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TRIBAL CAPACITY FOR CLIMATE CHANGE ADAPTATION:
Identifying the Impact of Fractionated Land for a Coastal Community

MELISSA K. WATKINSON

Advisor: Dr. Santiago Lopez
Second Reader: Dr. Nives Dolšak

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University of Washington Bothell

Abstract

Coastal Washington tribes are experiencing loss of land due to sea level rise (SLR), flooding, and land erosion as a result of global climate change. However, consolidating fractionated lands through the Land Buy Back (LBB) program may build the capacity for tribal governments to make decisions regarding adaptation to the loss of land. This study used a case study research design to address one primary research question: (1) How can consolidating fractionated land through the LBB program increase the Quinault Indian Nation (QIN) tribal government's capacity to adapt to the impacts caused by climate change?; and one community identified needs question: (2) What is the least costly emergency evacuation route for the QIN community, and how is this route affected by fractionated land? Using secondary spatial data, a spatial analysis was conducted to identify the extent to which land that is suitable for future development on the Quinault reservation is fractionated, where suitability is defined as areas that (a) are outside of climate change vulnerability to SLR and flooding, (b) has a slope degree of 20 or less, and (c) lie outside of cultural lands identified by the community as inappropriate for disturbance. An additional analysis was conducted, using the same criteria, to identify the most cost-effective emergency evacuation route. Lastly, this study interviewed QIN experts to find how the results of the spatial analyses can enable QIN to make decisions about climate change adaptation. Consolidating fractionated land through the LBB program can increase the adaptive capacity for tribes impacted by climate change. Additional funding and similar consolidation programs should further be made available to tribes that have fractionated land on their reservations and who are vulnerable to climate change impacts.

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1 Introduction

The greatest risks of climate change impacts in Washington State are land erosion and flooding caused by an increase in extreme weather events and variation (Cordalis & Saugee, 2008; and Mote & Salathe, 2010). Specific to Washington's coasts, sea level rise (SLR) has been an observed impact, is projected to increase up to 43 inches by 2100 (Mote, Peterson, Reeder, Shipman, & Binder, 2008), and can result in a loss of land (Huppert, Moore, & Dyson, 2009). This projection is higher than the global mean SLR projection of up to 23 inches used by the Intergovernmental Panel on Climate Change (IPCC) (Nicholls et al., 2007). American Indian tribal nations with coastal settlements are faced with additional hazards as a result of climate change, particularly because of their relationship and traditional dependence with the land and their natural resources. Additionally, the limitation of tribal sovereignty to reservation lands restricts a tribal nation's adaptive capacity. When tribes become displaced or experience a loss of land due to the impacts of climate change, they may struggle to demonstrate their sovereignty in the decision processes for adaptation and resettlement because of their limited relocation options.

This paper examines how the Quinault Indian Nation (QIN), an American Indian tribal nation along the coast of Washington State, can increase their adaptive capacity to address climate change vulnerabilities by reacquiring tribal land through a fractionated land consolidation program such as the Land Buy Back (LBB) program. The primary research question for this study is: How can consolidating fractionated land through the LBB program increase QIN's tribal government capacity to adapt to the impacts caused by climate change? A second research question was identified by the QIN Department of Natural Resources (QDNR) as a strategy for disaster risk reduction: What is the least costly emergency evacuation route for the QIN community, and how is this route affected by fractionated land? I will begin by providing background information and definitions of critical concepts within this study, followed by a summary of literature that addresses risks and vulnerabilities of climate change, the existing barriers for implementing adaptation strategies, and how American Indians are uniquely affected. I will then explain how this study fills gaps in the literature. Following, I will give a discussion of the data sources and analytical methods, followed by a description of the study findings. Finally, I will give a discussion of the results, explore alternate explanations of the findings, and provide policy recommendations, and will conclude with suggestions for future research.

1.1 Background and Definitions

Coastal communities who are affected by climate change impacts may relocate as a climate change adaptation strategy (Krishnamurthy, Fisher, & Johnson, 2010). For American Indian nations, relocation could occur by moving inland on the reservation. The selection for an area of relocation would rely on the tribe's individual land use needs, which might include areas for commercial and residential uses, agriculture or other production, and cultural and spiritual practices. However, the historical allotment of land as a result of the 1887 Dawes Act, also known as the General Allotment Act, put all land that was previously in tribal trust into a new land classification, individual trust land, for tribal members. This process began on the Quinault reservation in 1907 when all "fish eating" Indians were given, on average, an 80 acre parcel of land (Allottees Association and Affiliated Tribes and Bands of the Quinault Reservation, n.d.). After the death of each owner, the land is fractionated to his or her heirs and this process continues unless the land is gifted, it is designated to one heir within an owners will, or it is sold to the tribe to put back as tribal trust land. Ultimately, tribal reservations are left with hundreds, to thousands of fractionated acres of land that are not owned or governed by the tribe (Indian Land Tenure Foundation, 2015). Tribal nation governments cannot utilize, manage, or pursue social or economic development and infrastructure on land parcels within their reservation unless they are owned by the tribe or are within the tribal trust land classification (Connor, 2014). Consolidating fractionated land may be a critical step toward addressing the social and economic opportunities for tribes, and most significantly, to plan for long-term climate change adaptation and the immediate need for identifying an emergency evacuation route.

The LBB program, managed by the Bureau of Indian Affairs (BIA), is an effort on behalf of the United States federal government to restore tribal homelands by facilitating the acquisition of fractionated lands (Connor, 2014). The program is a result of the Cobell Settlement, which has \$1.9 billion set aside for federally recognized tribes to consolidate allotted lands on their reservations that are highly fractionated (Connor, 2014). While tribes themselves determine which land parcels should be prioritized to purchase through the LBB program, the BIA facilitates the purchase of these lands. Once the tribe identifies which fractionated land parcels are prioritized, the BIA will contact the owners who have interest on the parcel, ask if they will voluntarily sell at fair market value, and then facilitate the purchase of the land parcel (anonymous interviewees, personal communication, April 13, 2015). Many individual

descendants of tribal members who have an interest (fraction) within these allotted lands have a desire to keep it, either because they have a connection to the family members who once owned it or because they themselves have developed the land, and may not volunteer to sell it (anonymous interviewees, personal communication, April 13, 2015). Though many others do not have this same sentiment to the land, and may not even be aware of their ownership (anonymous interviewees, personal communication, April 13, 2015). Consolidating fractionated land from voluntary sellers through the LBB program may provide tribes an opportunity to address limitations regarding climate change adaptation.

1.1.1 Vulnerability, risk, and adaptive capacity. Risks are “the potential for an unwanted outcome resulting from an event... [and are] determined by the product of (a) the likelihood of the impact and (b) the consequence of the impact” (Adapting to Rising Tides, 2011). This study identifies the potential impacts of climate change (SLR, flooding, and land erosion) as risks associated for the QIN community that create the need for adapting to climate change. Additionally, the risk of a tsunami is the cause for identifying an emergency evacuation route. The IPCC defines vulnerability to climate change as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes” (Nicholls et al., 2007). This study addresses climate change vulnerability for QIN in both research questions by analyzing how susceptible they are to the impacts of SLR and flooding (see CC map model in methods section).

I used the “Adaptive Capacity” framework (Berger, Ensor, Wilson, Phukan, & Dasgupta, 2014; and McNeeley, 2012) to identify the impact of consolidating fractioned land on the capacity to adapt to climate change in a resilient challenged century. This framework is based on the linkages of vulnerability and resilience and how well a community can adjust to anticipated impacts of climate change (Berger et al., 2014). I define adaptive capacity for this study as the capacity, measured by the level of ability to address a phenomenon, for QIN to adapt to climate change risks and vulnerabilities. In this study, loss of land is the adverse effect that is vulnerable to climate change, safety of the community is the concern resulting from the risk of tsunamis, and the tribal community is the entity that requires capacity to adapt. Berger and colleagues (2014) have suggested that the “institutions and networks of relationships that determine the nature of achievable change” are a focus of adaptive capacity. The LBB program and its facilitators, the BIA, then, can represent a critical part in the adaptive capacity of QIN.

1.2 Literature Review

This research builds on the concepts of tribal coastal vulnerability and the need for resources that enable tribal governments to enhance their adaptive capacity in relocation processes. Existing literature explains that local and state agencies are beginning to create adaptation plans and policies that affect their communities, and engaging tribes in the decision-making processes can contribute to evaluating the impacts of, and their vulnerability to climate change (Gorokhovich, Leiserowitz, & Dugan, 2014; Huppert et al., 2009; and Montag et al., 2014). However, tribes will continue to experience spatial limitations in adaptation approaches (Cordalis & Saugee, 2008; and Thom, 2009). Additionally, the sovereign status of American Indian nations and their resulting land rights allow them to make claims about the environment that surrounds them (Flanders, 1998; Gross, 1978; Riley, 2013; Ranco & Saugee, 2007; and Whyte, 2013). The literature suggests that tribal nations are becoming forced to relocate their communities to be less vulnerable to the impacts of climate change, and that integrating relocation resources and planning principles in these processes is critical (Maldonado, Shearer, Bronen, Peterson, & Lazrus, 2013; Paton & Fairbairn-Dunlop, 2010; and Whyte, 2013).

1.2.1 Climate change vulnerability. American Indians are not only vulnerable to a loss of land as a result of climate change, but also to a loss of cultural and traditional places and practices. Montag and colleagues (2014) determined that cultural, familial, and traditional knowledge aspects are affected by climate change impacts because of the shift in natural resources that these aspects are dependent on. It is critical to incorporate these aspects when conducting research or making decisions that may impact tribal communities (Climate and Traditional Knowledges Workgroup [CTKW], (2014); and Whyte, 2013). Gorokhovich et al. (2014) incorporated these aspects in their research relating to tribal communities affected by climate change. They utilized geographic information systems (GIS) tools in their analyses to find community vulnerabilities of different climate-related impacts within their case studies, such as the loss of subsistence resources and other natural resources. I adapted their model by using a GIS framework to analyze climate change vulnerability to loss of land. Specifically, I conducted a land suitability spatial analysis was conducted to identify potential areas on the reservation that may be most suitable for future commercial and residential development, and to find how these areas are impacted by fractionated land. To incorporate the tribal value aspects identified by Montag et al. (2014), the analyses considered a cultural site identified by tribal members.

1.2.2 Barriers to adaptation. Communities adapt to situations differently depending on their level of vulnerabilities and the resources they have to address them. Scholars have provided valuable insights into the resources needed by stakeholders at multiple levels for such relocation efforts. Maldonado and colleagues (2013) used three case studies of coastal tribes that are experiencing climate-induced forced relocation to find how they adapt to climate change when few relocation mechanisms exist. The authors expressed that no US federal government agency is mandated to manage relocation efforts, and that few funding options exist to support such an adaptation strategy. Their findings is the impetus for developing this research study, particularly because it seeks to suggest that the LBB program, funded and managed by a US federal government agency through the BIA, can be used as a mechanism to adapt to the impacts of climate change through relocation. Additionally, Paton and Fairbairn-Dunlop's (2010) found through their study with Tuvaluans that adaptation to climate change through relocation would be most effective through an investment in relocation mechanisms, new technologies for communication, and to engage the affected community in climate change discussions. Cordalis and Saugee (2008) suggested that a government implemented program to support tribal relocation might include the consolidation of tribal lands. The LBB program supports such efforts by consolidating fractionated lands on reservations into tribal trust, which would grant tribes the right to govern and manage the land on their reservations. It is evident that many tribes are experiencing the need for relocation, and it is possible that relocating within the reservation will increase these options if consolidating fractionated lands can reduce barriers to adaptation.

1.2.3 Sovereignty and self-determination. Gross (1978) defined sovereignty as people with self-governing powers over their own territory, which must be recognized by the world community. The sovereign status and federal government trust obligations to American Indian tribal nations grant the inherent rights to self-determination and self-governance for each federally recognized tribe (Flanders, 1998; Ranco & Saugee, 2007; and Riley, 2013). Additionally, tribes are afforded the opportunity to make policies and govern their land and natural resources to suit their cultural practices and economic endeavors because of their federally recognized sovereignty (Ranco & Saugee 2007). However, tribal nations are still under the US federal jurisdiction, restricting these rights to their reservation boundaries (Flanders, 1998; Riley, 2013; and Thom, 2009). Further, these rights are only available to tribes when land is owned by the tribe or under tribal trust land classification.

The use of tribal sovereignty to make claims about their communities, how their land is used, and how the environment and natural resources around them should be governed is necessary to empower the tribe in its opportunities to adapt to the loss of land caused by climate change (Coombes, Johnson, & Howitt, 2012; Gross, 1978; and Ranco & Suagee, 2007). Yet, tribal nations have spatial limitations when addressing their land use planning for relocation needs. Fulfilling this self-determination depends on the federal government's ability and willingness to provide access to funding and to honor the trust obligation (Gross, 1978; and Ranco & Suagee, 2007). It is necessary for the US to honor their governmental relationship by facilitating the acquisition of allotted, and now fractionated, lands through the LBB program to ensure that tribes can practice full sovereignty over the lands and resources within their reservation borders.

Review of the literature suggests that coastal tribes are experiencing the loss of land due to their vulnerability to climate change impacts. Ultimately, tribes need to consider relocation efforts for adaptation, and must consider the spatial limitation of exercising their sovereignty within their reservation boundaries. Notions of consolidation of lands in relation to climate change may be used in planning for climate change adaptation because of the severe impacts and climate risks that coastal tribal communities face. Tribes have the ability to exercise sovereignty over environmental claims and land use planning, but little federal support is provided in the process of relocation. However, acquiring land that lies within the reservation, and placing it within the governance of the tribe, such as the process of purchasing fractionated land on tribal reservations, may provide more options for relocation within the reservation while maintaining autonomy for the tribe. Using participatory methods and GIS tools to determine if the LBB program can enhance a tribe's ability to adapt to climate change by consolidating fractionated lands outside of vulnerable areas is necessary to determine if this strategy will improve tribal adaptive capacity.

