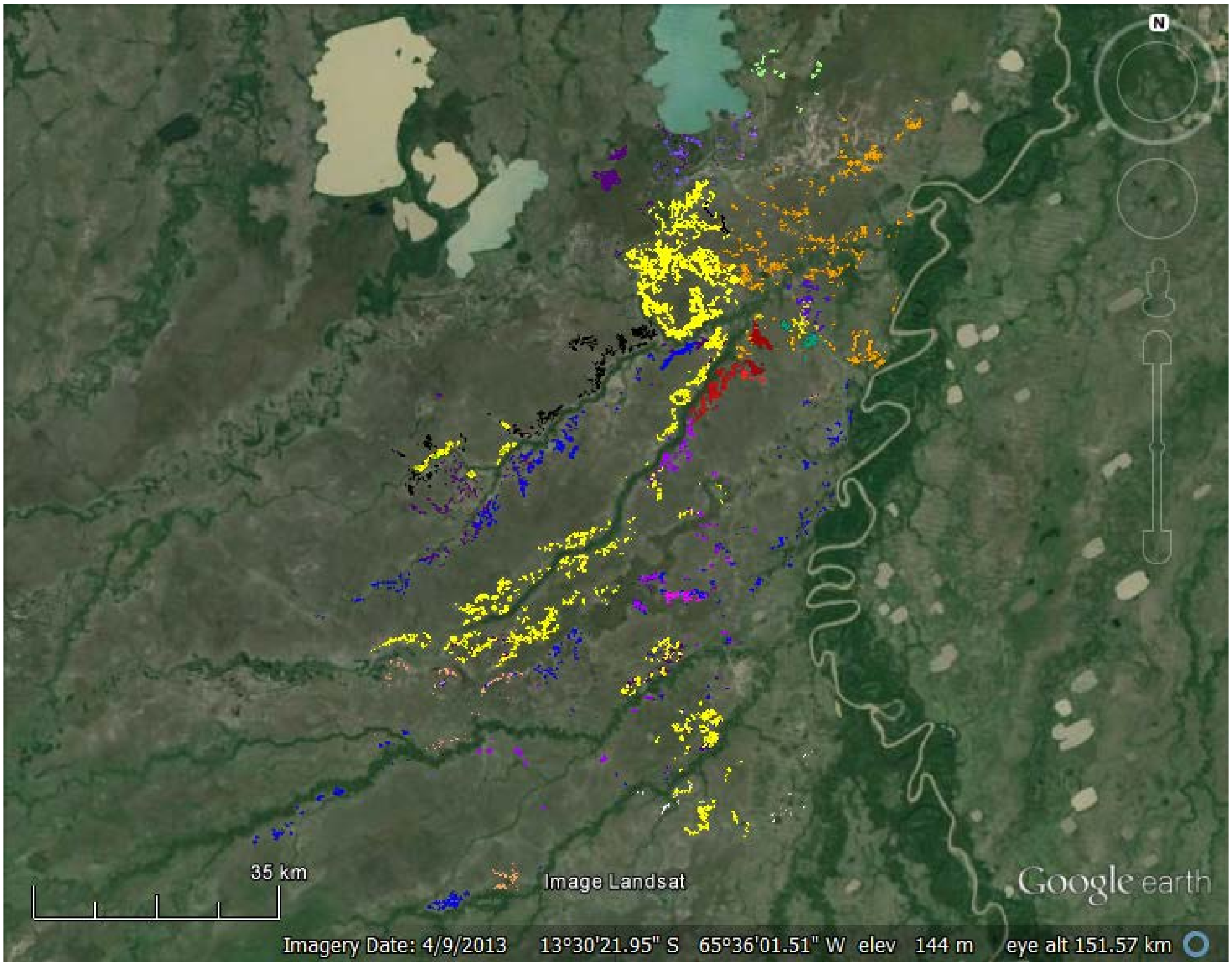

Figure 3-12 All raised fields utilized in the analysis. These were digitized on Google Earth by a group of undergraduate students and the author.

Figure 3-13 All forest islands digitized. From this file, the forest islands found within the selected study area were chosen. These were digitized by numerous individuals.

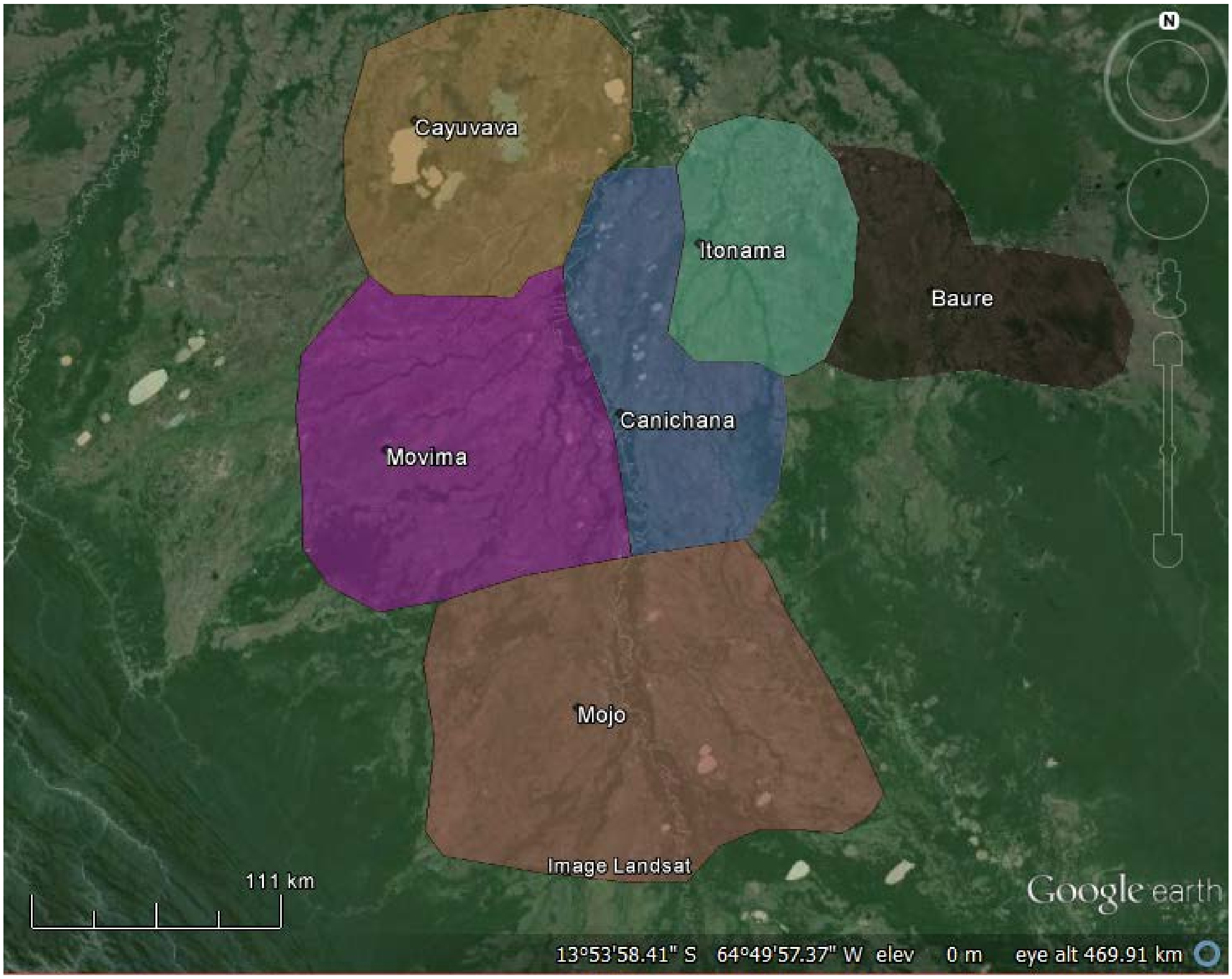

Figure 3-14 Linguistic groups distribution on Google Earth. The distribution and extent of these groups is based on Denevan (1966b:41).

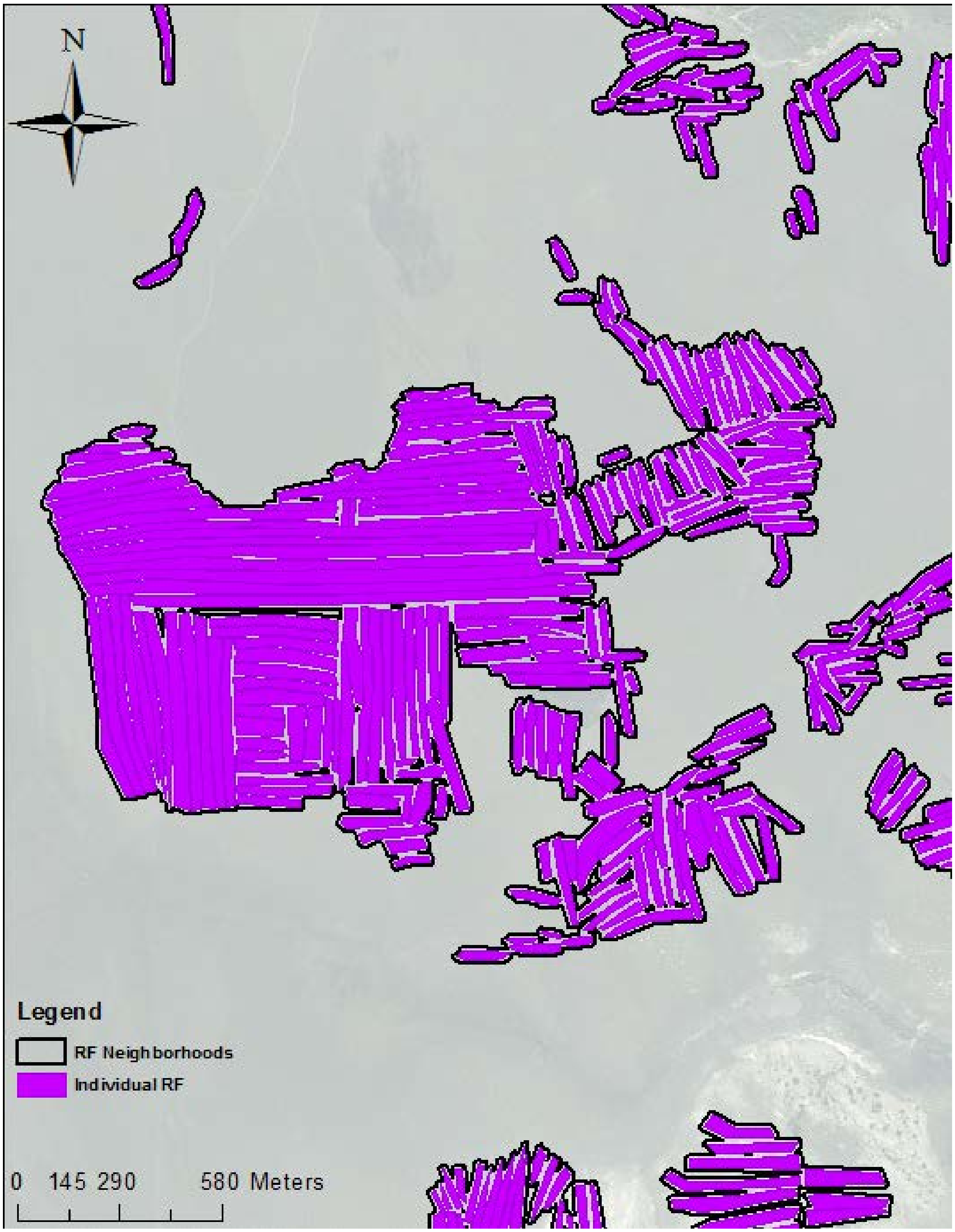

Figure 3-15 Close up view of raised field neighborhoods. The black outline is the dissolved 10 m buffer that encircles each neighborhood. The purple polygons represent each individual field.

