FACTORS FOR TECHNOLOGICAL APPROPRIATENESS OF RENEWABLE ENERGY OPTIONS ON NATIVE AMERICAN RESERVATIONS

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FACTORS FOR TECHNOLOGICAL APPROPRIATENESS OF RENEWABLE ENERGY OPTIONS ON NATIVE AMERICAN RESERVATIONS

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Tribes are shifting to investing in renewable energy projects. Technological appropriateness is fundamental to knowing which renewable energy project is a viable investment for tribes. Because tribes have limited resources, they need to know two primary aspects of technological appropriateness: mechanical efficiency and economic efficiency. Both are based on the geography of the reservation. Using GIS, I have evaluated the mechanical and economic efficiency of solar, biodiesel and wind renewable energy systems for every reservation in the United States. In addition, I have examined in more depth the Yakama, Standing Rock Sioux, and the St. Regis Mohawk reservations to determine what mix of these technologies to create an effective renewable energy portfolio based on several factors that could affect tribes' investment decisions. The second chapter focuses on the cultural elements that can impact a technology's appropriateness for a reservation using linguistic analysis and GIS to demonstrate the relationship between culture, technology and the land. The third chapter examines opportunities for tribes to create stronger collaborations with policy makers and academics by using linguistic analysis to highlight the highest frequency of words that each group uses in their documents concerning energy. The fourth chapter analyses the

resource availability for each technology for each reservation using GIS to determine the environmental and economic factors that can impact a technology’s appropriateness. The fifth chapter highlights the best practices that researchers can use when collaborating with Indigenous communities to conduct research as a means to strengthen those collaborations to increase the likelihood that a renewable energy project on a reservation will be successful. The goal of this research is to provide tribes with a tool that will help them to partner with government and academic institutions to build renewable energy systems to strengthen the tribe’s sovereignty

BIOGRAPHICAL SKETCH

Michael Dunaway is a Choctaw that was born in Pueblo, Colorado in 1978. He graduated from Santo High School in Santo Texas in 1996. His undergraduate work was at Haskell Indian Nations University where he earned a bachelor's degree in American Indian Studies with an emphasis on Sovereignty and Decolonization Theory in 2010. He then went on to attend the University of Kansas and earned his master's degree Geography with a focus on Indigenous Geography and a graduate certificate in Environmental Science in 2015. Currently, he is a Ph.D. Candidate at Cornell University in the Natural Sciences Department.

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Chapter 1: Introduction

For Indigenous communities, sustainability is not a luxury, it is a matter of survival. In the United States, most Native American tribes have few natural resources, a small land base, and insufficient infrastructure. Tribes are interested in renewable energy project investments as a part of their sustainable development plans. Tribes need to invest wisely in appropriate technologies to maximize their limited resources. But, how do tribes know which renewable energy projects will be appropriate? This dissertation focuses on methods that tribes can assess the technological appropriateness of wind, solar and biodiesel refining technologies to strengthen their energy sovereignty.

Investigating the appropriateness of solar, wind and biodiesel technologies for Native American reservations is the aim of this study. This goal is based on the understanding that tribes have different development agendas, cultures, and relationships with the United States government. Therefore, this study focuses on examining the technological appropriateness of the three technologies for the Standing Rock Sioux, Yakama, and the St. Regis Mohawk reservations. The outcome of the research is to provide tribal leaders, academics, and policy makers a way to determine which technology or combination of technologies best suits a particular reservation.

First, it is important to define what makes a technology appropriate for a Native American reservation. Kassam (2015) asserts, technological appropriateness has four main components: 1) mechanical efficiency, 2) economic efficiency, 3) social and cultural compatibility, 4) environmental compatibility. Mechanical efficiency is determined by the geography of the location that the renewable energy system is built. Therefore, it makes little sense to build a project that does not produce energy effectively, for example placing solar panels where there is not enough sun or building wind turbines where there is little sustained wind. In addition, this study explores the limitations of each technology and discuss how those downsides can be mitigated through investing in a combination of multiple technologies.

There are several factors that determine the economic efficiency of a renewable energy system. First, the main source of revenue for a renewable energy system is the energy that it produces. Therefore, a higher resource density indicates that a project has more revenue potential. This study explores other factors like the price that energy can be sold at, labor costs, maintenance costs, etc. The goal is to create a clearer understanding of the economic efficiency of solar, biodiesel and wind technologies on the Yakama, the Standing Rock Sioux, and the St. Regis Mohawk reservations.