2 Data and Methodology

2.1 Research Questions

This study sought to answer two research questions. The first is a primary research question to address adaptive capacity, and includes a necessary follow up question to identify the impact of fractionated land on adaptation; the second question addresses an immediate need identified by the QIN community:

1. How can consolidating fractionated land through the LBB program increase the QIN tribal government's capacity to adapt to the impacts caused by climate change?
 - a. How does fractionated land affect the availability of suitable land for future development?
2. What is the least costly emergency evacuation route for the QIN community, and how is this route affected by fractionated land?

These questions address risks and vulnerabilities related to climate change for QIN. The first is related to a general concept of climate change adaptation, the second is primarily concerned with disaster risk reduction. Integrating climate change adaptation and disaster risk reduction can be beneficial because it allows for an opportunity to “manage risks and opportunities holistically”, and because both risks are addressed by the same local government, and each is concerned with the “protection of lives, livelihoods, and assets” (Wisner et al., 2014). A land suitability analysis (Model 1) was designed to answer the primary research question, and a least-cost route analysis (Model 2), was designed to answer the community needs research question.

2.2 Research Design

This study used a single place-based-case study research design with QIN as the unit of analysis. Criteria for selecting a case included (1) the tribal reservation was on the coast of Washington state, (2) was experiencing immediate climate change impacts and, as a result, had intent to relocate their community, (3) had fractionated parcels of allotted land eligible to be purchased through the LBB program, (4) the tribe was willing to collaborate on this study, and (5) access to data was available. Justification for selecting QIN as the case for this study is provided in the Study Area and Subjects section of this chapter. Case study designs have been utilized extensively among other scholars of climate change in indigenous communities (Cordalis & Saugee, 2008; Maldonado et al., 2013; McNeeley, 2012; Montag et al., 2014). Because there are over 500 federally recognized tribes, each with its own policies on collecting

and accessing data in their community, and because such research requires careful attention and collaboration with the tribe, other research designs may not be appropriate for this research. This case study was explanatory to determine how consolidating fractionated land through the LBB program can impact the capacity for making decisions about climate-induced relocation efforts. It also relied on a holistic perspective of the community to determine if other factors might be relevant in relocation efforts, as it explored other potential land-based and community limitations to climate change adaptation through literature and interviews. DeVaus (2001) determined that case study designs have challenges of external validity; however, case studies typically do not seek to be generalizable. Additionally, case studies that use a strategic selection of cases have an enhanced external validity over statistically selected cases (DeVaus, 2001). Internal validity concerns may arise in this study if other key variables that may impact the observed changes are overlooked in the data collection and analysis processes.

I used mixed-methods for data collection and analyses to address the primary and secondary research questions. First, I collected spatial data and analyzed them for the purpose of identifying the impact of fractionated land for both research questions. Longley, Goodchild, Maguire, and Rhind (2011) have defined spatial analysis as a process that transforms raw spatial data into information that can be used for “more effective decision making.” The aim of these spatial analyses was to support climate-related decision making by the QIN tribal government. Second, expert interviews were conducted to collect primary qualitative data used to supplement the results of the spatial analyses and to identify other variables that might be present in the support or limitation of tribal adaptation. Huppert et al. (2009) and Paton & Fairbairn-Dunlop (2010) have used interviews for additional qualitative data collection in their case study research to answer community climate change-related questions.

2.2.1 Participatory research. I partnered with the QDNR to incorporate participatory research methods. The primary goal of creating this partnership was to ensure best practices of: 1) addressing community identified needs, 2) having results useful for making decisions by the tribe, and 3) incorporating other ethical considerations. Participatory approaches can be a useful method for working with communities to identify strategies that may have direct implementation, and to support decisions related to climate change adaptation. Further, participatory research practices with tribal communities is recommended by scholars and professionals, who argue additional principles should be implemented when research with tribal

communities incorporates climate change issues. For example, The CTKW (2014) created a set of guidelines for incorporating multiple knowledge systems, including how to communicate, train, and acknowledge sovereignty of tribal traditional knowledges in climate change initiatives. The identification and examination of these principles are critical steps when building relationships for participatory research with tribal communities facing climate change impacts.

The partnership began after I presented the draft proposal of this study to the QDNR Climate Change Committee. At this meeting, feedback was given and a community need (an emergency evacuation route) was identified to incorporate into this research. Following, I presented a final proposal to QDNR who approved that such a collaboration would be useful for the tribe and its planning purposes. Our second meeting was held to address data needs and access. A Data Storage and Confidentiality Statement (Appendix 1) and Study Consent Form (Appendix 2) was drafted to be incorporated into a non-disclosure agreement (NDA). After presenting to the Quinault Business Committee (the tribe's governing body), the NDA was approved for this study to receive secondary spatial data and to conduct interviews with tribal members and leaders. From the inception of the partnership with the QDNR, communication was necessary to ensure that the study accurately addressed community needs and QDNR requests, and that the study had the essential data for addressing the research questions.

2.3 Study Area and Subjects

The Quinault reservation is located along the central coast of Washington State, primarily within Grays Harbor County, and in the southwest corner of the Olympic Peninsula. It has an area of over 200,000 acres and its land encompasses forests, rivers, lakes, and 23 miles of Pacific coastline (Official site of the Quinault Indian Nation, 2015). The Köppen-Geiger classification, the most frequently used climate classification, identifies QIN as a "Cfb" region, which has a "marine west coast climate" with its typical climate characteristics consisting of a warm temperature, and is fully humid with warm summers (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006). The primary community settlement with a population of 500 is in the Lower Village of Taholah, which has experienced an increase in flooding and coastal erosion (Walker, 2014). Taholah is a Census Designated Place that lies along the coast of the Pacific and at the mouth of the Quinault River, with elevation ranging between seven and 21 feet above sea level (Walker, 2014). In addition to climate change impacts, the Taholah community is concerned with the potential risk of a tsunami (Montreuil, 2014).

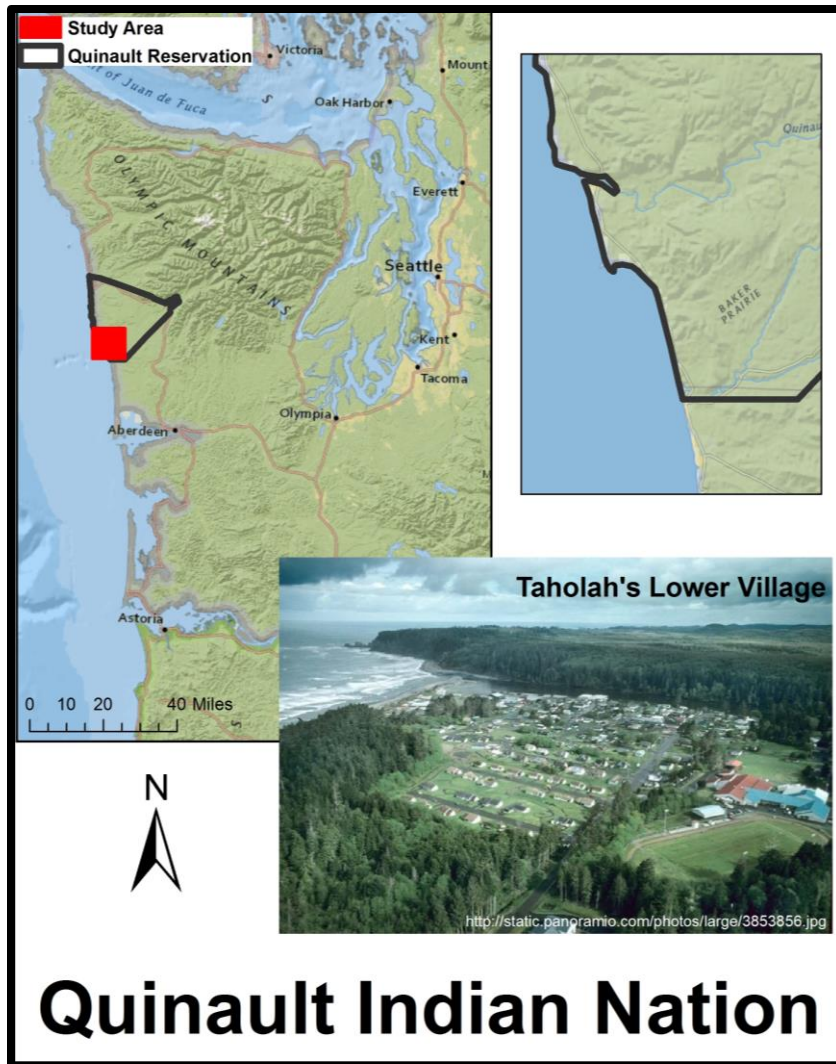


Figure 1 - Quinault Indian Nation and Study Area

of all QIN trust land, is fractionated with two or more owners (Dickson, 2013). Other coastal tribes in Washington State met a majority of the selection criteria, including the Quileute and Hoh tribes who each have reservations along the coast, are experiencing immediate climate change impacts and have made plans to relocate or have relocated (Winters, 2014). However, the QIN has a high proportion of its land in fractionated allotments and, therefore, was identified as the ideal case for this study. Other considerations that made QIN an ideal case was that at the start of this study the QIN was still deciding its relocation area and news about their participation in the LBB program had just begun. The timing of this study aligned well with QIN needs and intentions. As a result, the partnership that developed was created in hopes that this study would have a direct supportive impact in the tribe’s decision making processes regarding climate change adaptation, consolidation of fractionated lands, and the LBB program.

QIN (figure 1) met all of the case selection criteria. Because of the immediate climate change impacts and the risk of a tsunami, the QIN government and its agencies are developing plans to relocate the community of the Lower Village of Taholah to the “Upper Village”, which is just southeast of the current location (inland from the coast and south of the river) and at an elevation of at least 120 feet above sea level (Montreuil, 2014). Finally, QIN also has a high proportion of fractionated land on the reservation. Over 1,400 parcels, or nearly 68%

2.4 Data Sources and Analyses

I created two spatial analysis models to address the research questions. Model 1 was used to answer the primary research question and analyzed the impact of fractionated land on climate change adaptation strategies of relocation or long-term community development. Model 2 was used to answer the community needs question, and analyzed the least-cost evacuation route and identified the impact of fractionated land on each proposed route. I used ArcGIS software (version 10.2.2, Esri 2014) to store, manage, and analyze the spatial data, and to create the final maps presented in the results section of this study. All analyses were done only for the southwest quadrant of the Quinault reservation, primarily because this is where the current community currently resides and where they plan to relocate, and due to the availability of data. Each model will be described individually in detail below, and the analysis of the qualitative data will be described at the end of this section.

2.4.1 Model 1: Land suitability analysis. The first model was created to identify how fractionated land affects the availability of suitable land for future development. This is necessary to answer first to be able to identify the impact of fractionated land on the tribal government's adaptive capacity. The adaptation strategy observed in this model is relocation on the reservation, where "suitable lands or future development" are areas that may be suitable for relocation. This study defines suitable land for future development as land that (1) is outside of climate change vulnerability to SLR and flooding, (2) has a slope degree of 20 or less, and (3) does not interfere with Baker Prairie as it is inappropriate for disturbance.

I used secondary data from three sources to conduct the land suitability analysis. First, I received a digital elevation model (DEM) from the United States Geological Survey website for Grays Harbor County. The DEM served as the primary spatial data to create the climate change vulnerability and slope layers. Second, I used a QIN reservation shapefile from the Census Topographically Integrated Geographic Encoding and Referencing American Indian Geography data files to clip all spatial layers to the QIN reservation. Lastly, spatial vector data was provided from the QDNR of features on the Quinault reservation, including: (1) a polygon feature of the 100 year floodplain of the Quinault River, (2) polygon features of the reservation's land parcels, which were classified as either fee land, Quinault owned land, or individual trust land (fractionated parcels), and (3) a polygon of Baker Prairie to represent a cultural feature (Baker Prairie is a wetland with traditional and subsistence significance to the tribe).

Model 1 was accomplished by creating a Land Suitability Index. Multi-criteria evaluations (MCE) were used to develop a climate change vulnerability map (CC Map) and to weight the spatial data layers for the Land Suitability Index. MCE's are conceptual frameworks of models that incorporate a number of factors that might influence a phenomenon, and the "combined impact of all of the factors is obtained by weighting and adding them" (Longley et al., 2011). The first step in creating the Land Suitability Index was to develop the CC Map (figure 2). I derived the CC Map using a MCE approach.