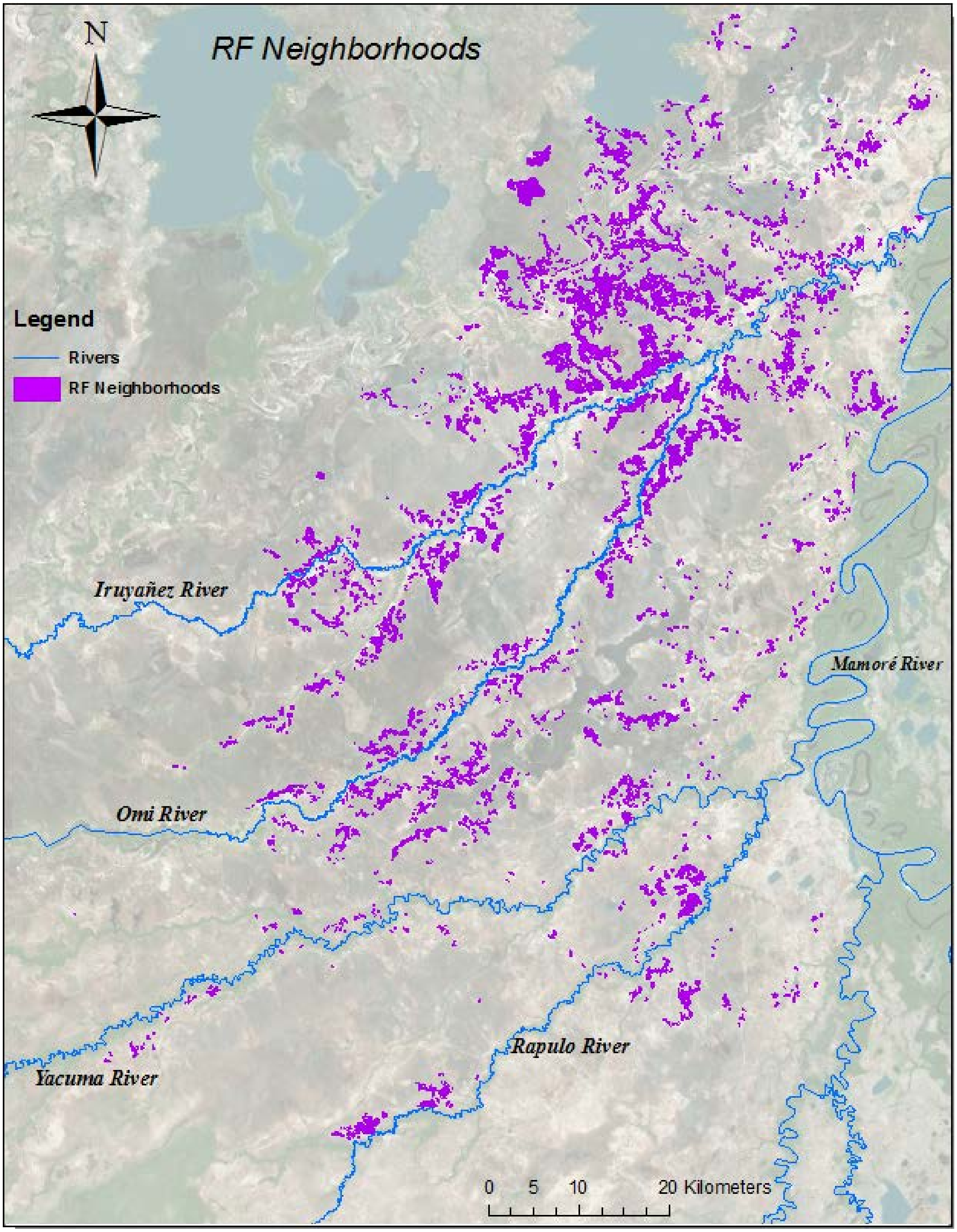

Figure 4- 1 The overall distribution of raised field neighborhoods in the study area including the Mamoré, Iruyañez, Omi, Yacuma, and Rapulo Rivers.

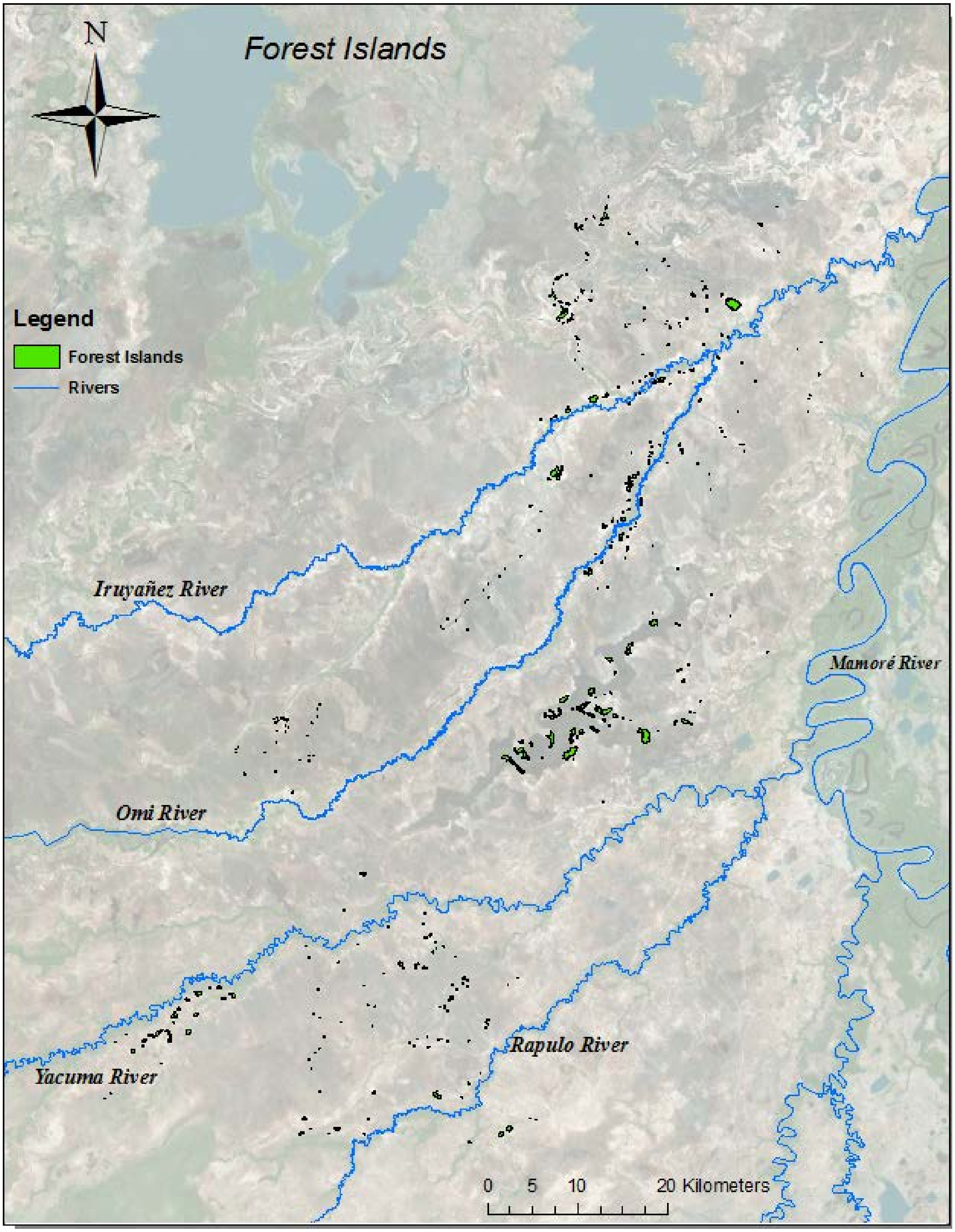

Figure 4-2 The overall distribution of forest islands in the study area including the Mamoré, Iruyañez, Omi, Yacuma, and Rapulo Rivers.

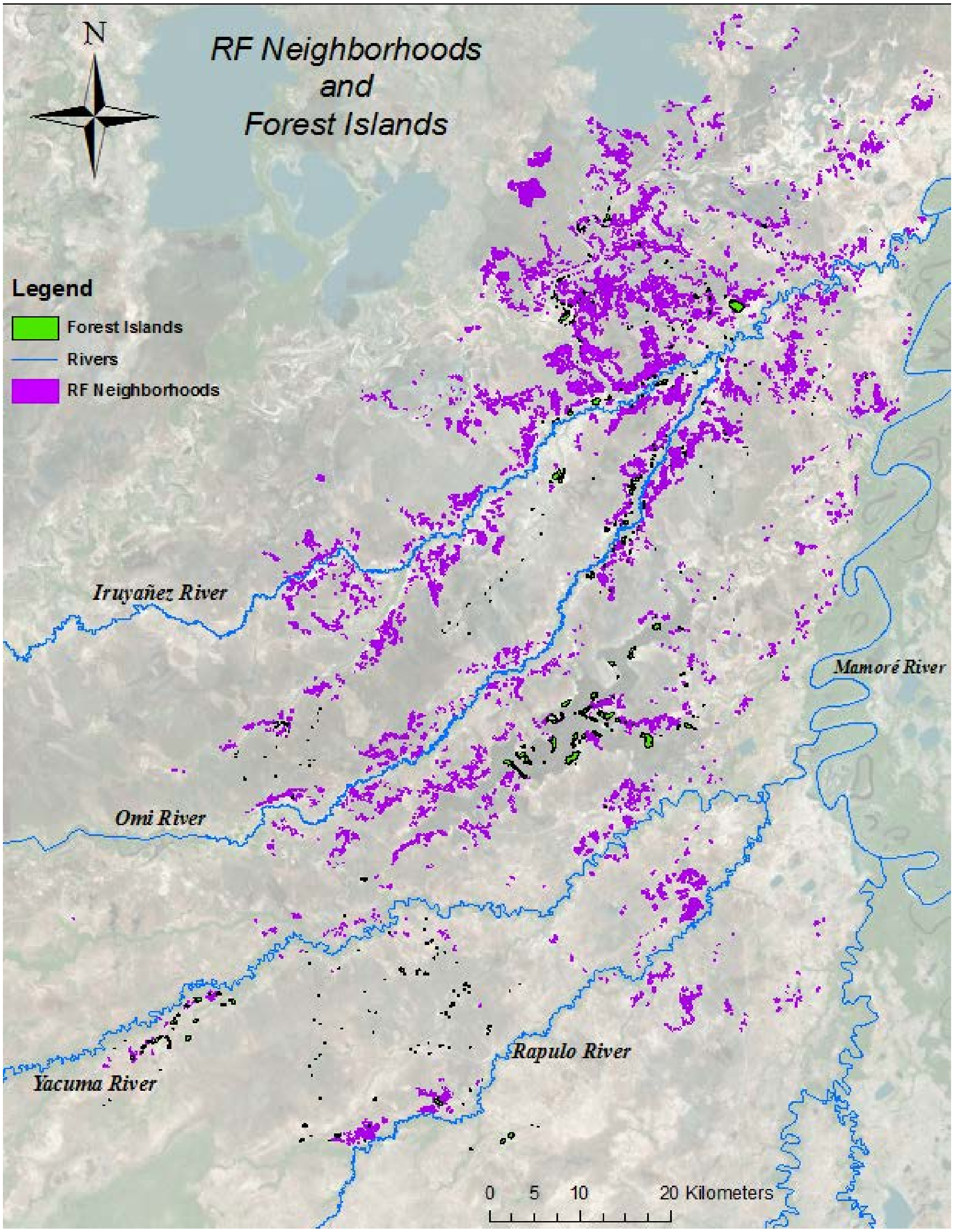

Figure 4-3 The distribution of both raised field neighborhoods and forest islands found in the study area including the Mamoré, Iruyañez, Omi, Yacuma, and Rapulo Rivers.

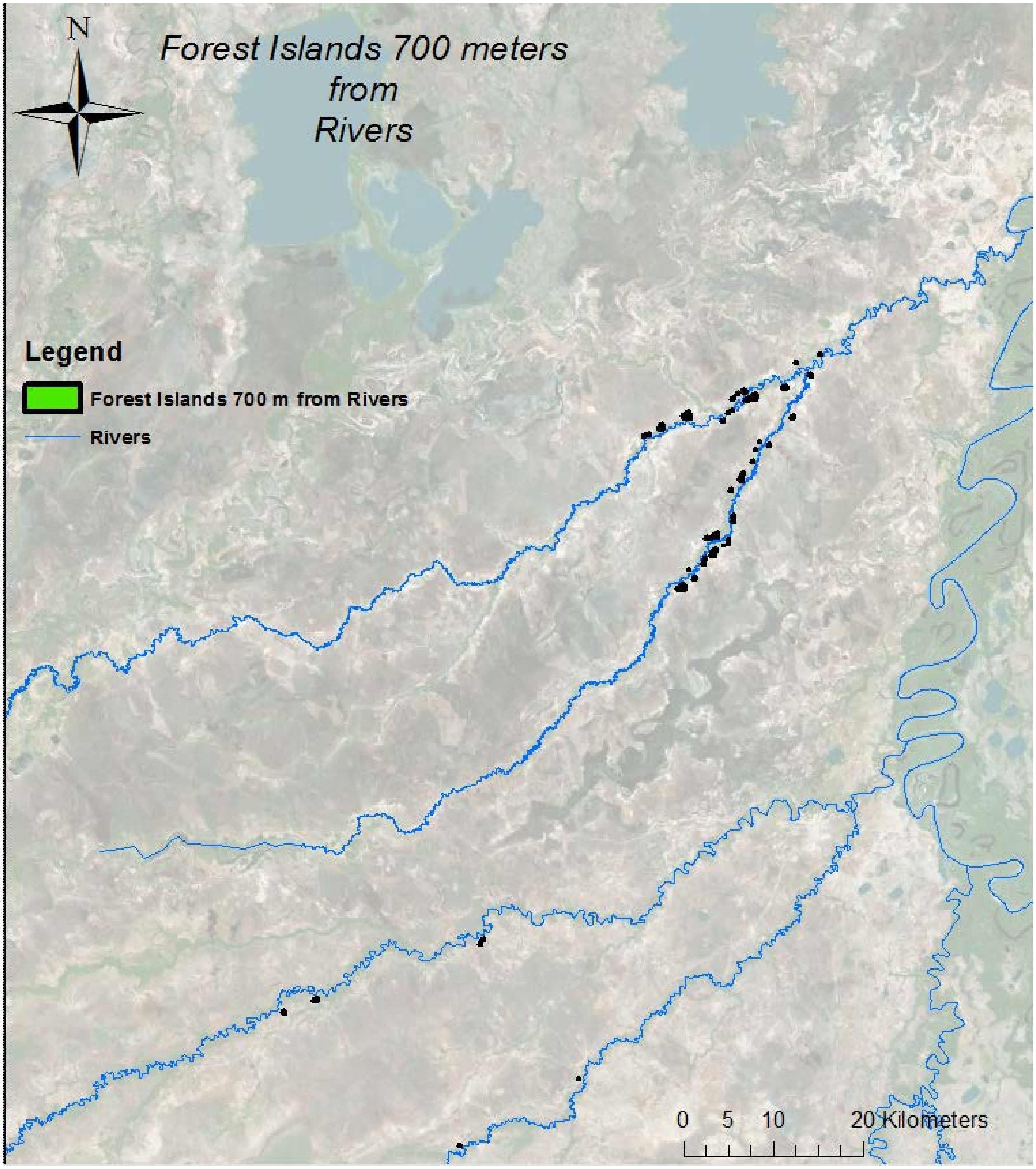

Figure 4-4 The forest islands that were found within 700 m (See Stone 1991:347) from the rivers.