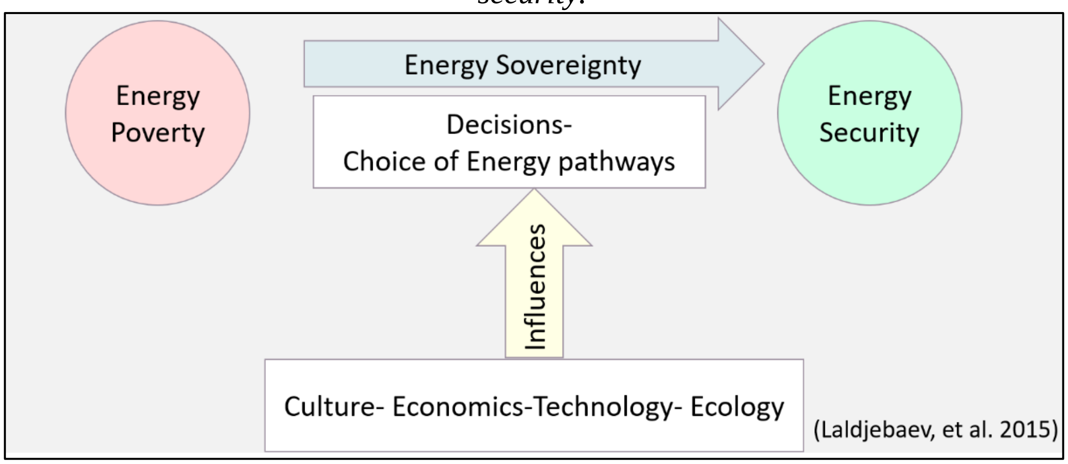
Social and cultural compatibility is also an essential element because if the renewable energy system is not in line with a community's culture, it is less likely that they will want to use or maintain the system. Tribes can preserve their cultural values while profiting economically by investing in renewable energy that is culturally relevant (Dreveskracht 2011, 145). Furthermore, culture and economics can synergize when tribes intentionally invest in renewable technology. This study is designed to connect culture, the environment, and the technologies through the usage of GIS. Spatial analysis shows the associations between biomes and the languages that emerged from them. In addition, this study examines the extent to which the connections between culture and the environment can factor into renewable energy investments.

Finally, environmental compatibility is about a system being sustainable and not just renewable. A system needs to be able to function for at least twenty years without degrading the land, which is based on the average life span of a solar panel (Müller, Wambach, and Alsema 2005, Latunussa et al. 2016, Laleman, Albrecht, and Dewulf 2011). This dissertation argues that for a renewable energy system to be truly sustainable on a Native American reservation, the tribe needs to be in control of the means of producing energy, distributing it and maintaining the systems. Thus, tribes need to forge strong partnerships with other groups, like academics and U.S. Government policymakers, to build environmentally compatible renewable energy projects. As a result, this study provides recommendations for effective communication between tribes, U.S. policymakers, and academics.

This dissertation examines the factors of technological appropriateness with the goal of strengthening tribal energy sovereignty. Energy sovereignty is the process that moves tribes from being energy poor to energy secure (Laldjebaev, Sovacool, and Kassam 2015, 107). Energy poverty and energy security are two ends of a spectrum. Energy poverty is the lack of absence or availability of energy (Laldjebaev, Sovacool, and Kassam 2015, 97-98).In this case, affordability of energy is defined by a household spending more than 10% of its income on energy (Liddell et al. 2012, 27-28). Affordability is an important element of Native

American energy poverty because 27% of Native Americans, (about 83 million Native Americans) live below the poverty line, the highest poverty rate of any ethnic group in the United States (U.S. Census 2013, 1). Specifically, the St. Regis Mohawk have a poverty rate of 30%, the Standing Rock Sioux are at 39% and the Yakama are at 27% (U.S. Census 2018), which is much higher compared to the national poverty average is 12.7% in the United States (Census. 2018). Tribes are more likely to live in a state of energy poverty than other people in the United States because they have the highest rates of poverty.

Figure 1. Energy sovereignty as a process from energy poverty towards energy security.



Energy security is defined as "low vulnerability of vital energy systems and sustained provision of modern energy services" (Laldjebaev et al. 2018, 113). One of the ways to reduce vulnerability is through the diversification of a tribe's energy portfolio. Diversification of energy sources is important to energy security because it decreases risks from market volatility, provides a more stable supply of energy, and can help keep energy prices affordable (Cherp and Jewell 2011, 4-5). It is important to note that Kassam's (2015) aspects of technological appropriateness (technical efficiency, economic efficiency, social and cultural compatibility, and environmental compatibility) are mirrored as the Laldjebaev's (2015) influences of energy sovereignty decisions. It is also important to note that these factors are not mutually exclusive. For example, Chapter 2 focuses on how technology can be influenced by culture, and visa versa. In addition, Chapter 4 examines how both economic and ecological factors are affected by the technological efficiency. By finding ways that these factors can synergize with each other one can discover new pathways to strengthen energy sovereignty through the lens of technological appropriateness. Technological appropriateness is one of the drivers of energy sovereignty for Native Americans. To this end, this dissertation looks at the mix of appropriate technologies to provide tribes with the choice of investing in several energy production technologies to further decrease their vulnerability.