The MCE model for the CC Map is defined as:

$$CC\ Map = SN*0.7 + SLR*0.3$$

Where: *CC Map = Climate change vulnerability raster*

SN = distance thresholds from stream network

SLR = reclassified elevation values based on sea level rise projections

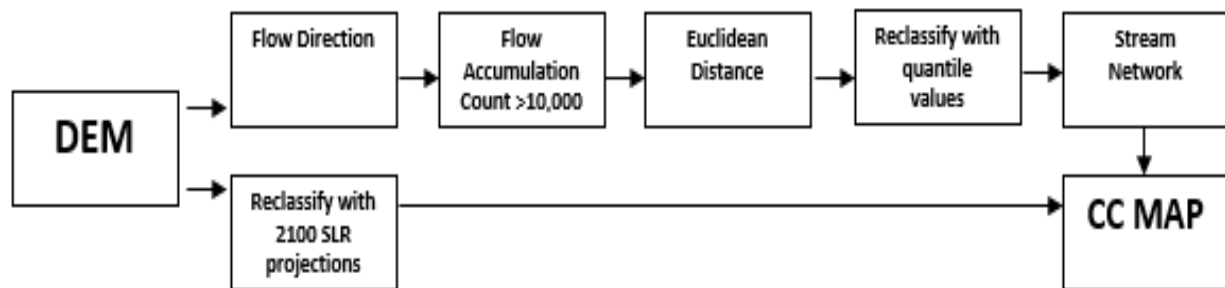


Figure 2 – Model for creating CC Map

This map used the DEM to incorporate the impacts of SLR and flooding. Because this model is concerned with long term development planning and climate change is a slow-progressing phenomenon, SLR projections from Mote and colleagues for the year 2100 were used. They projected that by 2100, sea levels in the central coast of Washington can rise by 2 inches (very low estimate) to 43 inches (very high estimate) (Mote et al., 2008). These projections were used in this study because they are created based on regional factors of Washington's varying coasts, including:

“(1) global SLR driven by the thermal expansion of the ocean; (2) global SLR driven by the melting of land-based ice; (3) local dynamical SLR driven by changes in wind, which push coastal waters toward or away from shore; and (4) local dynamical SLR driven by local movement of the land itself, due primarily to tectonic forces” (Mote et al., 2008).

Elevation (m)	SLR Value
1.0922	10
40.587855	9
62.726685	8
81.175709	7
95.934929	6
110.694149	5
129.143174	4
162.351419	3
361.600888	2
937.210464	1

Table 1- DEM reclassification to SLR

The DEM was reclassified by giving the projected 43 inches of SLR, converted into meters, the highest value (10) because these areas are more vulnerable to SLR impacts, and then reassigning the remaining quantile values between 1 and 9, where 1 represents the least vulnerable estimate. This process gave the very high SLR estimate the greatest weight, while creating a buffer throughout the remaining SLR layer. Table 1 displays the reclassification values used to create the SLR layer.

Following, a stream network was created using standard GIS functions. A Euclidean distance function was applied to the stream network and the resulting raster was reclassified in quantile units to express the range of flooding vulnerability with values 1-10. Table 2 displays the reclassification of the stream network from the Euclidean distance (distance from streams).

Old Values (m)	New Values
60.192253	10
123.117416	9
192.2771	8
266.565674	7
346.632477	6
438.543549	5
546.892334	4
683.003296	3
888.852722	2
7353.039063	1

Table 2 - Euclidean distance reclassification to stream network

Finally, the reclassified stream network and the SLR 2100 raster were combined to create a climate change vulnerability map. Because flooding and tsunamis are more immediate risks for QIN, the stream network raster was given a higher weight. Figure 3 displays the resulting CC Map for the southwest quadrant of QIN.

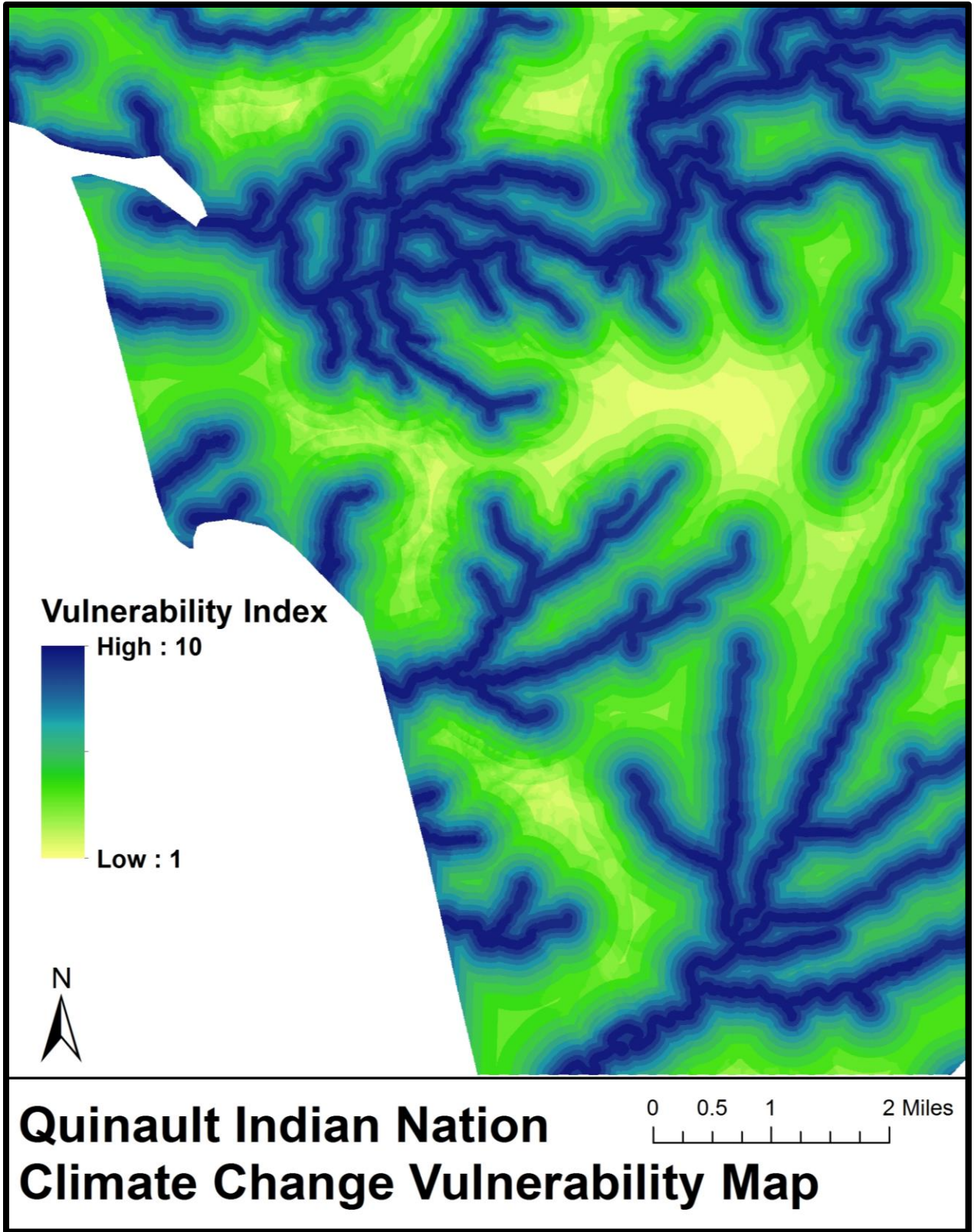


Figure 3 - CC Map

Lastly, an MCE was applied to create the Land Suitability Index.

The MCE is defined as follows:

$$LSI = (CC\ Map^{-1} * 10) * 0.6 + Slope * 0.2 + Floodplain * 0.2$$

Where *LSI* = Land suitability index raster

CC Map⁻¹ = reciprocal climate change vulnerability map (the reason for multiplying this reciprocal by 10 is to maintain a reclassified raster ranging from 1 to 10, not from 0.1 to 1)

Floodplain = 100 year floodplain of the Quinault River

Slope = is a reclassified map based on slopes (i.e. slope degrees between 0 and 2 were reclassified to 10, degrees between 2 and 6 were reclassified to 8, degrees between 6 and 20 were reclassified to 5, and slope degrees higher than 20 were reclassified to 1).

The Baker Prairie was added with a value of 1 using a standard GIS conditional tool because it is not suitable for future development. Figure 4 displays the model for creating the Land Suitability Index. Final values for the Land Suitability Index (figure 5) ranged between 1 (least suitable) and 10 (most suitable). Values from this index were reclassified to create Suitability Classifications (displayed in Chapter 4) with values between 1 (not suitable) and 6 (most suitable). The Suitability Classification layer was overlaid with the fractionated lands layer and the results of these analyses with the impact of fractionated land are also displayed in the following study findings chapter.

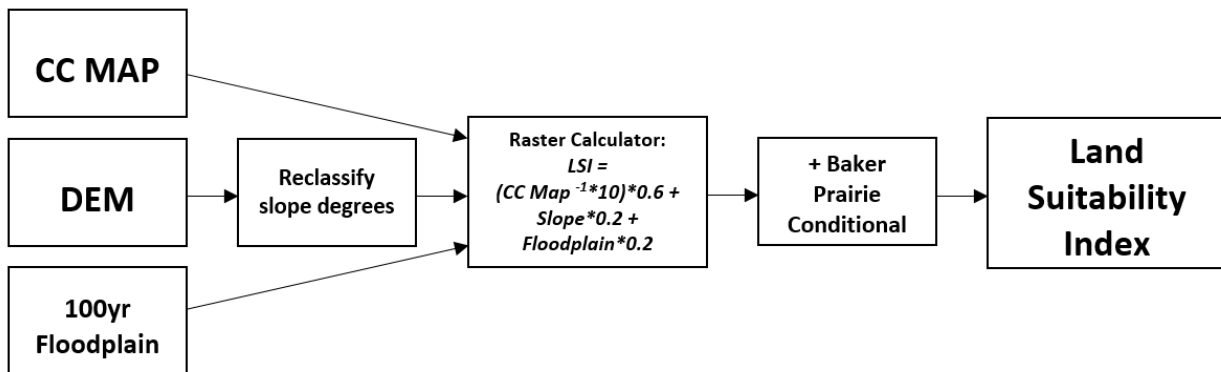


Figure 4 - Land Suitability Index Model

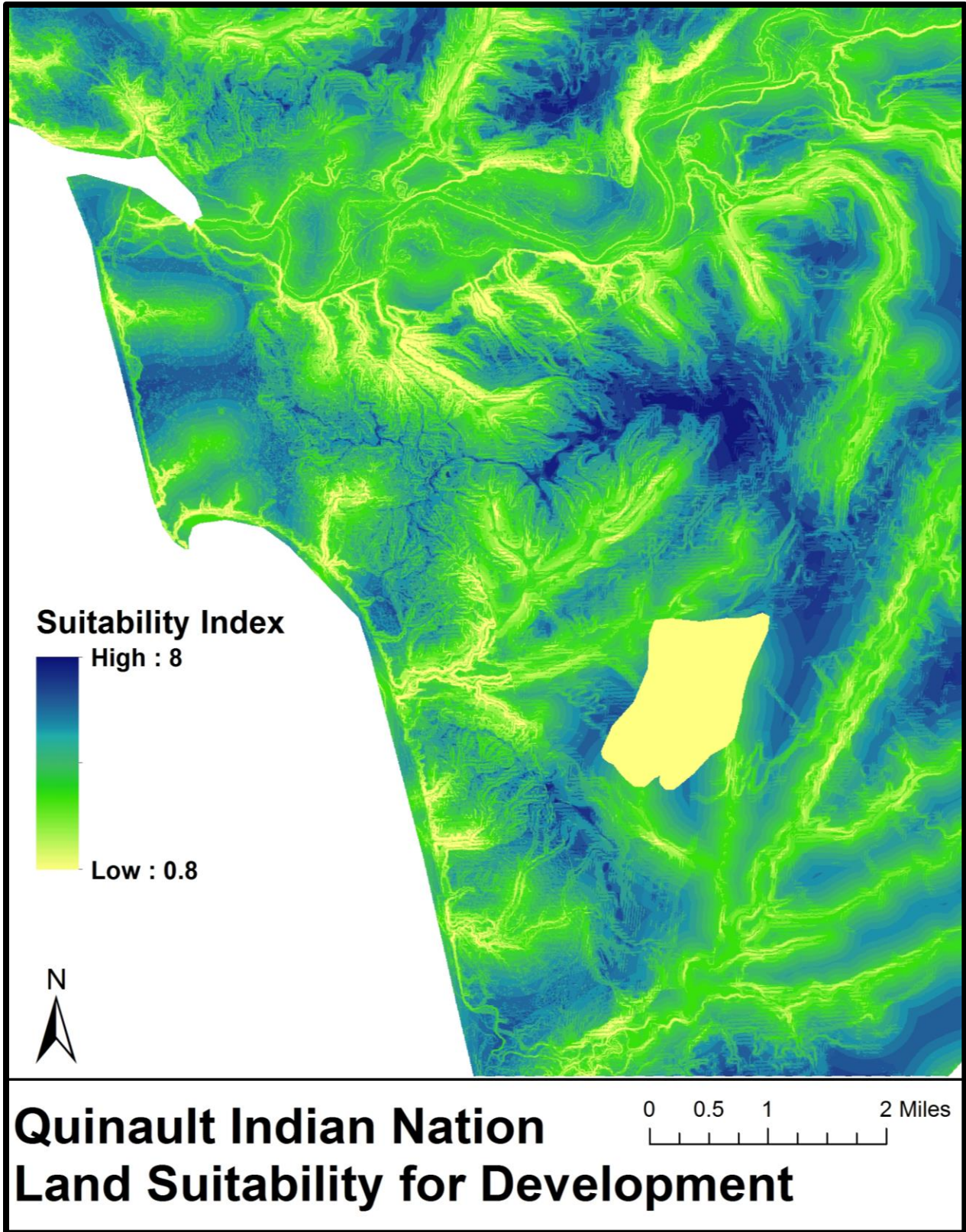


Figure 5 - Land Suitability Index

2.4.2 Model 2: Evacuation route analysis. The second model (figure 6) sought to answer the community needs question by identifying the best evacuation route for QIN. The Land Suitability Index was inverted to transform the suitability values into cost values, which was used as the cost index (displayed in figure 7) for the least-cost path analysis. Additional secondary spatial data was provided by the QDNR to conduct the evacuation route analysis: (1) polyline features of main transportation routes, and (2) polyline features of the proposed evacuation routes. The QDNR and other QIN departments will decide between the proposed routes for the development and reconstruction of a new evacuation route, but the least-cost evacuation route will provide an additional route option.