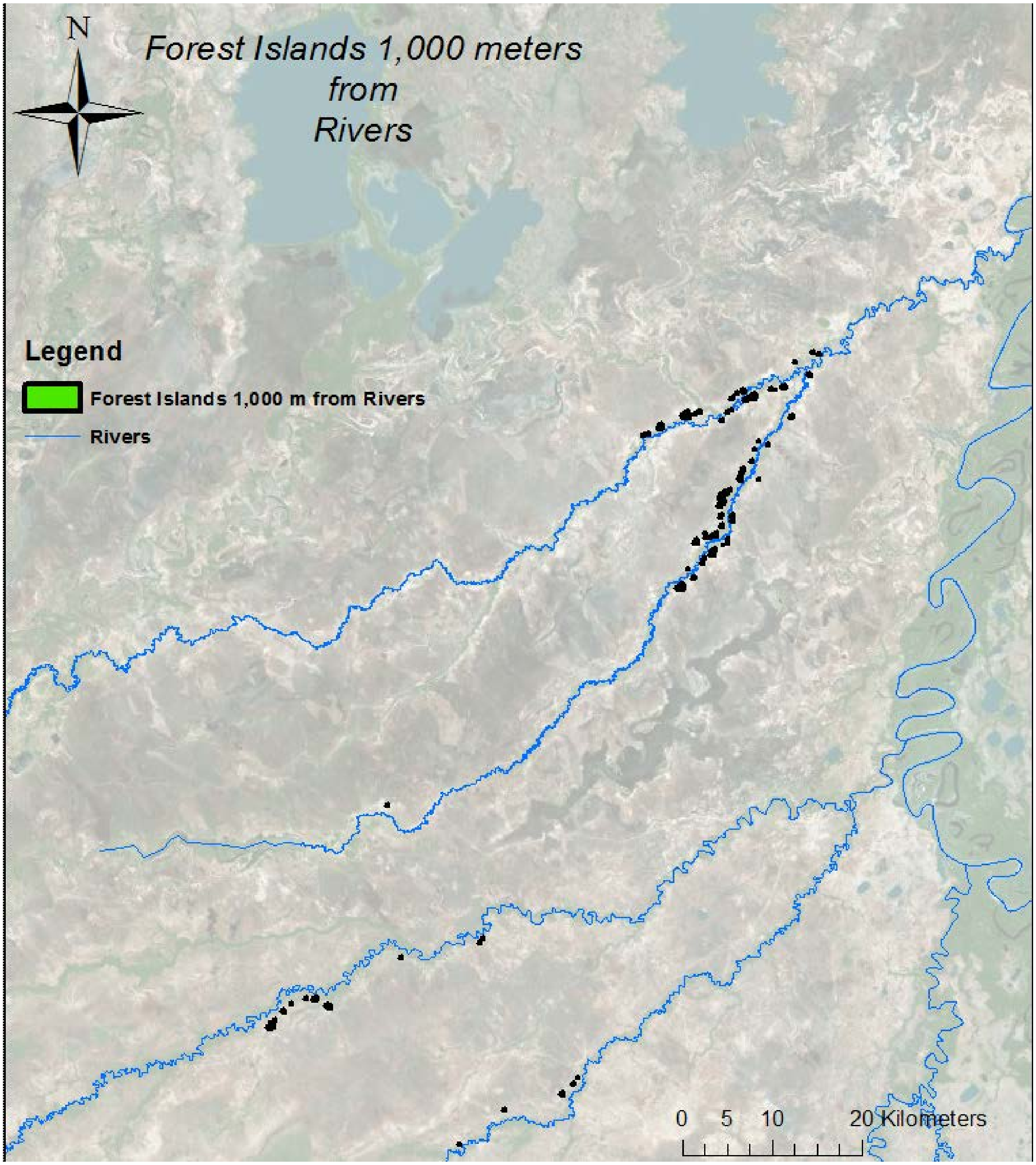

Figure 4-5 The forest islands that are found within 1,000 m (See Chisholm 2007:148) from rivers.

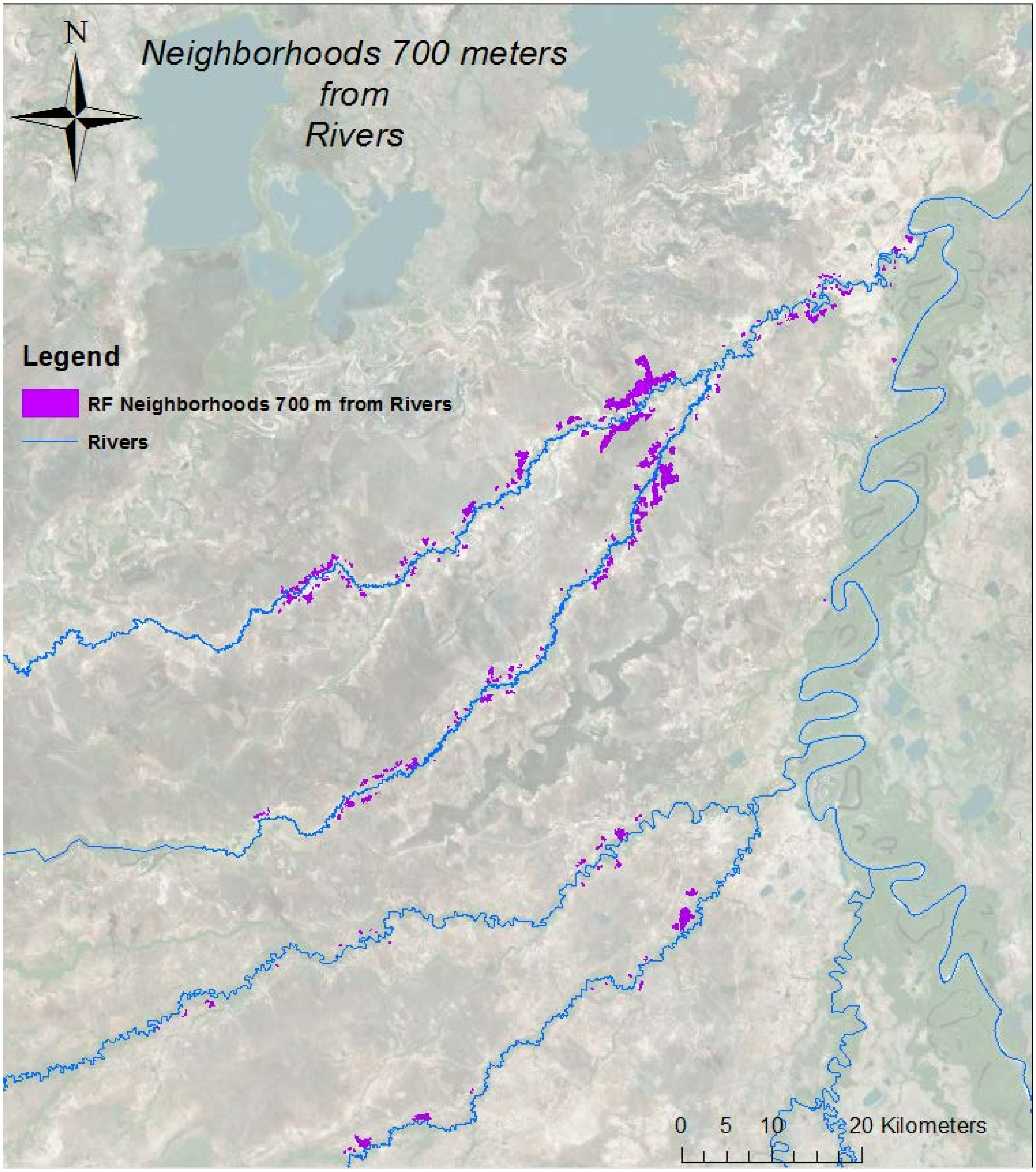

Figure 4-6 The raised field neighborhoods that are found within 700 m (See Stone 1991:347) from rivers.

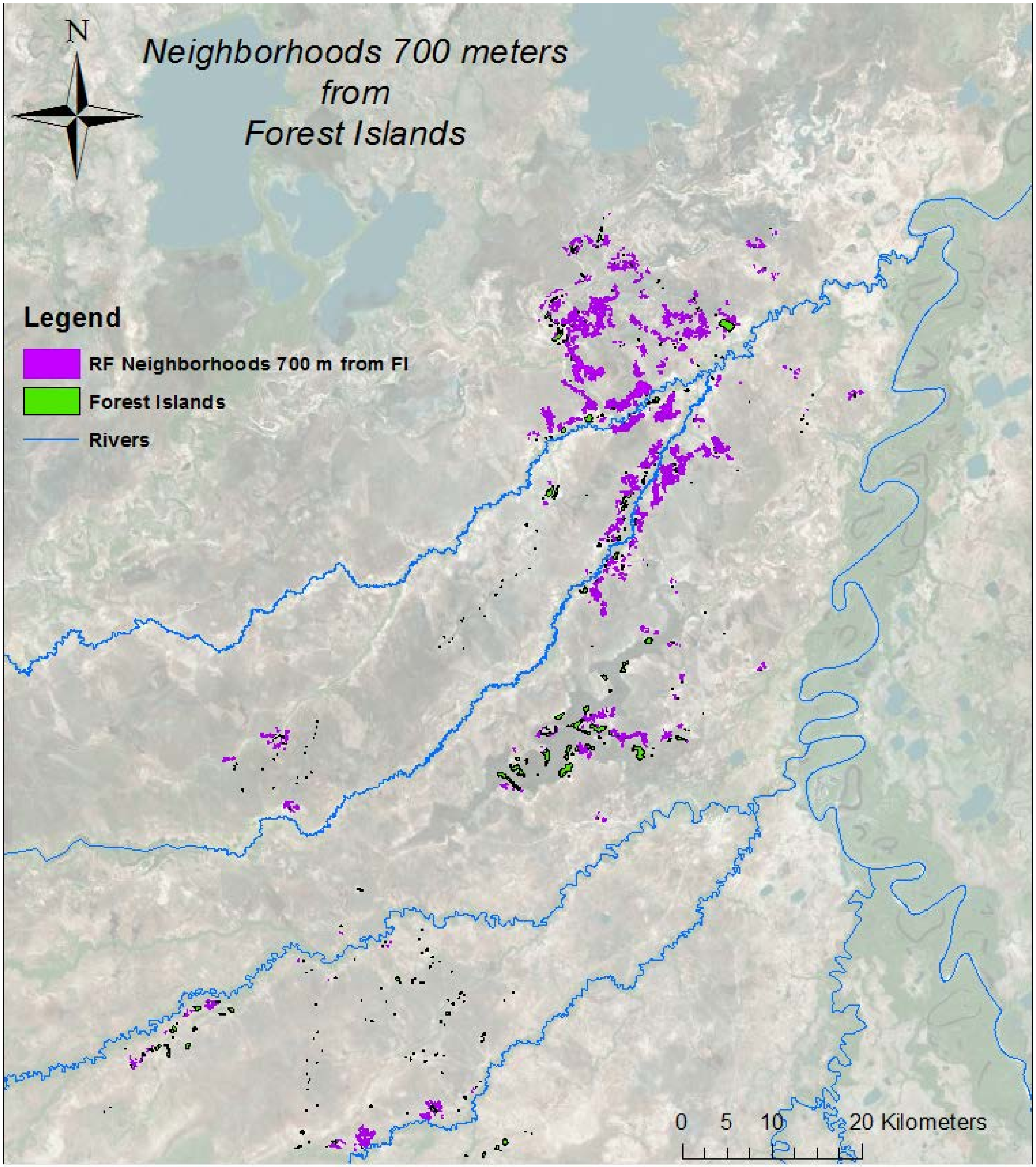

Figure 4-7 The raised field neighborhoods found within 700 m (See Stone: 1991:347) of forest islands.