Each route shares the same source and destination. Typically, residents of Taholah would begin evacuating from Taholah, go south on State Route 109 along the coast for approximately 2.5 miles, and then head east onto McBride Road for another approximately 2.5 miles. However, parts of the McBride Road are not drivable or developed to a capacity that would be sustainable for an evacuation route. The point where the McBride Road is no longer suitable for evacuation is also the designated source for all proposed evacuation routes. This location is northwest of Baker Prairie. The rerouted or developed evacuation route would lead to Aloha Mainline, which runs from northeast of Baker Prairie to the central point just south of Baker Prairie where Aloha Mainline connects Iron Gate Road. This portion of the evacuation route is 3.3 miles from the end of Options 1 and 2, and 1.2 miles from the end of the South Option. This is the destination for all proposed evacuation routes. Aloha Mainline leads to Moclips-Olympic Highway, a main highway for Grays Harbor County. This would eventually lead east off the reservation and into Aberdeen, the nearest city to QIN. Figure 8 displays the proposed evacuation route options provided by QDNR.

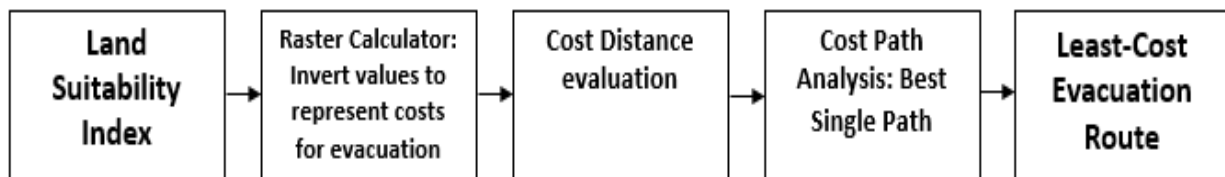


Figure 6 - Model for creating Evacuation Cost Index and Least-Cost Evacuation Route

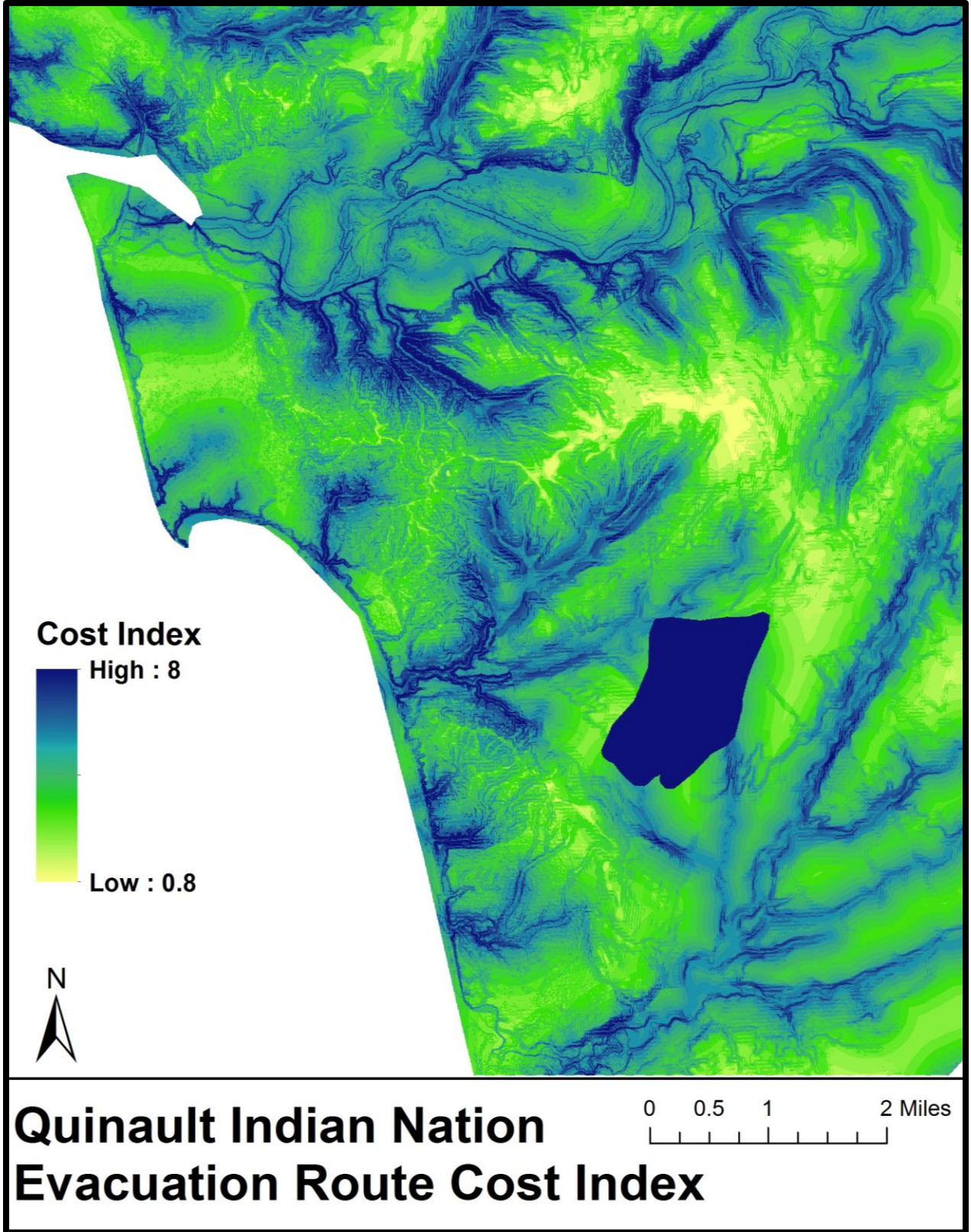


Figure 7 - Evacuation Route Cost Index

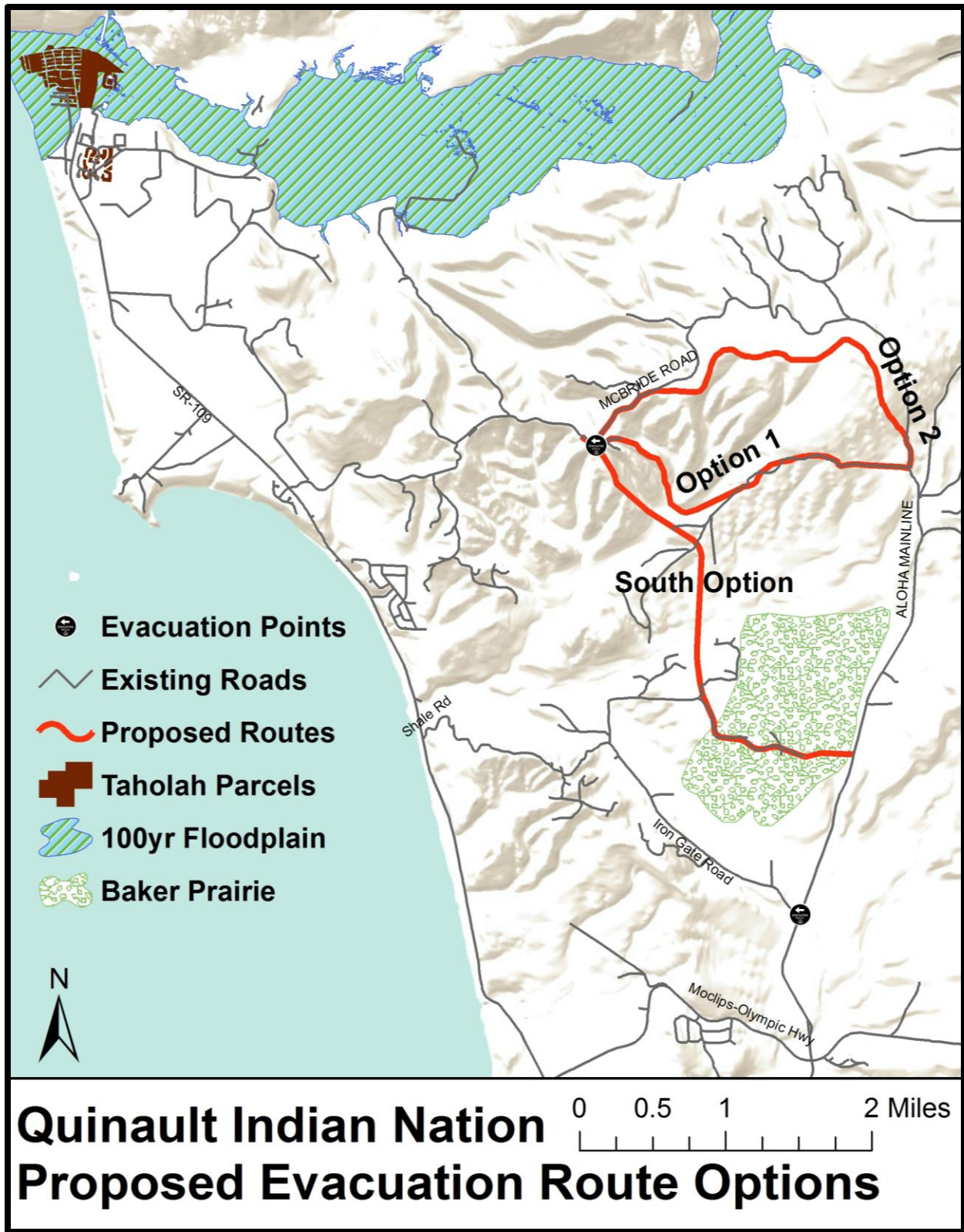


Figure 8 - Proposed evacuation route options

A least-cost path analysis was conducted to identify the best, least costly route between the source and destination (evacuation points). The purpose of this analysis was to find if there is an additional evacuation route that is more optimal when considering climate change vulnerability, slope, and flooding that may be incorporated in the options for QIN. First, cost distance was measured from the evacuation source using the evacuation route cost index, which examined the costs associated to travel to any distance within the study area from the source. Next, a cost path analysis was conducted to find the best single route from the source to the destination. The result of this analysis would provide additional criteria for QIN decision makers, and an additional potential evacuation route for the QIN community.

The final cost and distance of the least-cost path was measured to compare them to the proposed evacuation routes. Each route was overlaid onto the cost raster and the GIS mask tool was used to find the cost values associated with each of the proposed routes. Additionally, the layer of fractionated lands was laid over the proposed evacuation routes and least-cost route to identify how each route is affected by fractionated land parcels. The results of the route costs, distances, and effects of fractionated land are expressed in the study findings chapter.

2.4.3 Expert interviews. Primary qualitative data was collected through expert interviews of Quinault tribal members and agency staff. The purpose of the interviews was to supplement the results of the spatial analyses with qualitative data regarding how climate change is impacting the QIN and how consolidating fractionated land can increase the capacity to make decisions about climate change adaptation. The interview responses cumulatively led to answering each research question. Five interviews were conducted with a total of nine participants, and each interview lasted between 30 and 45 minutes. Interviewees were selected based on their role as a community member or as an employee of a Quinault agency department and were invited to participate via email using the Study Invitation Letter (Appendix 3). Interviews were conducted on the Quinault reservation at a location designated by the participant. Each interview was audio recorded and transcribed with the permission of the interviewee. An interview guide (table 3) was used to conduct semi-structured interviews, while each participant was asked questions that best suited their role with QIN. The audio records of the interviews were transcribed and analyzed by question and its application to the study. To protect the confidentiality of the interview participants, the QIN departments involved are not mentioned here. The analysis did not seek to generalize responses into codes or themes.

Table 3 – Semi-structured Interview Guide

Introductory	<ol style="list-style-type: none"> 1. How long have you lived/worked with Quinault Indian Nation? 2. What does climate change mean to you? 3. Describe the meanings of “land” and “community” in relation to QIN?*
Climate Change Vulnerability	<ol style="list-style-type: none"> 1. Do you feel that climate has changed in your region since you were a child? In the past 5 years?* 2. What do you think is the greatest climate change threat for QIN? 3. <i>~Show climate change vulnerability results</i> 4. What needs do these vulnerable lands currently meet? 5. What adaptation strategies have been used to reduce vulnerabilities to climate change at QIN?*
Barriers to Adaptation	<ol style="list-style-type: none"> 1. What existing barriers might hinder your community’s capacity to cope with or adapt to climate changes? What strategies might increase this capacity?* 2. <i>~Show land suitability analysis results</i> 3. How has fractionated land affected your work or your personal community experiences? 4. What activities and uses of land can be relocated?
Decision Making and Adaptive Capacity	<ol style="list-style-type: none"> 1. What is the process for formal decision-making and policy making in the community regarding fractionated land acquisition?* 2. What are the major planning initiatives and policies (local, regional, and federal) that will effect and influence the development of your community over the next 25-50 years?* 3. <i>~Show evacuation route analysis results</i> 4. How do you perceive your role at QIN to be related with fractionated land and/or climate change? 5. How do you believe these results will impact the capacity to make decisions about climate change adaptation strategies? 6. What else is needed to prepare your community and increase your community’s capacity to adapt?*

*Questions adapted from MacKendrick’s (2009) Interview Guide

Results of the interviews were incorporated into various sections of this study. For example, responses related to observed climate change were included in both the introduction of this study, as well as in the results and conclusion sections. Information gathered from the interviews were used to inform the study of observed climate change impacts and adaptation strategies, to clarify the processes related to fractionated land ownership and consolidation, and to identify the decision making processes that the results of the study might engage in.

3 Study Findings

The results of the analyses have the potential to have a direct impact on decision making for QIN. First, the results from each model’s analysis will be provided. Then, I will provide a summary of the expert interviews for general context based on the questions outlined in the interview guide. Further, results from the interviews will be discussed where appropriate in other portions of this section and in the discussion and conclusion chapter. Some responses also guided the information outlined in the introduction chapter, particularly because the interviews were conducted to 1) clarify factors pertinent to this study and 2) provide responses about how the results of the analyses can influence decision-making at the local and national levels.

3.1 Model 1: Land Suitability Analysis Results

The purpose for the Land Suitability model was to identify regions within the study area of the Quinault reservation that would be most suitable for the tribe to relocate to or develop plans for long-term commercial or residential uses. The Suitability Classifications map (figure 9) was created through a reclassification process of the Land Suitability Index; table 4 displays the reclassification of these values. The Suitability Classification values range between 1 (not suitable) and 6 (most suitable). Areas on the classification map in green represent areas that are not suitable for future development with low suitability values between 1 and 3, and were not further analyzed in this study. These areas reflect the Baker Prairie, Quinault River, and major streams and coastal features. Areas in blue with values between 4 and 6 represent suitable land. Figure 10 displays the combined classification values (4-6) for suitable land, and figure 11 displays them individually.

Suitability Index Values	New Classification Values
0.8-2	1
2-3.5	2
3.5-5	3
5-6	4
6-7	5
7-8	6

Table 4 – Land Suitability Index reclassification to Suitable Land Classification values

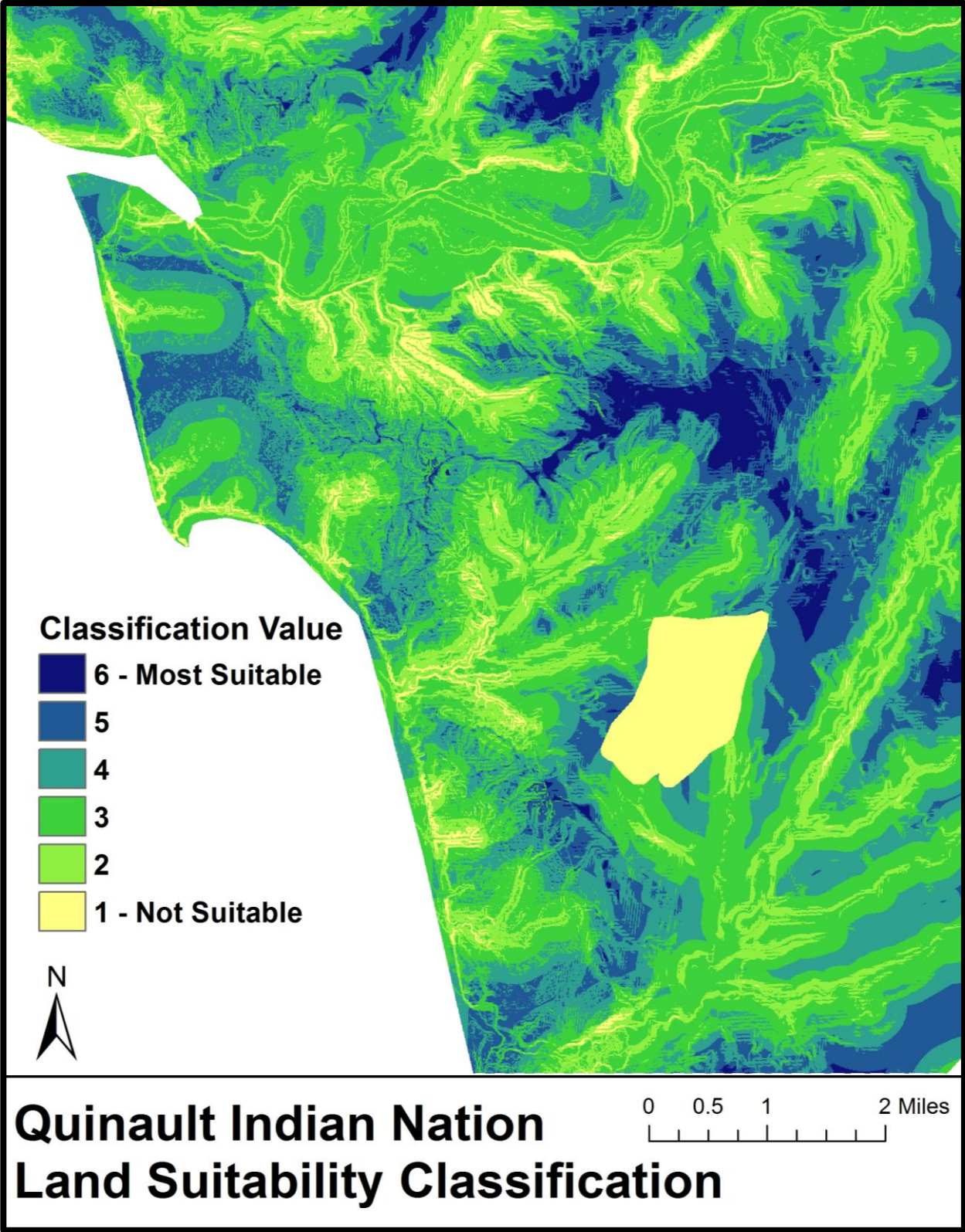


Figure 9 – Suitability Classifications

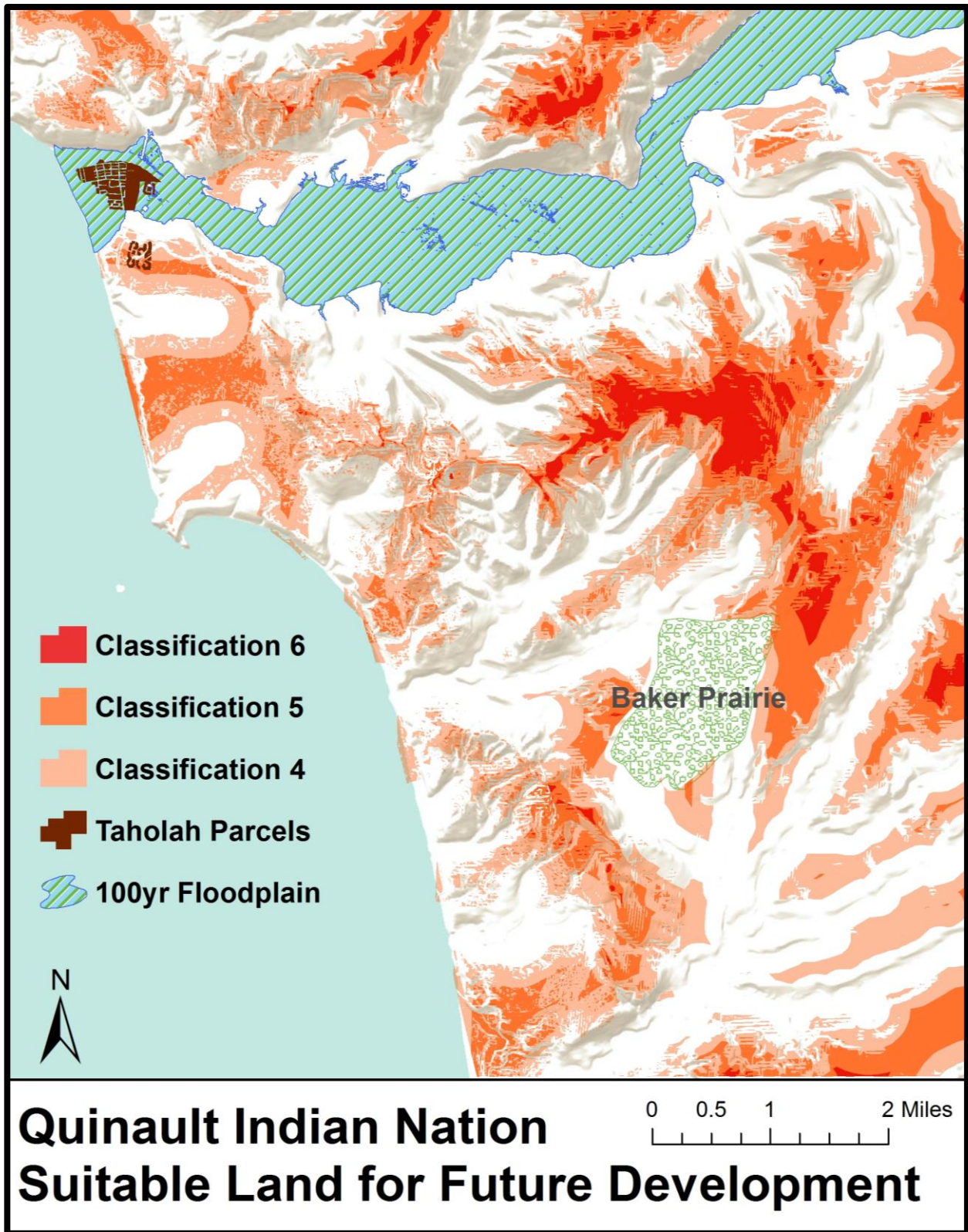


Figure 10 – Suitability Classifications 4-6 combined

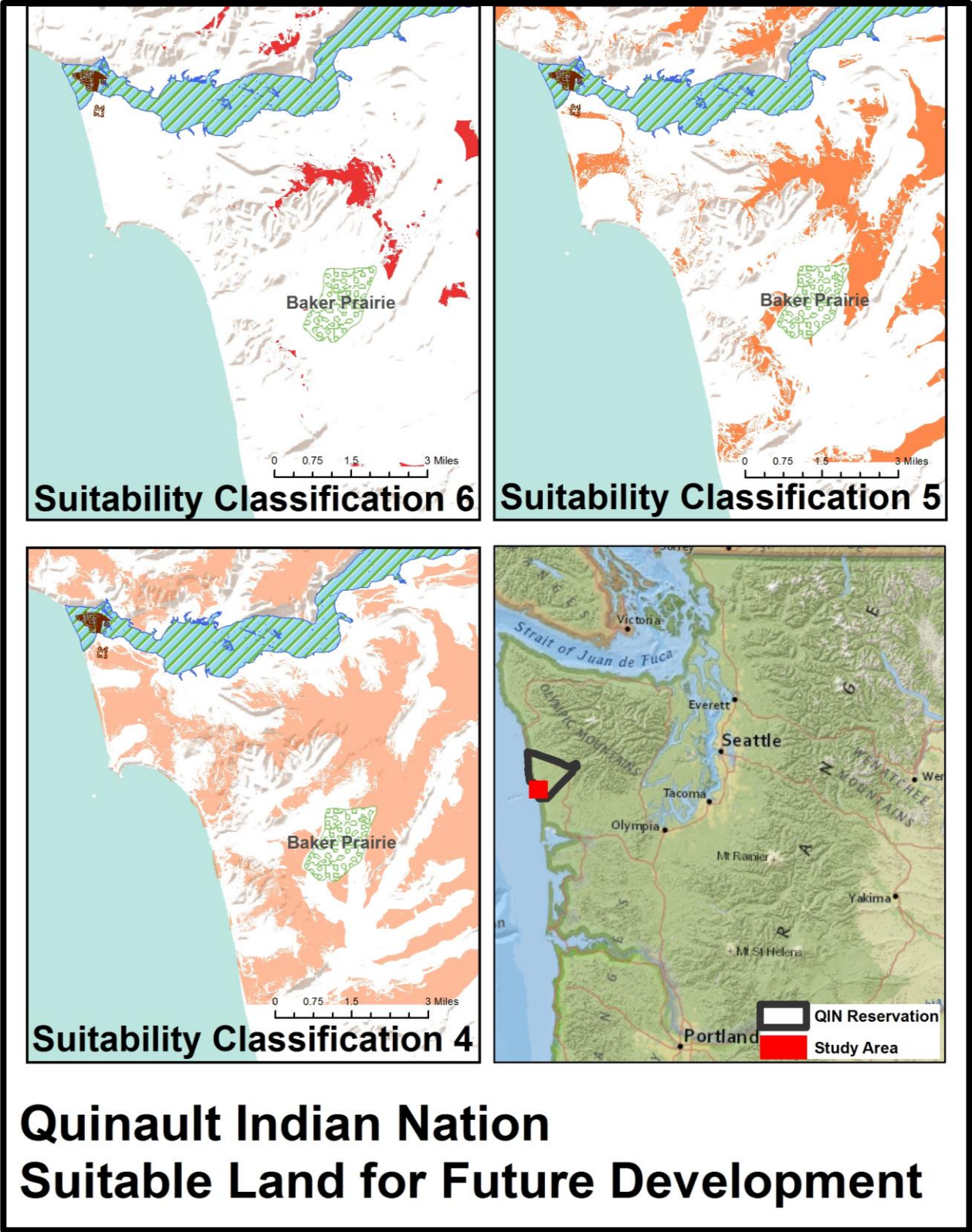


Figure 11 - Suitability Classifications 4-6 individually

Suitability Classification 6 is the most conservative land suitability estimate, with an area of 1.3 square miles. These areas are furthest away from streams, rivers, and the coastline, and are the least vulnerable to SLR and flooding. They also have minimal slopes and do not intersect with Baker Prairie. Expert interviews indicated that these areas are remote from where current communities live on the reservation, and do not currently have access to power or water. Additionally, little infrastructure exists to get to most of these areas. Taholah's Lower Village and the village relocation site in the Upper Village are not suitable in this estimate.