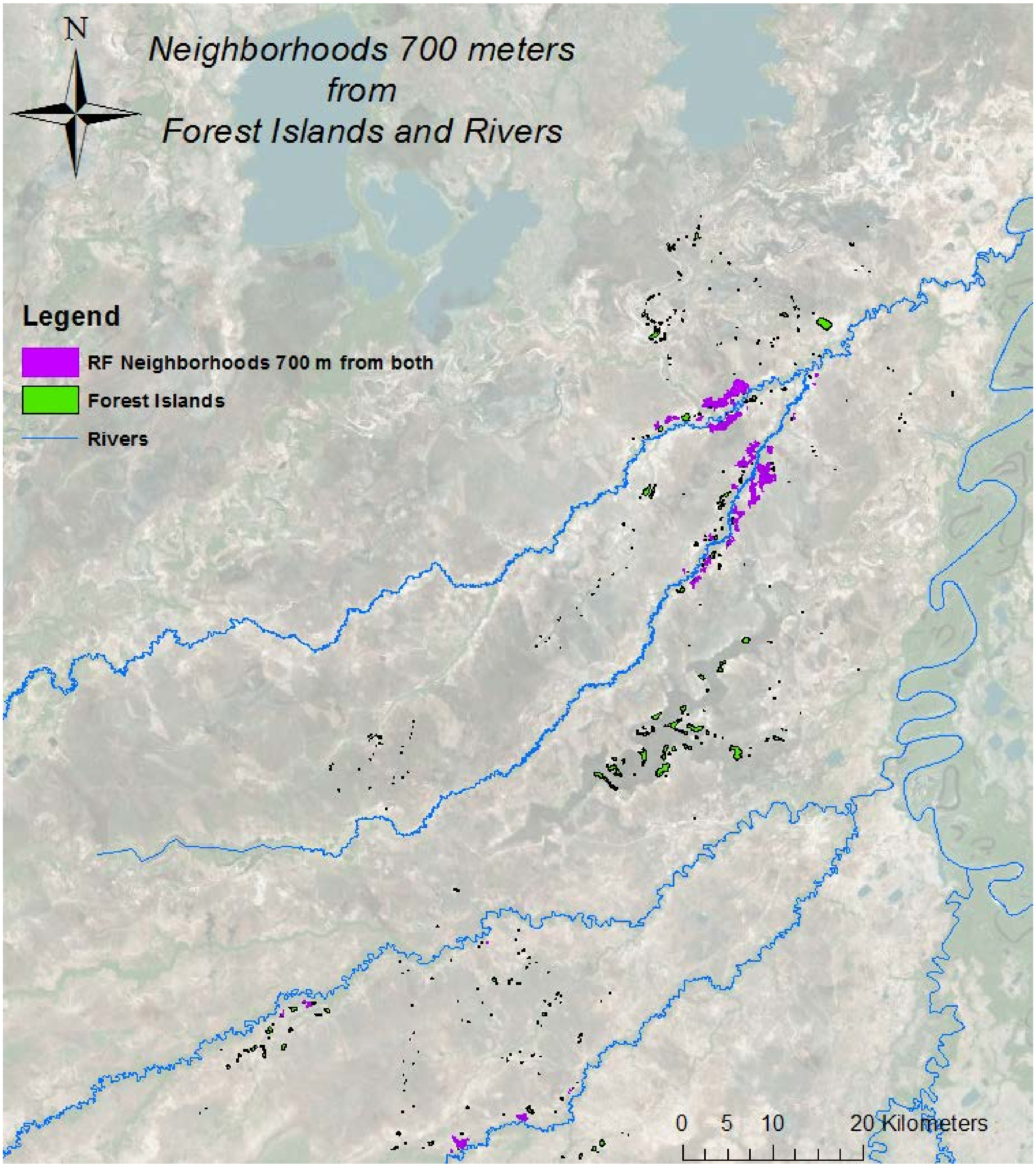

Figure 4-8 The raised fields neighborhoods found within 700 m (See Stone 1991:347) from both forest islands and rivers in the study area.

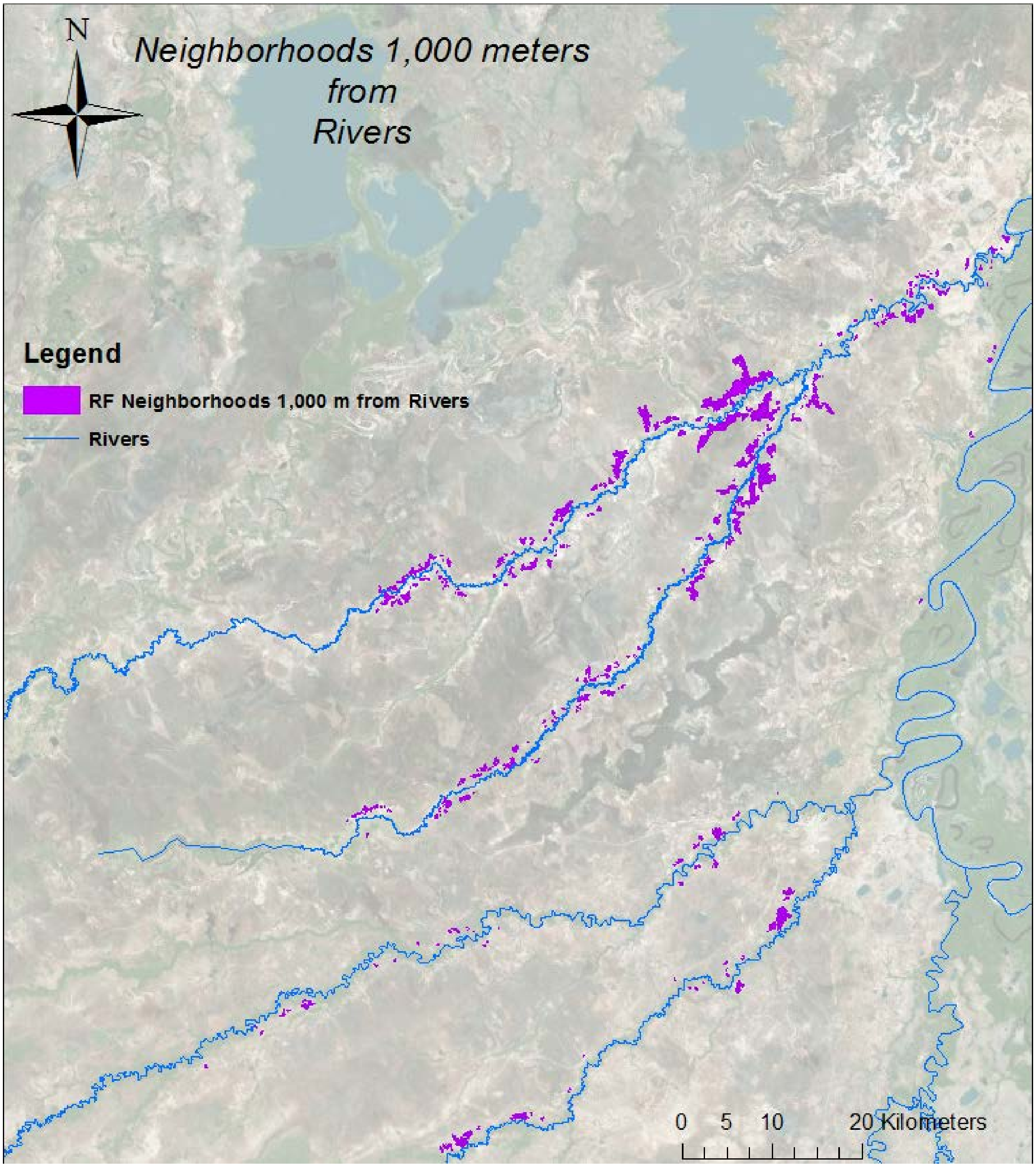

Figure 4-9 The raised field neighborhoods that are found within 1,000 m (See Chisholm 2007:148) from rivers.

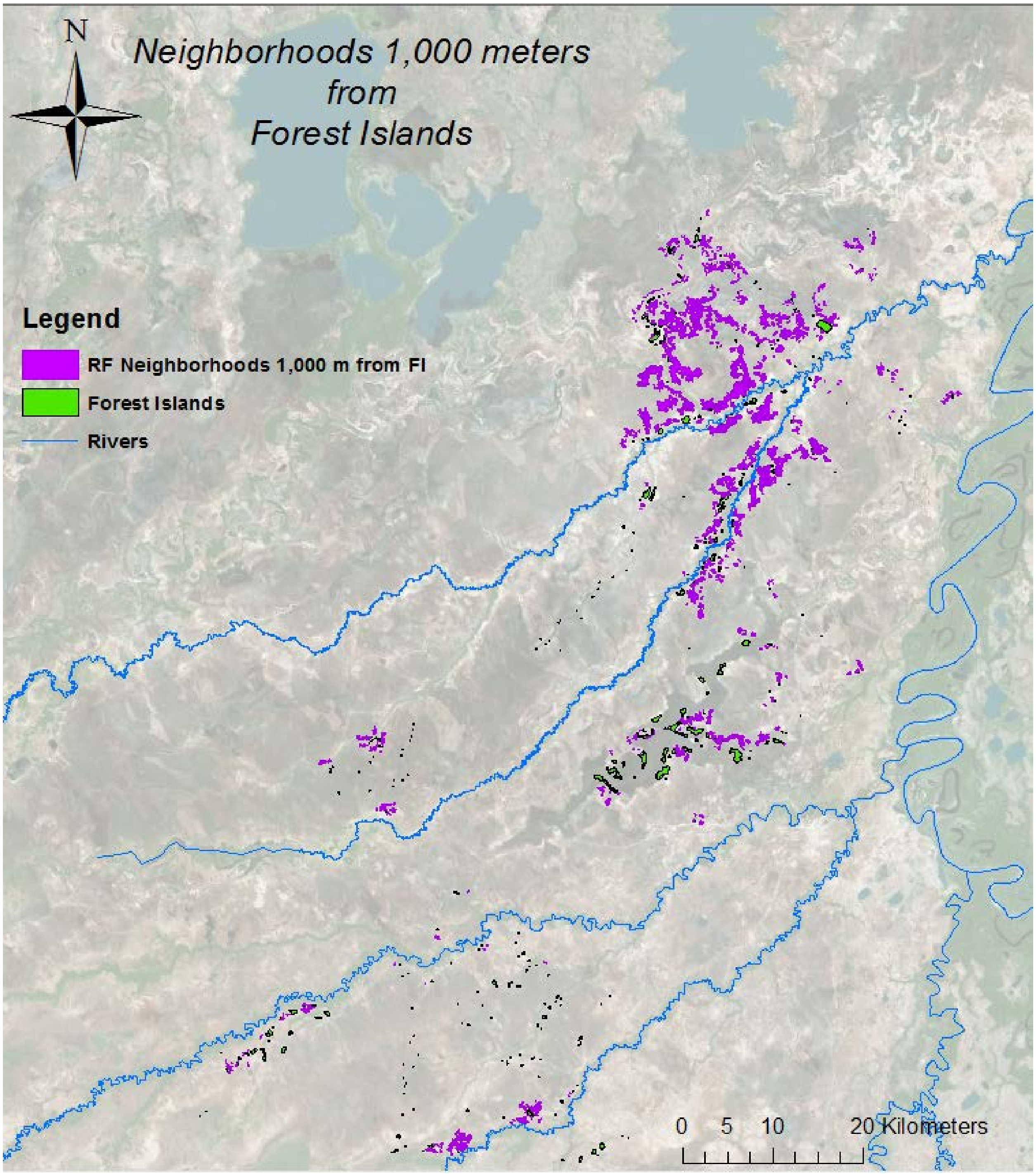

Figure 4-10 The raised field neighborhoods found within 1,000 m (See Chisholm 2007:148) from forest islands.

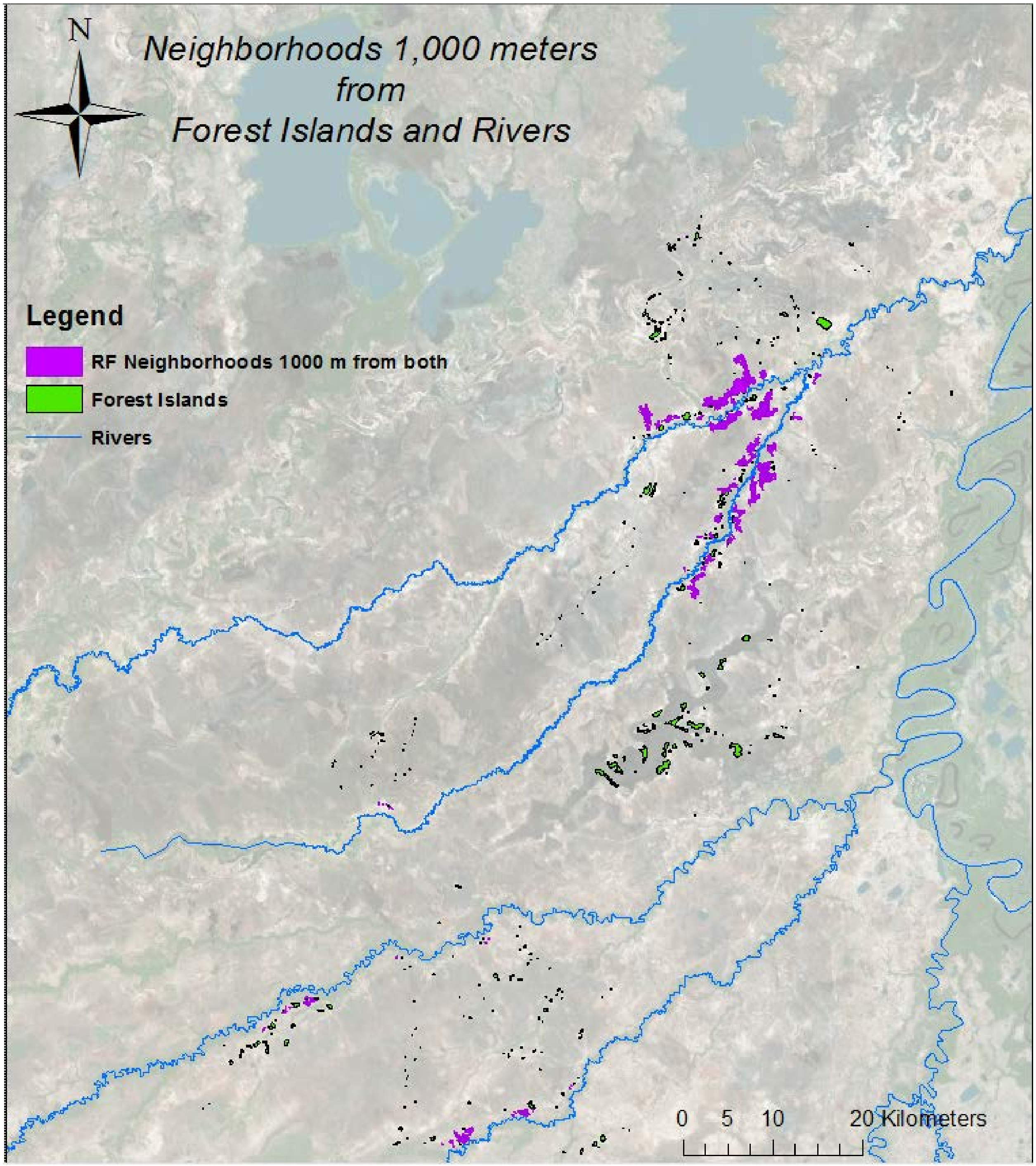

Figure 4-11 The raised field neighborhoods found within 1,000 m (See Chisholm 2007:148) of both forest islands and rivers in the study area.

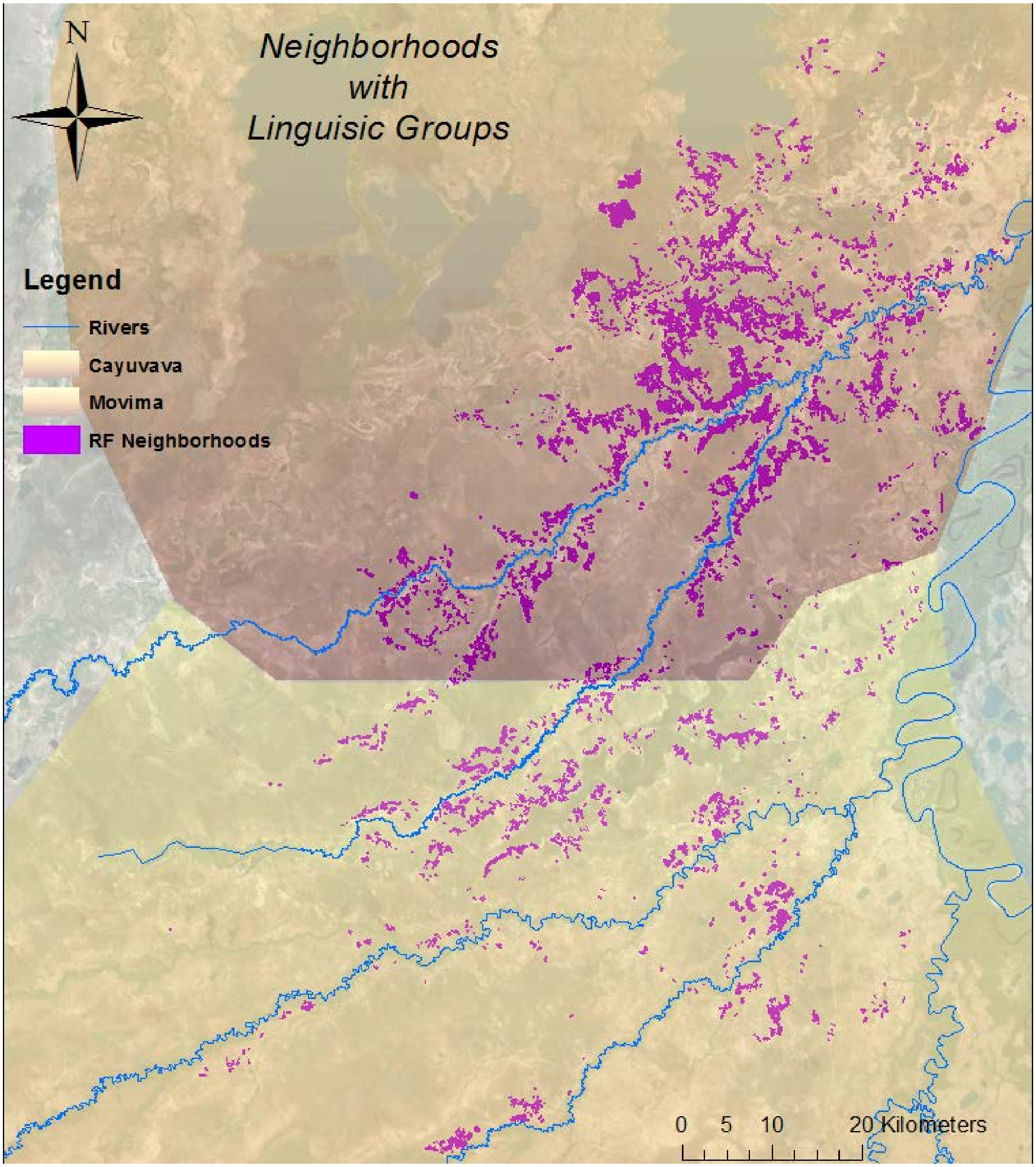

Figure 4-12 The overall distribution of raised field neighborhoods with the distribution of linguistic groups found in the study area. (See Denevan 1966b: 41)

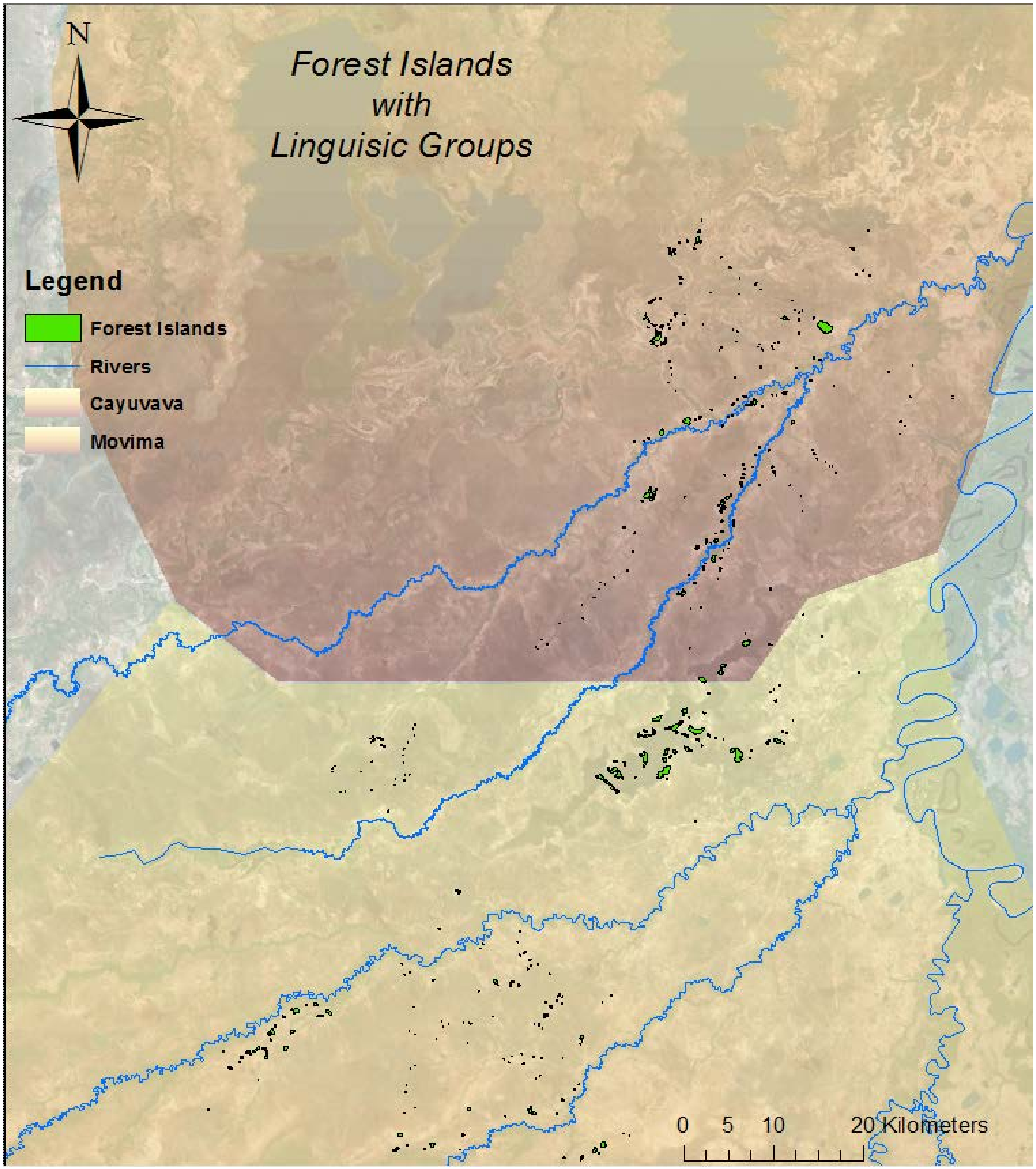

Figure 4-13 The overall distribution of forest islands with the distribution of linguistic groups found in the study area. (See Denevan 1966b:41)

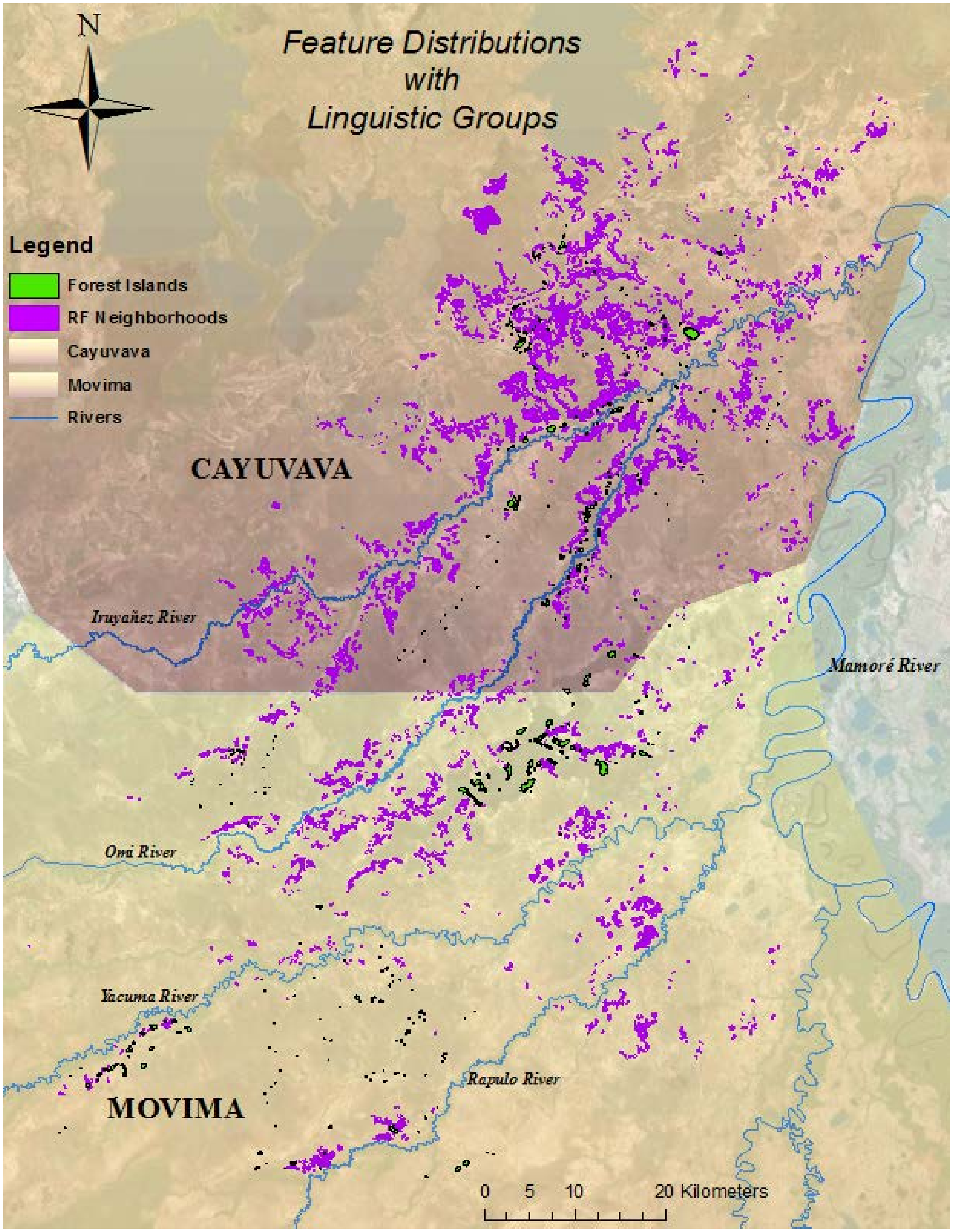

Figure 4-14 The distribution of both raised field neighborhoods and forest islands with the distribution of linguistic groups in the study area including the Mamoré, Iruyañez, Omi, Yacuma, and Rapulo Rivers. (See Denevan 1966b: 41)