Suitability Classification 5 is a less conservative estimate for land suitability, and covers a total area of 7.3 square miles. Much of the Upper Village is now suitable at this estimation. Because the Lower Village is within the 100-year floodplain of the Quinault River, it will not be suitable at any estimate. While this value is a less conservative estimate for land suitability, its locations are outside of areas that have the highest vulnerability to climate change. Similar concerns regarding lack of infrastructure also pertain to most of the areas within Suitability Classification 5, however the area does extend to locations that are closer to current communities and along the coast.

Suitability Classification 4 has a total area of 19.6 square miles, or almost half of the entire study area. It is also the least conservative land suitability estimate. All of upper village is included in this estimate, and it has more areas closer to the Quinault River and the coast than the other suitable land values. This estimate is the least concerned with climate change vulnerability and slope values, but the extent of this area is still classified as suitable for the purposes of providing a range of suitability estimates. Overall, the analysis of all three suitable land values can provide multiple results and perspectives to QIN decision makers. Depending on how climate change vulnerability weighs against other critical factors, including community desires and infrastructure costs, these results can give decision makers a broad range of impacts to consider when planning for future development.

The next phase of the analysis for model 1 was to identify the impact of fractionated land on the Suitability Classification values. Figure 12 displays the Suitability Classification values of 4-6 together overlaid with the fractionated land layer, and figure 13 displays them individually. A visual observation of this set of projections led to determine that the rate of intersecting parcels of fractionated land does not increase at the same rate as suitable land.

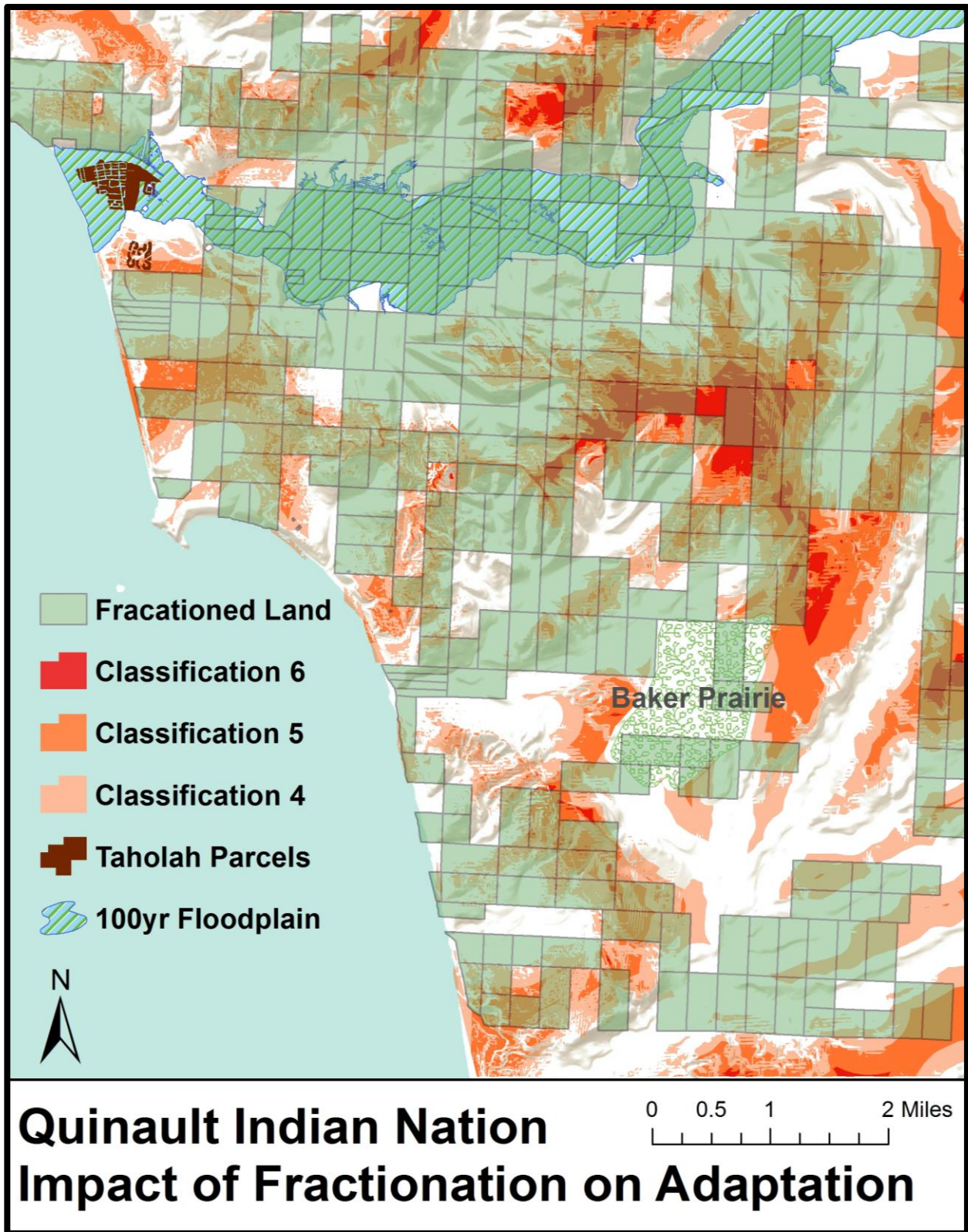
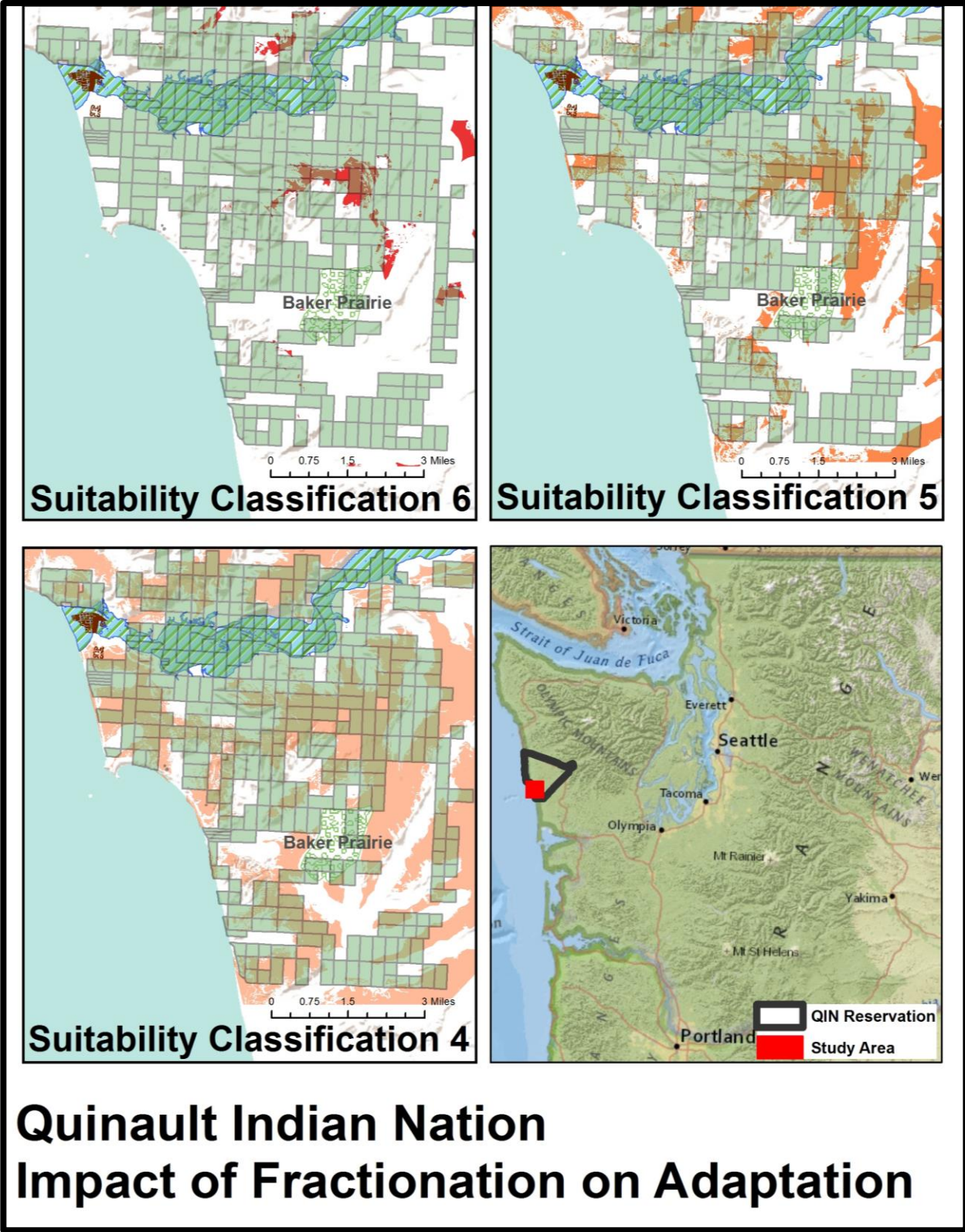


Figure 12 - Suitability Classifications 4-6 combined with fractionated land overlay



Quinault Indian Nation Impact of Fractionation on Adaptation

Figure 13 - Suitability Classifications 4-6 individually with fractionated land overlay

Suitability Classification	Suitable Area (sq mi)	# of Frac. Land Parcels	Frac. Land Parcel Area (sq mi)	# of Frac. Parcels per Suitable sq mi
Study Area	(total area) 50	340	33.3	7
6	1.3	73	8.2	56
5	7.3	188	20.3	26
4	19.6	305	31.2	17

Table 5 - Quantitative results of Land Suitability Analysis

The quantitative results in table 5 confirm the observed notion that fractionated land is proportionately less of an impact with less suitable land. There are seven parcels of fractionated land per square mile of the entire study area. However, there are 56 intersecting fractionated land parcels per square mile of the most conservative Suitability Classification 6. The fractionated land parcel area and number of fractionated parcels per suitable square mile decrease with less suitability values. Areas that are most suitable are also areas that are most fractionated. These results indicate that fractionated land does have an impact on climate change adaptation because suitable lands for future development are disproportionately affected by fractionated land.

3.2 Model 2: Evacuation Route Analysis Results

The first phase of the evacuation route analysis was to conduct a least-cost path analysis to identify an additional evacuation route that considers the costs associated with the impact of climate change vulnerability. This analysis sought to find a path from the source at McBride Road to the destination at the intersection of Aloha Mainline and Iron Gate Road. This meant that the route could have taken any direction, including an alternate south option that did not intersect Baker Prairie. Figure 14 displays the result of the least-cost path analysis. The path closely follows that of the northern reroute of McBride Road in Option 2. However, it veers south to cross Aloha Mainline before Option 2, and passes Aloha Mainline to go south where it eventually meets at the destination. Because the costs associated with constructing an entirely new road are significantly higher than all proposed routes, and these costs were not incorporated in the cost raster used in this analysis, the least-cost path was adjusted (figure 15) to reroute only to the point where it intersects at Aloha Mainline.

Figure 15 displays the impact of fractionated land on the evacuation route options. Major streams are also displayed to show how each route may or may not cross streams. Developing a bridge or other structures over streams is more costly than to develop roads that do not cross over these areas. While this analysis does not consider the absolute costs associated with each type of road structure, it is critical to assess the relative costs of these features in the overall analysis.

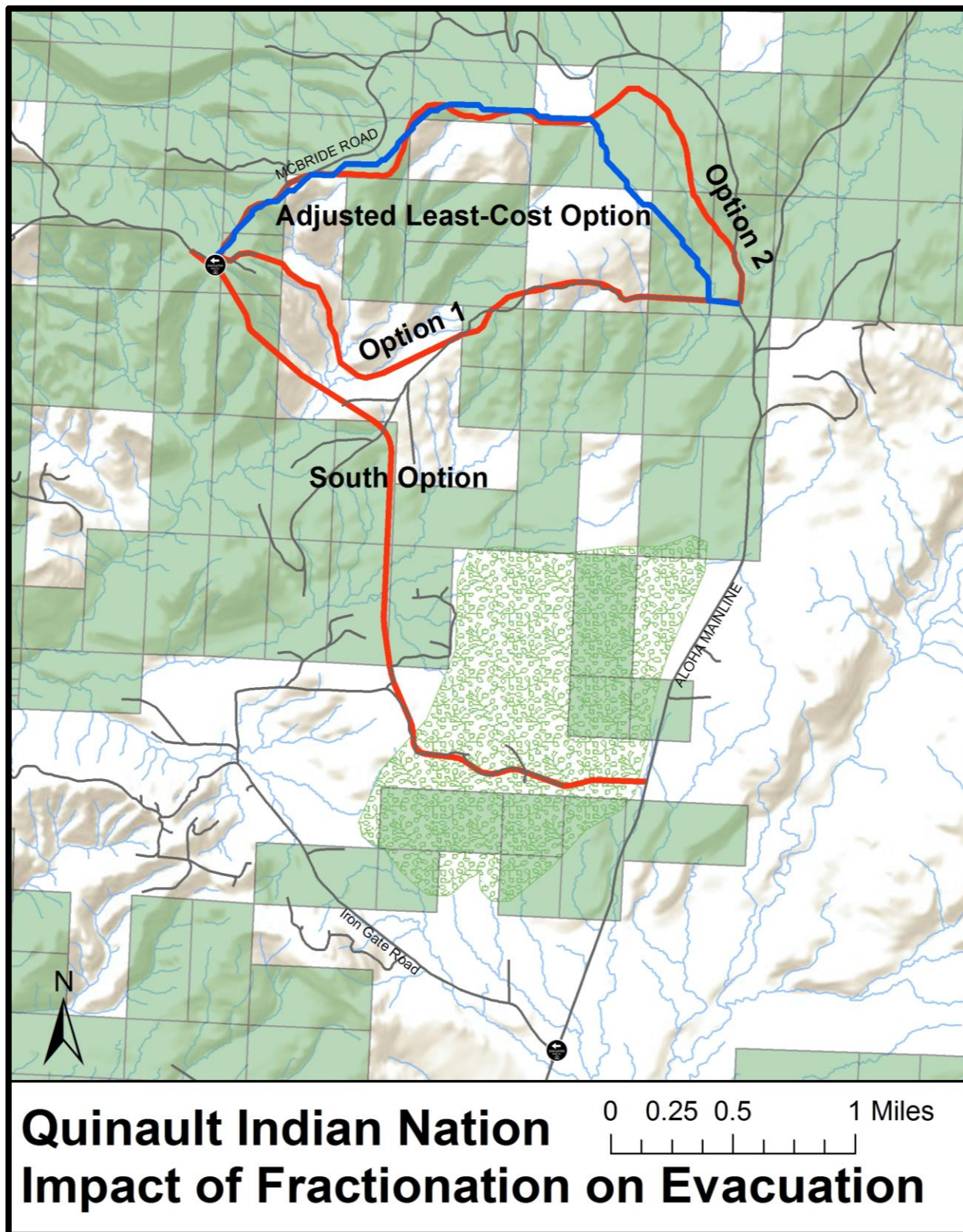


Figure 15 - Adjusted least-cost path and fractionated land overlay of all route options

Route Option	Reroute distance (mi)	Total Distance (mi)	# of Fractionated Land Parcels	Cost Range	Mean Cost	SD
Option 1	2.6	10.9	12	1.1-7.6	3.9	1.4
Option 2	3.2	11.5	15	1-3.6	1.8	.8
South Option	3.4	9.6	6	1.5-7.8	5.1	2
Least Cost Path	2.9	11.2	14	1-3	1.4	.5

Table 6 - Quantitative results for evacuation route analysis

Table 6 displays the quantitative results of the evacuation route analysis. The “total distance” is the distance of the entire evacuation route from Taholah to the destination at the intersection of Aloha Mainline and Iron Gate Road. The South Option has the least total distance and crosses the least amount of fractionated land. However, it has the greatest reroute distance and crosses Baker Prairie. These factors are necessary to consider because (1) the reroute distance has the greatest total cost associated for developing an entirely new road, and (2) Baker Prairie is not an appropriate location to disturb in the process of developing an evacuation route because of the cultural value it has to the community and because, as a wetland, it is not suitable for developing infrastructure. The mean cost (5.1) and greatest cost (7.8) of the South Option is higher than all other evacuation route options because of the high cost associated with Baker Prairie.

Option 1 evacuation route has the shortest reroute distance, but the second highest mean cost of 3.9 because it follows an area with a creek and high slope degree. Developing this route would require building a bridge to cross this creek, adding additional costs to develop. Additionally, the highest cost reaches 7.6, and it is the second costly route. Option 2 is similar to the least cost option as it follows the same path but diverts south after the proposed path from the least-cost analysis, and has the second lowest mean cost of 1.8. It’s reroute distance is almost as long as the South Option distance, and it crosses more fractionated land parcels than all other route options.

The least-cost path option has the lowest mean cost of 1.4, and the lowest high cost of 3. This path is least vulnerable to the impacts of climate change and has the lowest slope degrees. Although its total evacuation distance is longer than both Option 1 and 2, it has one of the shortest reroute distances. It also does not cross any streams or Baker Prairie. It is impacted by fractionated land at a high rate similar to Option 2 as it crosses 14 fractionated land parcels. If the committee who is charged with selecting an evacuation route were concerned with developing an evacuation route that is outside of areas vulnerable to climate change, than the least-cost path option would be most suitable.

3.3 Expert Interviews Results

To protect the identification of participants, no names or departmental affiliations are revealed. The length of work and community tenure of participants ranged between one year and over 60 years. Participants included American Indians from Quinault and other tribal communities, and non-natives. Some participants discussed climate change impacts that they have personally observed, while others were only able to comment on impacts that they have learned from community members and elders. No participant was asked all the questions in the interview guide, as interviews were structured to reflect the role of the participant both in the community and in relation to climate change adaptation and fractionated land. Below (table 7) is a summary of responses to the topics addressed in the interview guide.

Introductory	Meanings of climate change	<ul style="list-style-type: none"> • Change in weather patterns. • Long-term impact on sea levels and natural resources.
	Meanings of land and community	<ul style="list-style-type: none"> • Land is what identifies tribal people. • Home since time immemorial. • Shared space with animals.
Climate Change Vulnerability	Observed climate change and impacts	<ul style="list-style-type: none"> • Increase in flooding, melting of Anderson Glacier, SLR, and coastal erosion. • Big changes might not be observable, and some question whether observed impacts are caused by climate change or by person-made changes to the local environment, i.e. seawall construction and dams. • Cultural impacts of shifts in land and environment, including salmon populations and seasons.
	Greatest climate change threat	<ul style="list-style-type: none"> • Safety of the Lower Village from rising sea levels, increased flooding, and tsunami threat. • Structure of Highway 109 not designed to meet potential impact.
	Response to vulnerability analysis	<ul style="list-style-type: none"> • Moclips River, Taholah, and Santiago communities currently in most vulnerable areas.
	Adaptation strategies	<ul style="list-style-type: none"> • Army Corps of Engineers restored sea wall. • “Village Relocation Master Plan” to Upper Village.
Barriers to Adaptation	Perceived barriers	<ul style="list-style-type: none"> • Cost of developing infrastructure. • Funding limitations. • Federal and non-native regulations on how to address or adapt to climate change. • Fractionation of land and other land classifications, including fee.
	Strategies to overcome barriers	<ul style="list-style-type: none"> • Land consolidation programs, including LBB. • Reduce administrative burden or increase capacity of BIA to process acquisitions. • Education and outreach programs to and support owners with wills and estate planning to reduce continuation of fractionation.

	Response to land suitability analysis results	<ul style="list-style-type: none"> • Most areas are remote and have little to no infrastructure, including power or water sources. • Should consider those areas that are associated with current populations and infrastructure. • Useful to understand where is most suitable for long-term future planning. • Shows where roads (evacuation) should be, and some areas intersect with the current McBride Road (current evacuation route source). • Some community members do not have a desire to relocate because of their relationship to the land and water where they are.
	Structures being relocated	<ul style="list-style-type: none"> • Housing, offices, the school, and community expansion. • “Everything in the Lower Village.”
	Impact of fractionated land	<ul style="list-style-type: none"> • Crossing the parcel can cost the tribe money because of associated fees. • Causes challenges and loss in economic opportunity from timber sales. • Getting permission to develop infrastructure such as water lines and power can take many years and incurs additional expenses. • Impediment on self-determination and sovereignty.
Decision Making and Adaptive Capacity	Decision making process	<ul style="list-style-type: none"> • All decisions related to land acquisition are presented to and approved by the QIN Business Committee. • Concern that State and Federal government regulations and western knowledge systems infringe on tribal sovereignty rights. • Managerial staff in QIN departments are primarily non-natives, and this came up as a concern for not only the representation of the tribal community, but that tribal members are not being aggressive enough to manage the environment in a way that acknowledges indigenous values.
	Response to evacuation route analysis	<ul style="list-style-type: none"> • Strong urge to not develop within Baker Prairie because 1) cultural resources would be potentially damaged and 2) as a wetland it would not be suitable to develop an appropriate road for evacuation. • A big challenge to develop the routes is that they cross a lot of fractionated lands.
	Impact of research on decision making	<ul style="list-style-type: none"> • Provide further evidence on climate change vulnerability. • Show where to develop into the future. • Identify which parcels to prioritize for LBB program. • Identify where roads should be developed for the evacuation route. • Add criteria to LBB program priorities, and lands that are “not otherwise on (their) radar.”

Table 7 - Summary of responses from expert interviews

4 Discussion and Conclusion

I will begin this chapter with a discussion and examination of the results of each research question and its associated model to provide a contextual understanding of the results. Responses from the expert interviews will be incorporated to provide meanings of the impact of the results on the community and decision-making. Then I will give alternate explanations of the results, and summarize my policy recommendations. Lastly, I will conclude with implications and limitations to the study, and suggestions for future research.

4.1 Discussion

The Land Suitability Analysis, designed to answer question 1(a), indicated the locations within the southwest quadrant of the Quinault reservation that are most ideal for relocation or future development. Suitable lands for future development has a high proportion of fractionated land parcels compared to the entirety of the study area. Suitable Land Classification 6 are areas where the tribe could develop when the greatest criterion for long-term planning of community expansion is to develop away from all areas that are vulnerable to SLR and flooding caused by climate change. These are also areas least likely to be effected by a tsunami, although Suitability Classifications 4 and 5 are also at minimal risk of being effected by a tsunami with the exception of those areas closest to the mouth of the Quinault River, not including Upper Village (Grays Harbor County Emergency Management, n.d.). Suitability Classifications 4 and 5 show less conservative estimates of land suitability, but provide an additional range of suitability levels that may be more appropriate when considering other factors beyond climate change vulnerability. Ultimately, fractionated land greatly limits the options for relocation or future development on suitable lands, but consolidating these lands can increase the available options.

Answering question 1(a) allows for a tangible understanding of the impact of fractionated land to answer the primary research question. The range of results in suitable land for future development provides decision makers with multiple concepts of land suitability. This is critical because there may be several additional factors that the tribe must consider when making decisions for future development and community planning. For example, long-term community desires to relocate away from the river and coastlines are necessary to consider, particularly for indigenous populations who are uniquely connected to the land and natural resources. One interview participant stated, “Most of us say we’re going to stay. I’ve made my life living off of the land and the water and if it’s my turn to give something back I’ll go with it.” It is unclear

what proportion of the community in the Lower Village will want to stay there because of their long-term connection with the river and coast, and what proportion has a desire to relocate to the Upper Village to decrease their risk of harm from climate change impacts or tsunamis. Weighing the desires for relocation and the tribal connection to the coast and rivers may present a challenge for Quinault leaders engaged in the decision-making processes for future development. It will be necessary to engage the community in the decisions regarding relocation that may affect them, as indicated in the expert interviews. Prioritizing the consolidation of fractionated lands in suitable areas that are near the places that fit community desires would allow for the tribal governments to improve their adaptive capacity while protecting tribal members' place-based connections to land and natural resources.

There are also additional barriers to adaptation beyond the impact of fractionated land that must be addressed for long-term planning. Access to public utilities, or resources to develop the appropriate infrastructure within the suitable lands is one example. Interview participants all indicated that the areas in the Suitability Classification 6 are remote, and most regions have limited to no access to current infrastructure, power, or water sources. In thinking about some of the implications of the land suitability analysis, one participant said, "You can't develop on it because of lack of utilities," while another stated, "I would be looking at areas that are associated with the population and the existing infrastructure that we have." QIN is currently collaborating with other Pacific Northwest tribes to advocate for funding to address adaptation to climate change, and federal agencies have recently announced funds specifically set aside for American Indian tribes (Cama, 2015; and Walker, 2015). It will be necessary for the use of these funds to allow for consolidation of fractionated lands, and to incorporate the needs and desires of the indigenous peoples it is meant to support.

Planning for community expansion and development in the long-term future for year 2100 can be a challenge. This is particularly true for American Indian communities, who have not previously had the opportunity to plan this long into the future since colonization because of the imposition of many historical policies. Though, many indigenous communities often value living a sustainable life that considers the future seven generations. Consolidating fractionated lands can increase the adaptive capacity of tribal governments to develop and manage the infrastructure on the suitable lands to consider the next seven generations into the future.

Finally, the evacuation route analysis, designed to answer the second research question, found that the least-cost evacuation route option intersects a high number of fractionated land parcels compared to alternative evacuation route options. In order for QIN to select the evacuation route option that has the least costs associated with climate change vulnerability, slope, and cultural lands, consolidating fractionated lands along this route will be necessary. The analysis of each research question has concluded that fractionated land impacts the capacity for QIN to adapt to climate change and plan for disaster risk reduction. However, prioritizing and consolidating fractionated lands will require additional efforts to address the challenges of the administrative burden on the BIA. The BIA has limited capacity to facilitate the purchasing of fractionated lands in a timely manner. This is particularly true because contacting and getting approval from all owners with interests in the prioritized fractionated land parcels can take a lot of time and resources. The BIA would also benefit with increased capacity to facilitate the LBB program so that tribes can reach the full potential of the lands on their reservations, including climate change adaptation and economic opportunities.

The responses of the expert interviews confirmed these limitations caused by fractionated land, and provided further evidence that fractionated land and its consolidation processes also impact the tribe's economic and self-determination opportunities. The review of the results has shown that fractionated land does impact QIN's ability to adapt to climate change and reduce the risk of disasters, including tsunamis. Without an option to consolidate these fractionated land parcels through a program such as the LBB program, QIN would have limited capacity to adapt to the climate change vulnerabilities identified in this study.

4.1.1 Alternate explanations. This study did not engage in testing a hypothesis of causal relationships. It also did not find that fractionated land causes a lack of suitable land for future development, or that there is an increase in fractionated land parcels because a particular area is more suitable for future development. However, it did find that there is some relationship between fractionated land and climate change adaptation, though this cannot be explained by a causal relationship. It is possible that other historical policies imposed on tribal communities or mismanagement of the land and natural resources have caused such a relationship to occur. Exploring these concepts is beyond the scope of this study; however, Stumpff (2008) has begun to address the relationship between fractionated land and development opportunities for QIN. It is also possible that other variables not incorporated in this study may link this phenomenon.