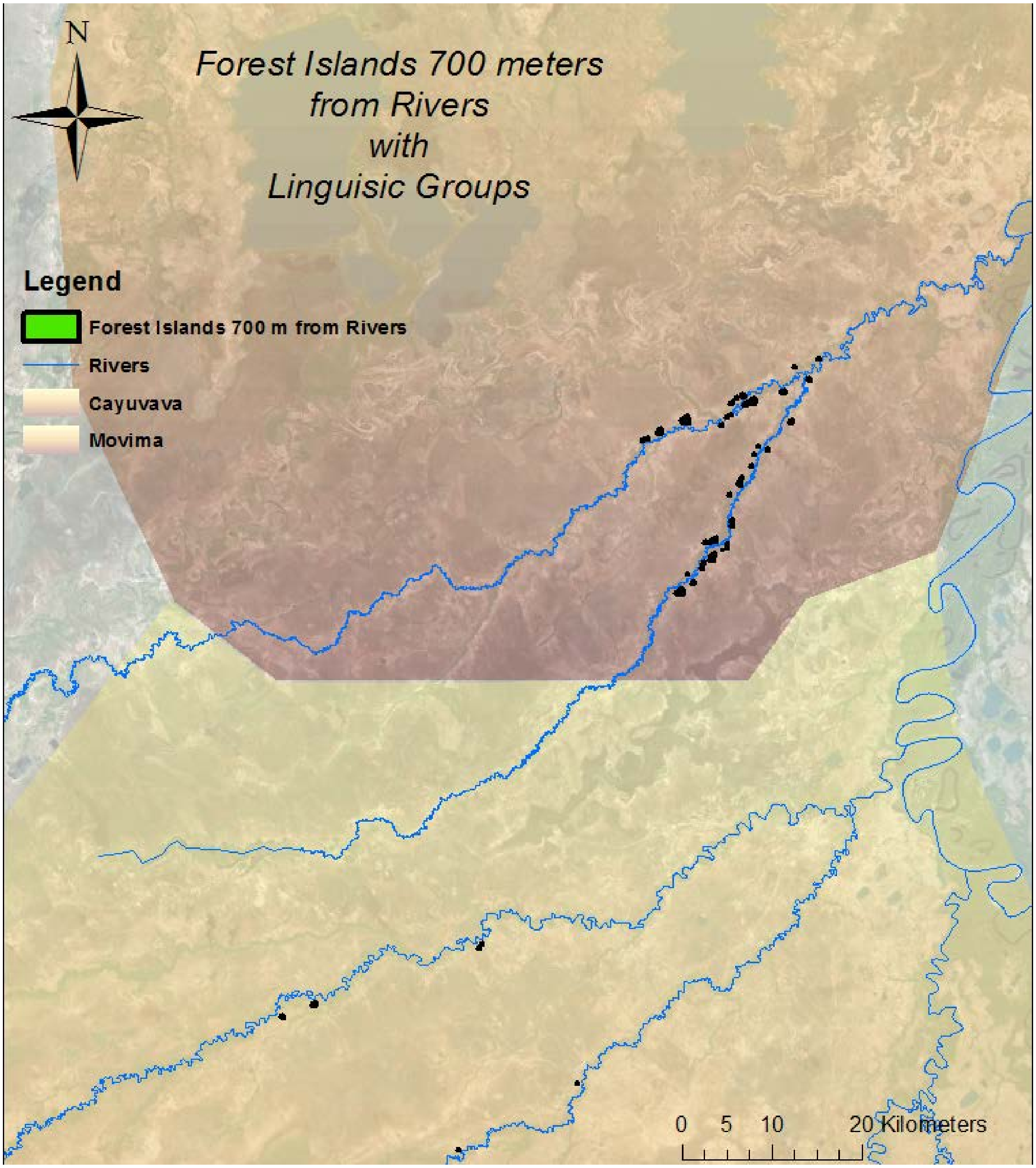

Figure 4-15 The forest islands found within 700 m from rivers with the linguistic groups. (See Denevan 1966b: 41; Stone 1991:347).

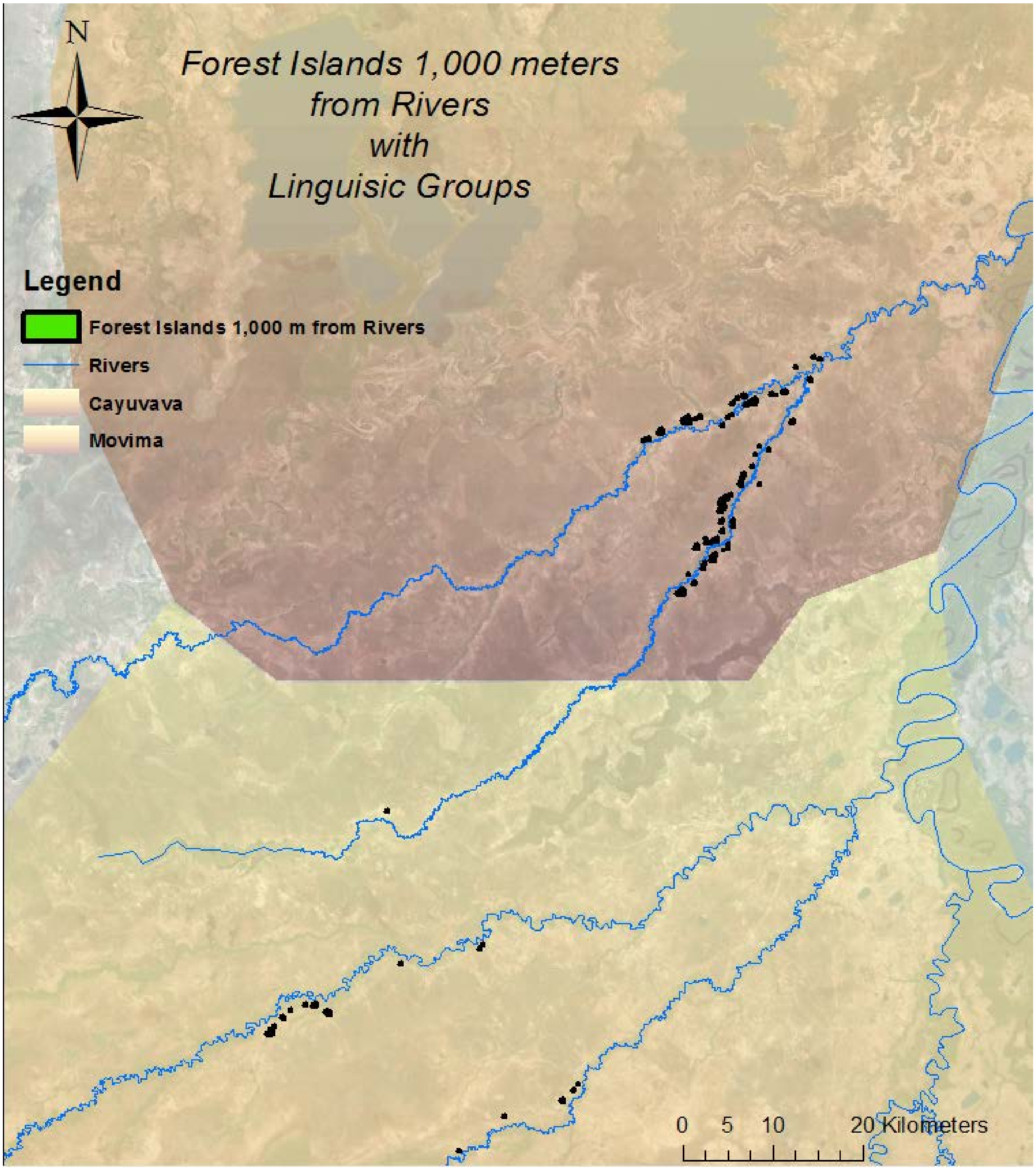

Figure 4-16 The forest islands found within 1,000 m from rivers with the linguistic groups. (See Denevan 1966b:41; Chisholm 2007:148)

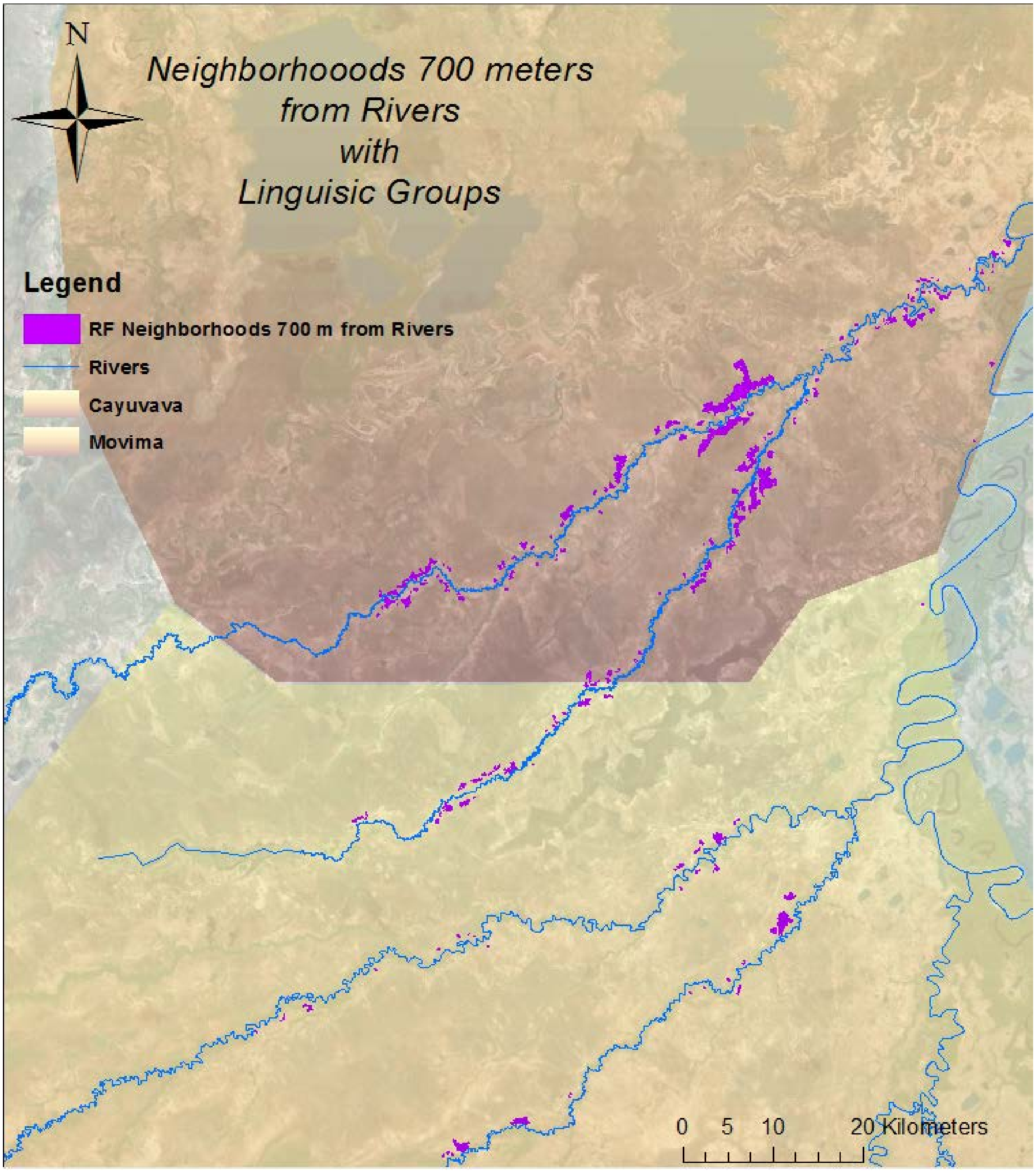

Figure 4-17 The raised field neighborhoods found within 700 m from rivers with the linguistic groups. (See Denevan 1966b:41; Stone 1991:347)

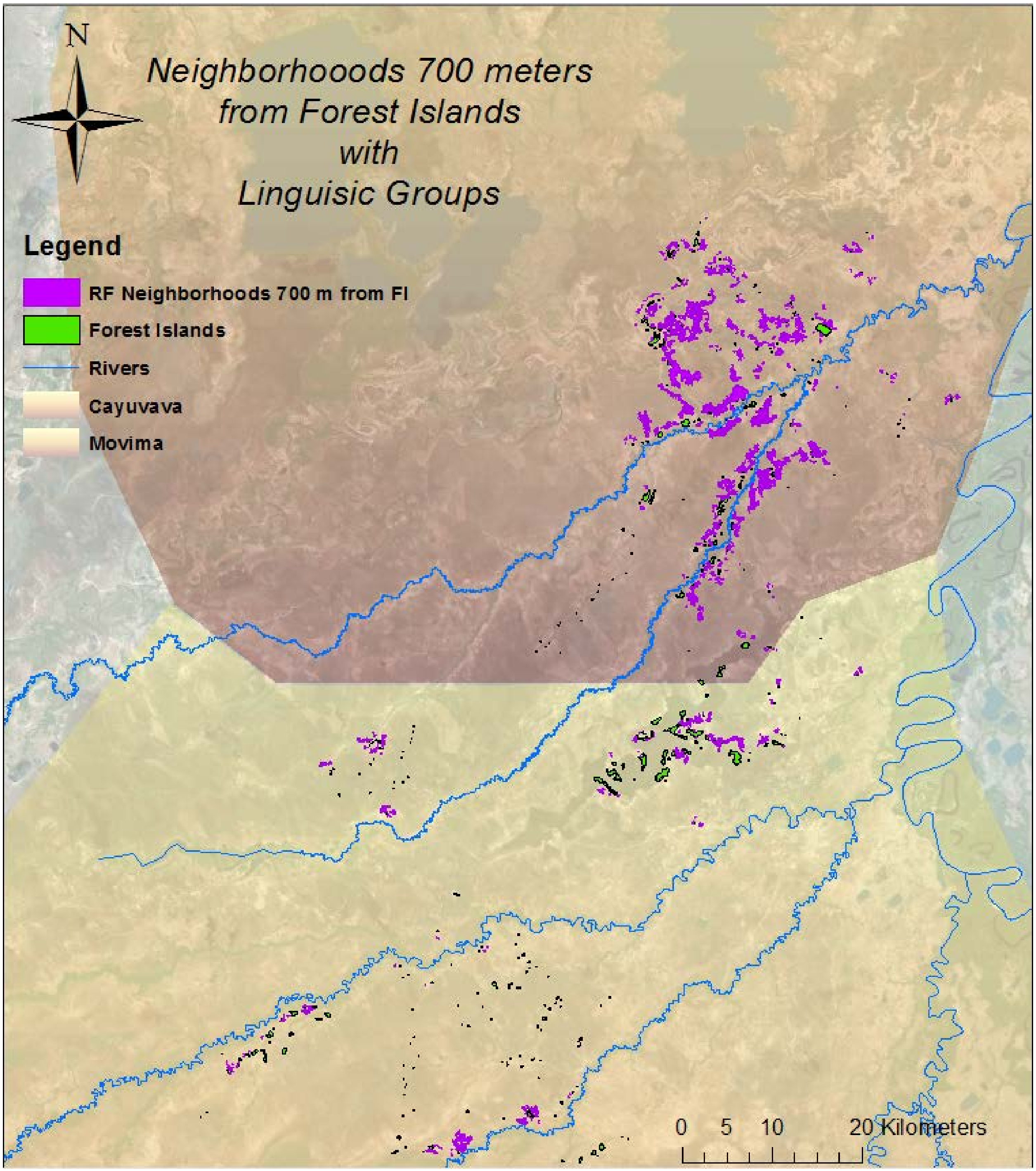

Figure 4-18 The raised field neighborhoods found within 700 m from forest islands with the linguistic groups. (See Denevan 1966b:41; Stone 1991:347)

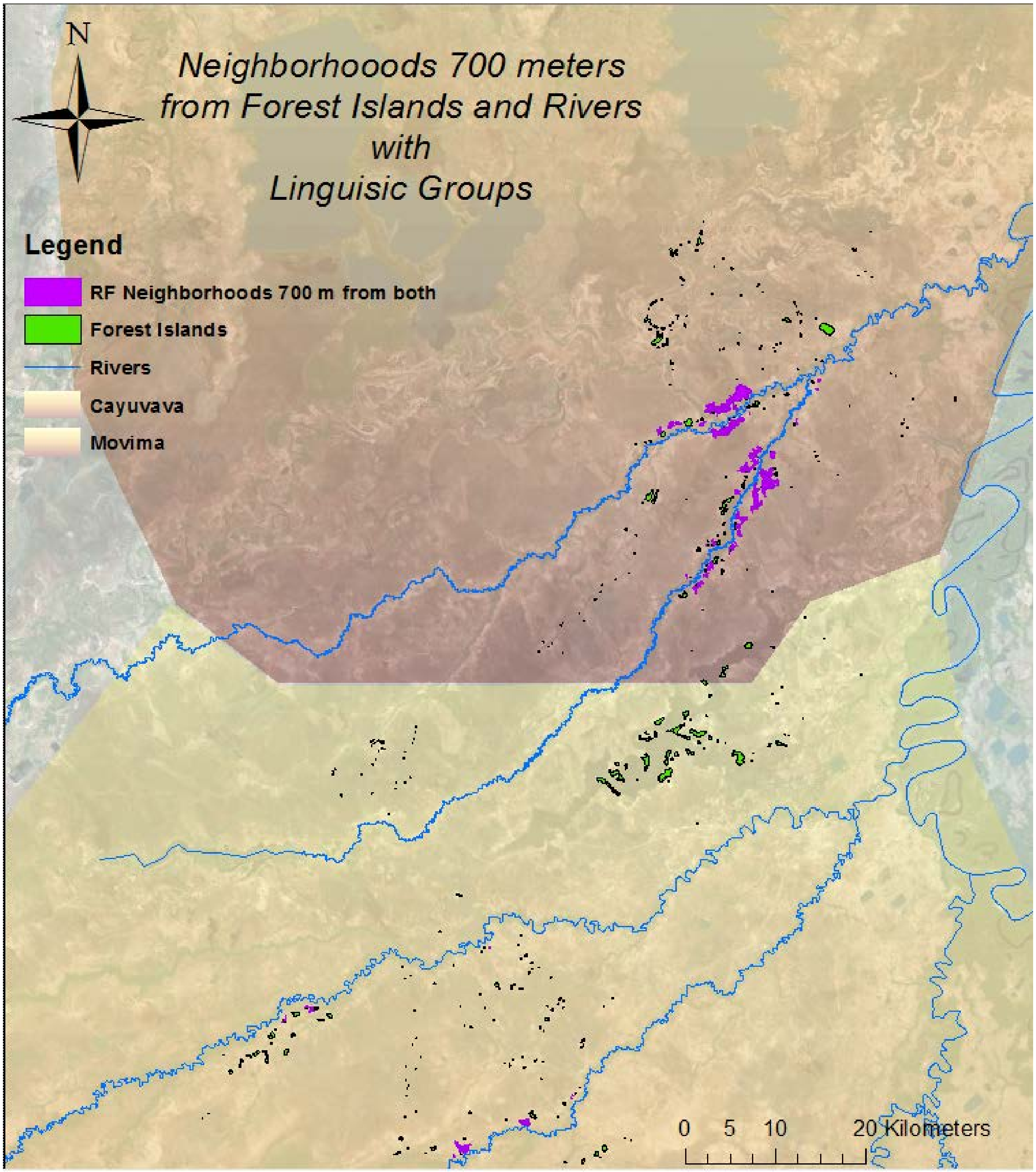

Figure 4-19 The raised field neighborhoods found within 700 m from both forest islands and rivers with the linguistic groups. (See Denevan 1966b:41; Stone 1991:347)

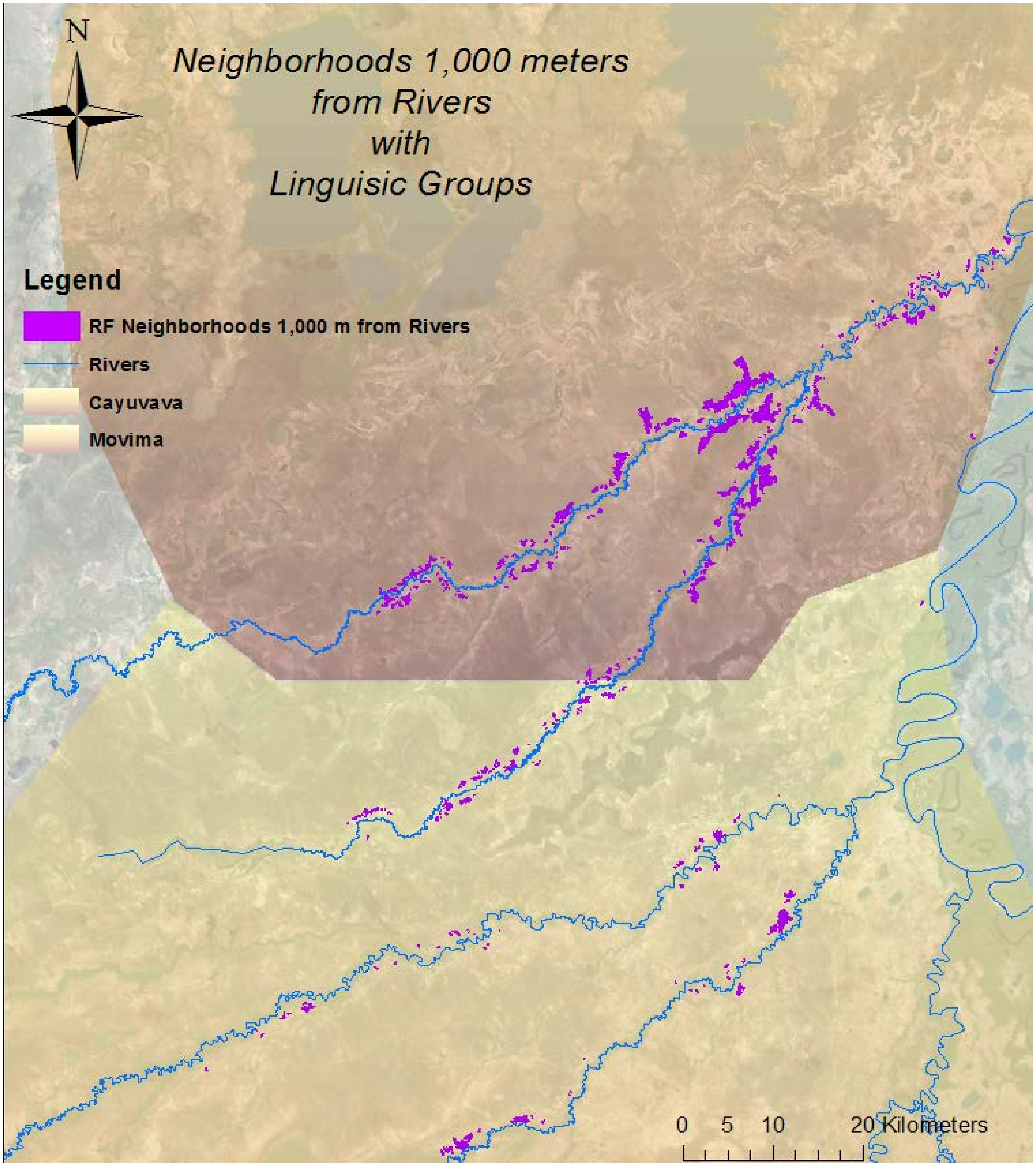

Figure 4-20 The raised field neighborhoods found within 1,000 m from rivers with the linguistic groups. (See Denevan 1966b:41; Chisholm 2007:148)

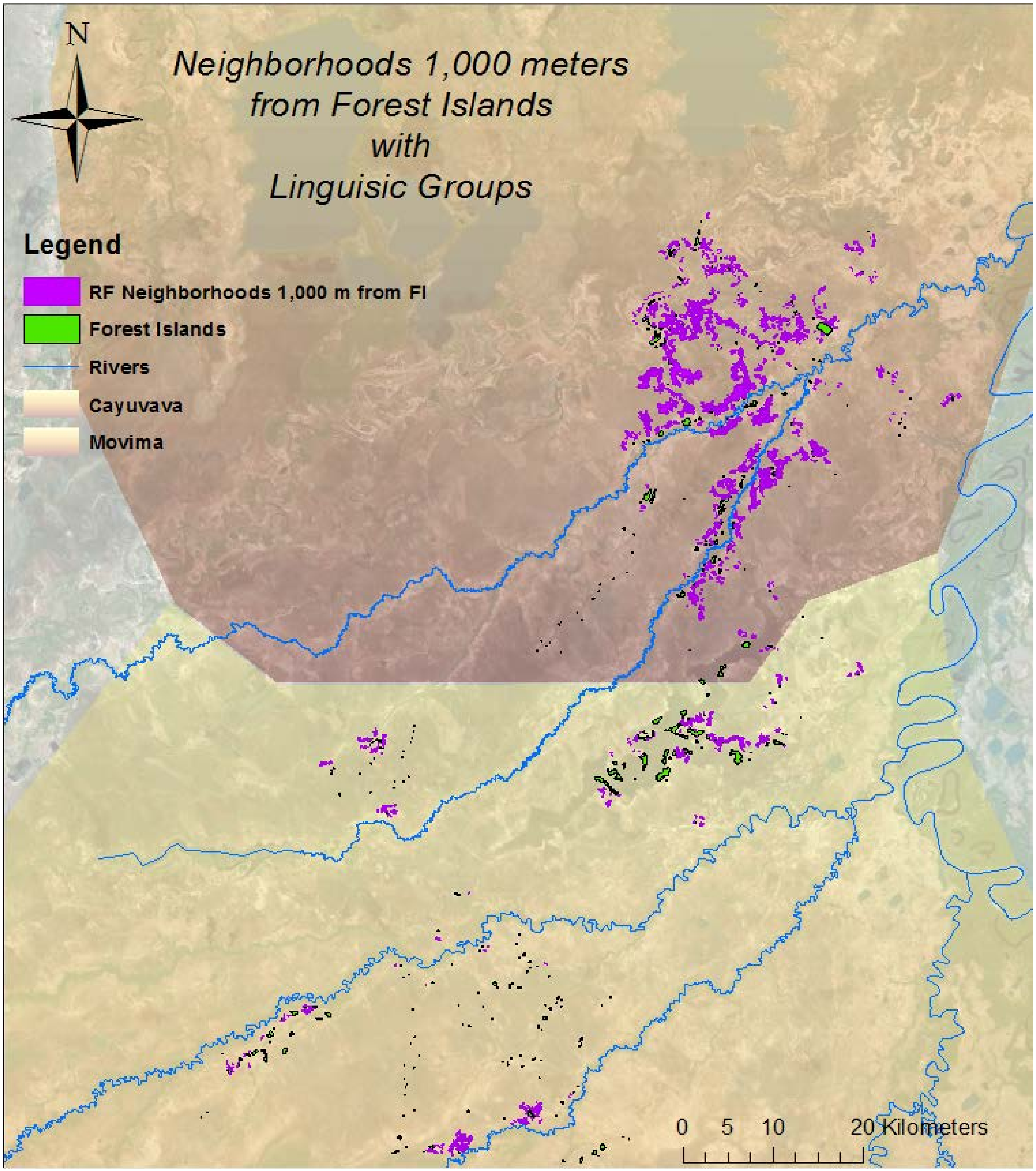

Figure 4-21 The raised field neighborhoods found within 1,000 m from forest islands with the linguistic groups. (See Denevan 1966b:41; Chisholm 2007:148)