4.1.2 Policy recommendations:

1. QIN leaders should prioritize purchasing fractionated lands through the LBB program that fall within the range of suitable lands, and select those areas that fit local needs and desires as identified through discussions about community development plans with tribal members.
2. The QIN should select the least-cost adjusted evacuation route for development of a new emergency evacuation route, and prioritize those fractionated land parcels that intersect this route for purchasing through the LBB program.
3. The federal government should continue to fund programs and provide resources for tribal climate change adaptation, and should do so in a way that allows tribal nations to practice their sovereignty rights, particularly where they can plan for the next seven generations into the future.
4. The LBB program and similar land consolidation programs should be further funded to transfer land back to tribes as a strategy to increase the capacity for tribes to adapt to climate change.
5. Future land consolidation programs must incorporate the opportunity for tribes to practice their traditional ways of doing and implement their traditional ways of knowing into their strategies for climate change adaptation or land consolidation.

4.2 Conclusion

The results of this study can have a direct and immediate impact on the decision making processes of both the QIN tribal government and the funding agencies of land consolidation programs. The Land Suitability Analysis should assist in providing additional criteria for prioritization of fractionated lands to be purchased through the LBB program. The Evacuation Route Analysis should have the same impact in addressing criteria for prioritization of fractionated land, and support the planning decisions toward which evacuation route will be least-costly. Additionally, this study found that fractionated land is a barrier for tribal self-determination and climate change adaptation because it limits reservation lands that may be available for relocation or future development. Consolidating land through the LBB program can support the adaptive capacity to climate change for the QIN tribal government, particularly when decisions about future development in areas not vulnerable to climate change must be made.

4.2.1 Limitations. There are many impacts of climate change beyond loss of land that should be evaluated when considering place-based climate change adaptation, particularly with indigenous communities whose cultural practices and traditional knowledges may also be at a loss. I only incorporated SLR and flooding projections in my analyses because there are limited methods to spatially analyze other climate change impacts, and more resources would have been needed to incorporate them. Therefore, this study can only address SLR and flooding in the analysis for climate change vulnerability. I also did not incorporate projections for tsunami risks, which can further benefit the spatial analysis for identifying an evacuation route.

4.2.2 Future research. This study did not seek to find a correlation between suitable land and fractionated land; however, the results show that there may be a correlation between these two variables. Future research should consider examining the possible correlation between suitable land and fractionated land not only within QIN, but also within other tribal communities who are experiencing the impacts of climate change. These findings can contribute to a generalized understanding of the impact of fractionated land on climate change adaptation, while also considering other historical policies that might have led to this conclusion.

Additionally, indigenous ways of knowing and traditional ecological knowledges are a significant aspect of tribal adaptation and self-determination. While the review of literature briefly addressed these aspects in this study, the data analysis methods do not fairly incorporate them. It was evident in the expert interviews that these knowledges are critically impacted by fractionated land and climate change. Future research should analyze the implicit and explicit impact of the relationship between fractionated land and climate change on indigenous knowledges through a critical lens such as decolonial theories.

Finally, an exploration of why coastal indigenous peoples have a preference to continue to live along the coastal regions, even with the risk of tsunamis and climate change impacts, should be conducted. While this may not contribute to the knowledge of the impact of fractionated land on adaptive capacity, it may help to identify other adaptation strategies that would support indigenous peoples who have an intrinsic desire to continue to live in coastal regions.

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I would like to express my deep gratitude to my partners with the Climate Change Committee at the Quinault Indian Nation Department of Natural Resources, with whom this research would not be possible. I also wish to thank my capstone advisor and GIS instructor Dr. Santiago Lopez for his close attention to detail in my writing, reporting, and analyzing of GIS applications, and to Dr. Nives Dolšak for her instruction and guidance in the policy and research design processes, each of their contributions will prove to be most helpful in my future work. Thanks of course to the 2015 graduating MAPS cohort for making the pursuit of a master's degree provocative and enjoyable, and to the MAPS faculty for encouraging us to critically address pressing policy issues we are concerned about, and, most significantly, for teaching us that even making sausage can be stimulating. For their guidance, mentorship, and friendship, I would also like to thank my colleagues from the Indigenous Wellness Research Institute, the Native Organization of Indigenous Scholars, and Washington Sea Grant. Special thanks to the many other indigenous scholars near and far who have guided and advised me throughout this research study. Finally, I wish to thank my family for their unconditional love, support, and encouragement throughout my academic endeavors, and to Traevis for believing in me beyond what I am able to comprehend.

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Appendices

Appendix 1: Study data storage and confidentiality statement

UNIVERSITY OF WASHINGTON

DATA SECURITY, STORAGE, AND CONFIDENTIALITY

Quinault Indian Nation Climate Change study

Researcher: Melissa Watkinson, graduate student
Master of Arts in Policy Studies
University of Washington Bothell
Contact information: ###-###-####; mkwatkin@uw.edu
Faculty Advisors: Santiago Lopez and Nives Dolsak

Researcher Obligations:

- A. This document describes the provisions for confidentiality and for the security of all data and individually-identifiable records and record information.
- B. The researcher agrees to comply with the specific safeguards established by the Quinault Indian Nation Business Committee concerning the confidentiality and security of all data and individually-identifiable records or record information.
- C. The researcher agrees that it will report and publish research findings and conclusions in a manner that does not permit identification of the persons whose records were used for the research. Research reports and publications will not include photographs or visual representations contained in the subjects' records.
- D. The researcher agrees that when the purposes of the research project have been accomplished that the individual identities associated with the records or record information will be destroyed, and any links connecting identities to the records or records information will be destroyed.
- E. The researcher agrees that it will not disclose the records or record information of any primary or secondary data associated with this study.
- F. The researcher agrees that it will report and publish research findings and conclusions, and protect and delete all data only in the manner that is described below:

End of study/data access	All original shared data files and all new created data files that contain any secured data records or information will be deleted by June 30, 2015, unless terminated sooner.
Description of requested data	<ol style="list-style-type: none"> 1) All requested data will encompass the SW quarter geographic region of the Quinault Indian Nation reservation. <ol style="list-style-type: none"> a. 100 year floodplain map b. Fractionated land available for Cobell – (1) land parcel shapefile with number of owners (2) range of potential property values/costs for those parcels that the evacuation routes would intersect c. Transportation routes – paved and non-paved d. Cultural region – shapefile of Bakers Prairie 2) Photographs <ol style="list-style-type: none"> a. Aerial photos of Taholah and the Quinault coast line b. Examples of flooding and climate change impacts on the reservation
Description of data to be collected	Up to ten in-person interviews with QIN department staff, leaders, or community members audio recorded and supplemented with hand-written notes. All audio records and notes will be destroyed after transcription, no later than April 30, 2015.
Data transmission	<ol style="list-style-type: none"> 1) Quinault Indian Nation Department of Natural Resources Climate Change committee staff/members will transfer the researcher with the data files through a shared Dropbox folder. 2) Only the QIN DNR team and the researcher will have access to the shared Dropbox folder, and anyone with access to this folder can only gain access through their password protected email accounts. 3) The researcher will download the data onto her password protected laptop. 4) The researcher will then also save the data files onto her personal flash drive for data backup. 5) Once data is retrieved from Dropbox, the researcher will delete the data files from the shared Dropbox folder.
Data storage and security	<ol style="list-style-type: none"> 1) Only the researcher will have access to the data on her personal password protected laptop and her personal flash drive. 2) The flash drive will be stored in her secured home and will be accessed when there is a need to also backup data analyses or if the original data files on the personal laptop are lost (either deleted or a computer crash). 3) The flash drive may also be used to transport the data to a campus password protected computer for use of data analysis software. This flash drive will only be transported while attached to a set of keys for insurance of safeguarding the data and flash drive. 4) Once the original data is analyzed, the flash drive with this data will remain in the secured home and will not be transported. The date that the analyses of the original data is expected to be completed is by April 30, 2015.

<p>Data analysis models</p>	<ol style="list-style-type: none"> 1) Evacuation Routes: Spatially analyze the most cost effective evacuation route for the Quinault Indian Nation community to evacuate the tribal reservation. Apply a multi-criteria evaluation with spatial layers that include transportation routes, fractionated land, cultural land, and climate change vulnerability (based on SLR projections and flooding from 100 year floodplain map and elevation map). 2) Land Suitability: Spatially analyze the reservation, using the same multi-criteria evaluation spatial layers, to determine locations on the reservation where future development can occur outside of climate change vulnerability and cultural lands. Through in-person interviews, supplement the quantitative spatial analysis results with qualitative data for how the reacquisition of fractionated land can increase the tribal governments' capacity for climate change adaptation.
<p>Retained files after project completion</p>	<ol style="list-style-type: none"> 1) No original data will be retained after project completion. 2) All geographic data relevant to the study area will be converted to the new resulting GIS layer to be retained and provided to the QIN Department of Natural Resources and other QIN governmental bodies interested in doing any further analyses. 3) Transcripts of the audio files will not be retained after project completion.
<p>How data will be displayed</p>	<ol style="list-style-type: none"> 1) The following may appear in the researcher's capstone report and any subsequent publications: <ol style="list-style-type: none"> a. Geographic features from the data analyses will be displayed as maps. b. Photos will be displayed within the map layout and the textual analysis. c. Themes and specific quotes from the in-person interviews that are not linked to any identifiable information. d. Tables that display the relevant total cost (range of property values), total number of owners, and total square meters of fractionated land that would be required to be purchased through Cobell within each model. e. Relevance/justification of the incorporation of the cultural region (Bakers Prairie), i.e. prevent the destruction of subsistence or traditional practices.

Appendix 2: Study Consent Form

UNIVERSITY OF WASHINGTON

CONSENT FORM

Quinault Indian Nation Climate Change study: In-Person Interviews

Researcher: Melissa Watkinson, graduate student
Master of Arts in Policy Studies, UW Bothell
Contact information: ###-###-####; mkwatkin@uw.edu
Faculty Advisors: Santiago Lopez and Nives Dolsak

Researchers' statement

We are asking you to be in a research study. The purpose of this consent form is to give you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask questions about the purpose of the research, what we would ask you to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions, you can decide if you want to be in the study or not. This process is called “informed consent.” We will give you a copy of this form for your records.

PURPOSE OF THE STUDY

This study will address the capacity of the Quinault Indian Nation to adapt to climate change-related impacts. The results are not intended to be generalizable, but may make recommendations for other American Indian communities and facilitating agencies to consider the impact of fractionated land on climate change adaptation. Specifically, the study will determine the costs associated with evacuation route options to determine the most suitable route. It will also seek to find land on the reservation that may be suitable for future development of commercial or residential infrastructure.

STUDY PROCEDURES

This study will involve collecting spatial data first, and then explaining the results with in-depth qualitative data through interviews. In the first phase of the study, quantitative spatial data related to the Quinault reservation will be analyzed to assess the impact of fractionated land and climate change on planning for an evacuation route and future infrastructure development.

The second phase of the study will collect qualitative data to understand the community perception of the quantitative results, and to further explain the function of fractionated lands in tribal adaptive capacity. *This will occur through up to ten in-person interviews that will each last between 20 and 30 minutes.* The exploratory follow-up will explore the ability of tribal leaders and members of the Quinault Indian Nation to adapt to climate change through acquiring fractionated land from the Cobell Land Buy Back program.

CONFIDENTIALITY OF RESEARCH INFORMATION

Interviews will be audio-recorded and notes will be taken for clarity. No names or other identifiable information will be audio-recorded or written, and all audio files will be deleted after transcription, no later than 30 days. At no point will the names or other identifiable information be linked to the audio-files.

OTHER INFORMATION

You may refuse to participate and you are free to withdraw from this study at any time without penalty or loss of benefits to which you are otherwise entitled.

Subject's statement

This study has been explained to me. I volunteer to take part in this research. I have had a chance to ask questions. If I have questions later about the research, I can contact one of the researchers listed on the first page of this consent form. If I have questions about my rights as a research subject, I can call the Human Subjects Division at (206) 543-0098. I will receive a copy of this consent form.

Printed name of subject

Signature of subject

Date

Appendix 3: Study Invitation Letter

Dear (interviewee name),

My name is Melissa Watkinson and I am a graduate student at the University of Washington. Bothell. As part of my studies, I am conducting a research study about the impact of fractionated land on tribal capacity for climate change adaptation. I have worked closely with the Quinault Indian Nation Department of Natural Resources Climate Change Committee to draft the final proposal for this study.

Because of your experience with the topics I am exploring, I'd like to invite you to participate in an expert interview for this research study. In the first phase of the study, quantitative spatial data related to the Quinault reservation will be analyzed to assess the impact of fractionated land and climate change on planning for an evacuation route and future infrastructure development.

The second phase of the study will conduct interviews to understand the community perception of the quantitative spatial results, and to further explain the function of fractionated lands in tribal adaptive capacity. *This will occur through up to ten in-person interviews that will each last between 20 and 30 minutes.* This exploratory follow-up will explore the ability of tribal leaders and members of the Quinault Indian Nation to adapt to climate change through acquiring fractionated land from the Cobell Land Buy Back program.

The results will help in the design of important recommendations and will identify areas for further research in this area. Specifically, the Quinault Indian Nation will be provided with copies of the final report to make decisions that may directly support the community.

Would you be available to participate in an interview on April *** at ***?

If you have any questions, please email me at mkwatkin@uw.edu or call at ###-###-####. I've also attached a consent form for further information. I appreciate the time that you will take out of your schedule to speak with me. This project is intended to be an important contribution to the field of tribal climate change adaptation strategies.