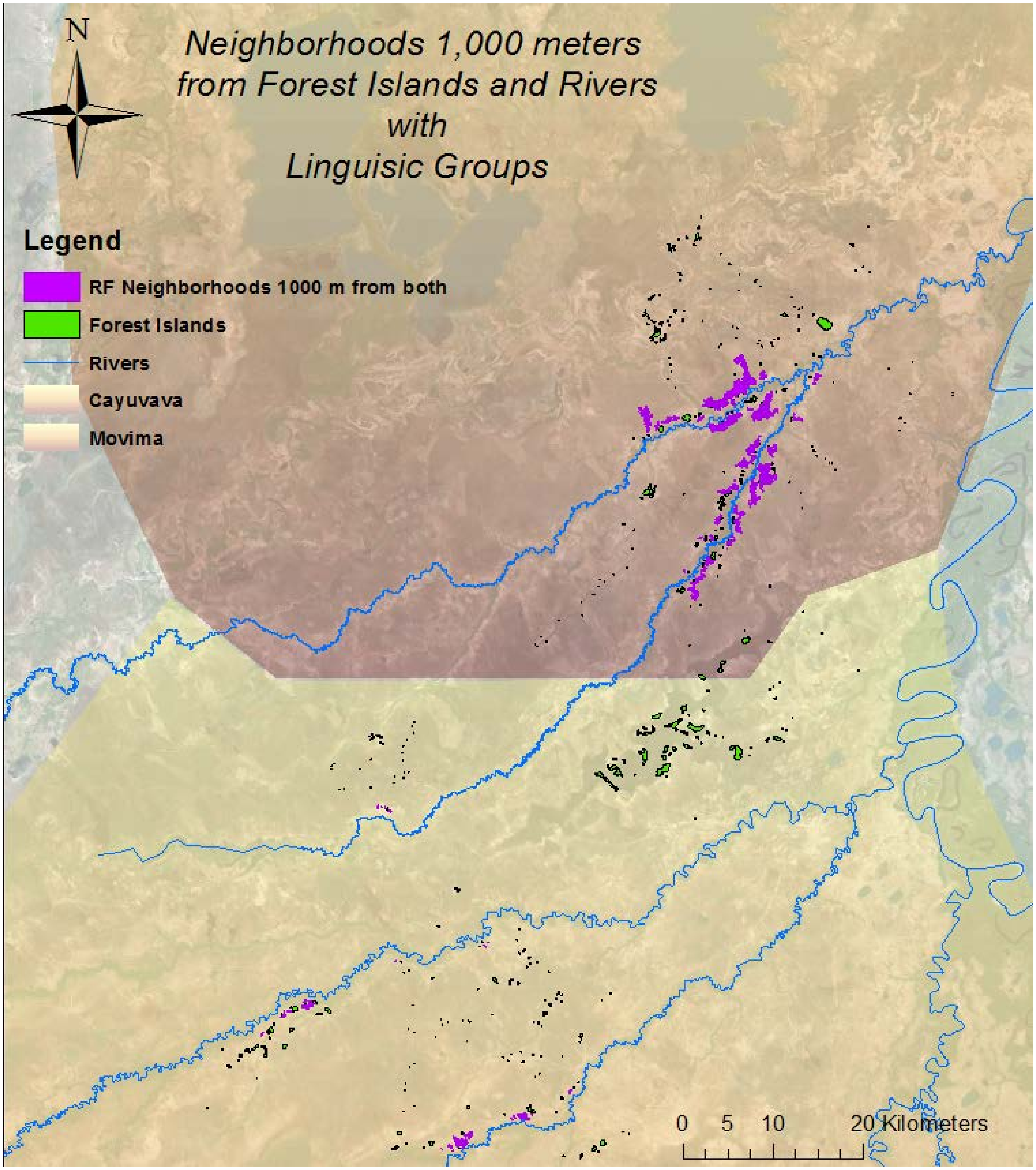

Figure 4-22 Raised field neighborhoods found within 1,000 m from both forest islands and rivers with the distribution of linguistic groups. (See Denevan 1966b:41; Chisholm 2007:148)

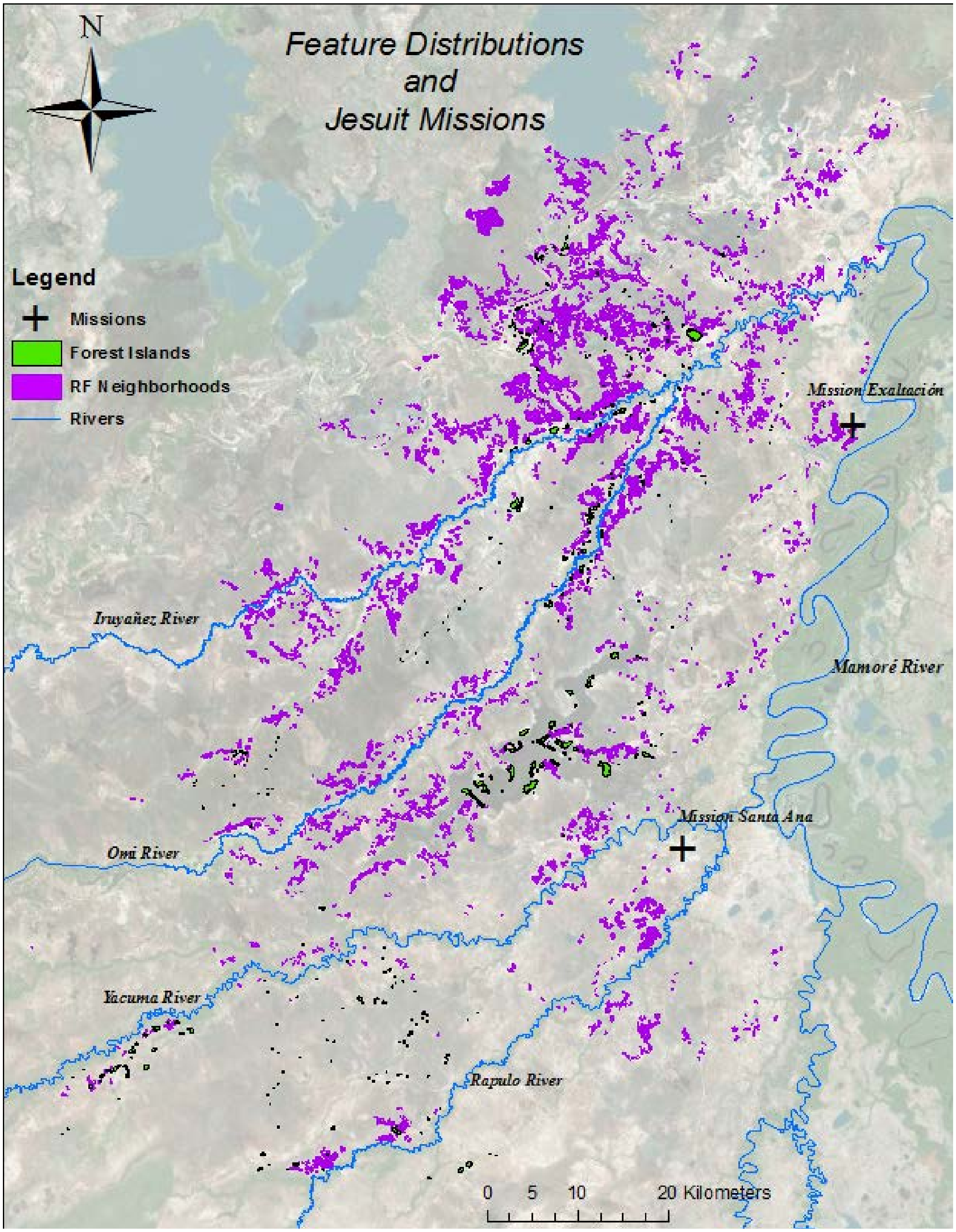

Figure 4-23 Raised field neighborhoods and forest islands with the Jesuit missions found in the study area including the Mamoré, Iruyañez, Omi, Yacuma, and Rapulo Rivers.

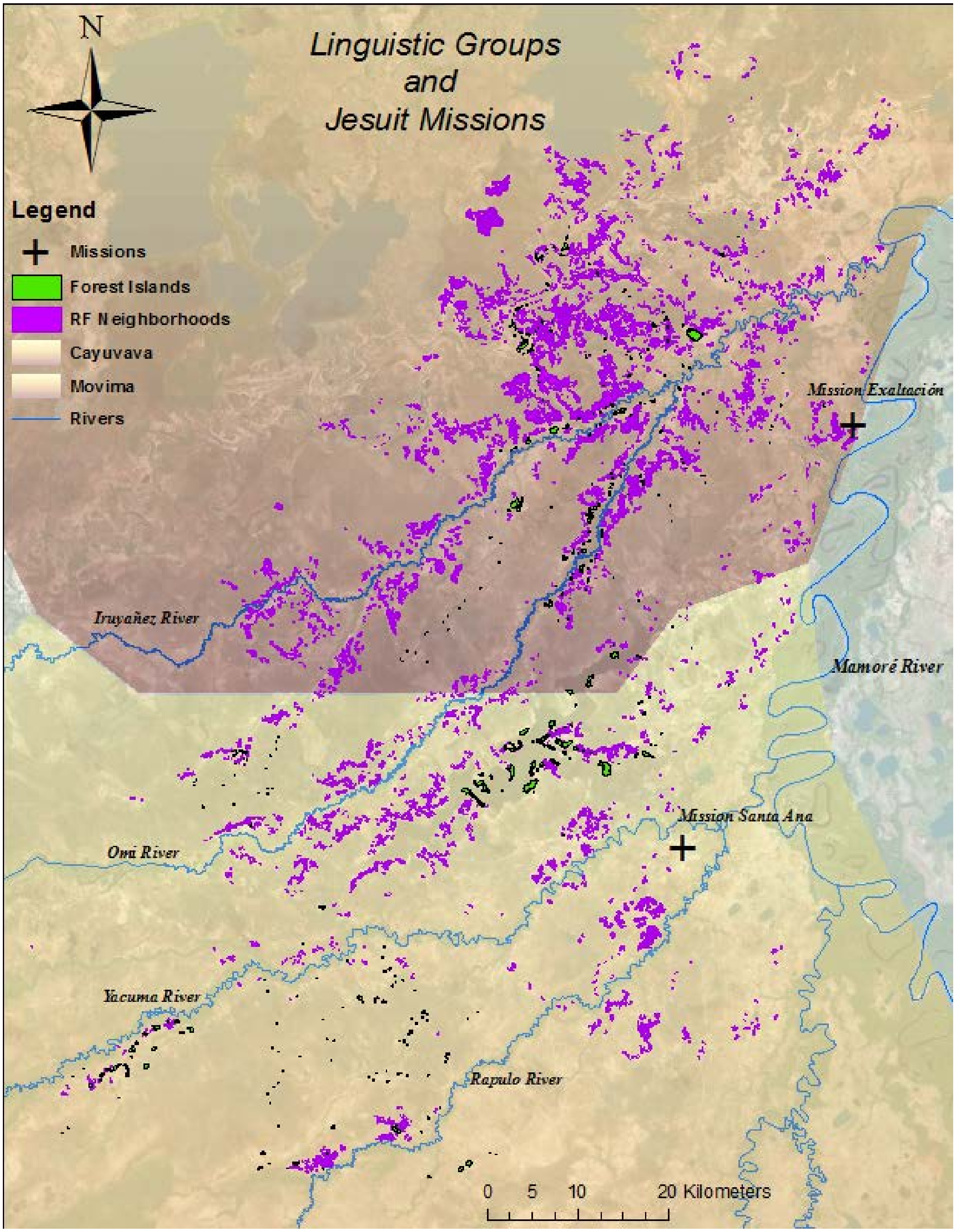

Figure 4-24 The raised field neighborhoods and forest islands with the Jesuit missions found in the area including the Mamoré, Iruyañez, Omi, Yacuma, and Rapulo Rivers. The linguistic groups are also presented. (See Denevan1966b:41)

APPENDIX B: TABLES

Table 1: Raised field neighborhoods and forest islands selected according to threshold distances

Features	Within distance of rivers	Within distance of forest islands	Within distance of forest islands AND rivers
700 meters			
RF Neighborhoods	583	1,026	104
Forest Islands	52	—	—
1,000 meters			
RF Neighborhoods	887	1,393	201
Forest Islands	78	—	—

This table provides the results of raised field neighborhoods in relation to forest islands and rivers, as well as the results of forest islands in relation to rivers. The raised field neighborhoods selected were out of a total of 6,639 neighborhoods and the forest islands selected were out of a total of 574 forest islands.

Table 2: Raised fields and forest islands selected according to threshold distances: percentages

Features	Within distance of rivers	Within distance of forest islands	Within distance of forest islands AND rivers
700 meters			
RF Neighborhoods	8.78%	15.45%	1.56%
Forest Islands	9.05%	—	—
1,000 meters			
RF Neighborhoods	13.36%	20.98%	3.02%
Forest Islands	13.58%	—	—

This table provides the percentages that reflect the results of Table 1. These percentages are the results of raised field neighborhoods in relation to forest islands and rivers, as well as the results of forest islands in relation to rivers. The neighborhoods selected are out of a total of 6,632 neighborhoods and the forest islands selected are out of a total of 574 forest islands.

Table 3: Forest Islands Statistics

Forest Islands Statistics		
	From Rivers	Area (km²)
700 meters	52	2.881
More than 700 meters	522	
1,000 meters	78	4.515
More than 1,000 meters	496	

This table provides the statistics of forest islands from the analysis. It includes the amount of forest islands found within 700 m and 1,000 m from rivers, as well as how many are found at more than each of these distances. The table also includes the land area covered by these forest islands at each threshold distance. These results are out of a total of 574 forest islands, with a total area of 29.29 km².

Table 4: Raised Field Neighborhoods Statistics

Raised Field Neighborhoods Statistics			
	From Rivers	From Forest Islands	From Both
700 meters	583	1,026	104
More than 700 meters	6,056	5,613	6,535
1,000 meters	887	1,393	201
More than 1,000 meters	5,752	5,246	6,438

This table provides the statistics of raised field neighborhoods from the analysis. It includes the amount of neighborhoods found within 700 m and 1,000 m from forest islands, rivers, and both features. Additionally, the number of neighborhoods found at more than each of these distances is included. These results are out of a total of 6,639 raised field neighborhoods.

Table 5: Raised Field Neighborhoods Area

Raised Field Neighborhoods Area	
	Area (km^2)
700 m from rivers	33.272
700 m from forest islands	57.988
700 m from both	15.360
1,000 m from rivers	46.135
1,000 m from forest islands	71.888
1,000 m from both	24.825

This table provides the area in square kilometers covered by neighborhoods selected according to each threshold distance in relation to rivers and forest islands. The overall area that the raised field neighborhoods cover in the study area is 192.155 km^2.

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