This study focuses on renewable energy technologies because there are several benefits beyond just the production of energy. Indigenous communities have existed in a multitude of climates since time immemorial. Adaptation to changes in the ecosystem was key to their survival as a community. In the past, relocation was a possibility. However, the creation of bounded Native American reservations has made it difficult for tribes to mitigate climate change impacts (Benson and Berry 2009). Investing in renewable energy technologies provides a means to strengthen tribal sovereignty, but it also is an adaptation strategy that tribes can use to mitigate climate change impacts (Bennett 2014, 298). Renewable energy is also preferable because it reduces a tribe's dependence, lowering the tribe's carbon footprint. In addition, an on-reservation renewable energy project promotes the tribe’s development agenda as well as increases the chances that the tribe will experience economic success (Bennett 2014, 300). Tribally owned renewable energy systems can keep tribal member funds on the reservation. Finally, tribes need to be in control of the construction, maintenance, and distribution of renewable resources, so that they are the primary beneficiaries of utilizing those resources.

Chapter 2 assesses the social and cultural aspects of the technological appropriateness of the three technologies on reservations. In this chapter, GIS shows the association between culture and the environment. Language is examined as a proxy for culture and biomes are used to delineate between environmental zones. This study uses spatial analysis to find connections between linguistic families and biomes. Confirming those connections by examining modern Native language dictionaries to determine the frequency of words associated with each biome. After displaying the association between culture and the environment, language is used to show the connection between culture and renewable energy technologies. First, the homelands of the three tribes were determined and then, the biomes that comprise the majority of those homelands were calculated using GIS. Subsequently, the number of words connected to specific biomes (for example sun, wind and trees) demonstrated a clear connection between word frequency and the largest biome of each tribal area. Tribes can utilize this type of analysis to determine the degree in which a technology is culturally appropriate for their reservation.

Chapter 3 addresses the added issue of energy policy regarding renewable energy investment options. In this chapter, a literature review is conducted in three principal areas: 1) U.S. Energy policy, specifically when it affects tribes, 2) energy policies of tribal governments, and 3) academic discourse on energy policy, focusing on tribal issues over the past ten years. A sampling of each group yields what types of words are used most by each group. Next, Chapter 3 analyzes the frequency of keywords for each groups' documents in order to contrast the important aspects of energy policy for each group. The differences between the frequency of the words used by each group can show how tribal leaders can change how they frame their energy issue discussions with U.S. policy makers and academics in terms that align with those groups' priorities in order to promote tribal energy development agendas.

Chapter 4 addresses the mechanical and economic efficiency, and environmental compatibility aspects of the technological appropriateness of biodiesel refining, solar panels, and wind turbines. By focusing on the accessibility of each of these technologies for reservations, both energy production, monetary profits, and carbon offsets are assessed. For the purposes of Chapter 4, the availability of the resources is examined through five perspectives: 1) Payback time, 2) Energy Cost, 3) Carbon offsets 4) Energy Cost Per Acre, 5) Energy Cost Per Person. Payback time is important because one important element of building a renewable energy system is knowing how long it will take to recover the initial investment. Another concern is maximizing the amount of energy that can be produced for the least amount of investment. A tribe may focus on the environmental impact of a renewable system, as such, Chapter 4 includes reservation maps showing the carbon offsets of each technology. Some reservations have a severely limited land base, or only have limited funds to invest in a renewable energy system. This study produced maps that show which energy systems are best suited for limited amounts of land to produce the most amount of energy. Different reservations have different energy demands and need to know exactly how much money they will need to provide renewable energy for every tribal member. Using GIS, Chapter 4 examines each of these aspects across all the reservations. In addition, this chapter takes a closer look at the Yakama, Standing Rock Sioux, and the St. Regis Mohawk Reservations to examine what mixtures of technology would be best for each perspective considering local and regional issues, like maintenance costs or local energy prices

Chapter 5 is a blueprint on how to partner with Indigenous communities to conduct applied research, specifically focusing on Indigenous energy sovereignty. The goal of this dissertation is to create a tool that will aid tribal leaders with their decision to invest in a diversified energy portfolio. However, the research in this dissertation is moot if the information contained within it does not reach the tribal leaders. Chapter focuses is a literature review that is primarily based in Indigenous scholars that have written about Indigenous methodologies and supplements their work with publications from non-Indigenous scholars. These methodologies focus on the best practices for academics partnering with Indigenous communities. The goal of this chapter is to show how academics can work to advance both a community's development agenda and the researcher's research agenda. This examination includes every aspect of working with an Indigenous community, from initial community capacity building to wrapping up the research project and post research obligations. It also includes recommendations to other researchers as well as how I plan to move forward with my research with Indigenous communities.

In conclusion, tribal nations have limited means to exercise control over their circumstances. The point of this research is not to tell tribes which technologies that they should invest in. However, this study is a means to provide information so that tribal leaders can choose the technology that is most appropriate for their development agenda. In addition, tribal leaders are able to use this information to apply for grants, work with nonprofits, and make energy policy decisions. One of the fundamental aspects of energy sovereignty is that tribes have the ability to invest in energy projects that are best suited for their needs. Tribes can utilize this dissertation as a tool to strengthen their own energy sovereignty with the added benefit of doing their part to mitigate climate change impacts. They can address issues of poverty by being able to control the production and distribution of energy. Furthermore, they can also reap the benefits of creating jobs and keeping tribal funds on the reservation instead of sending their money to off-reservation energy companies.

Chapter 2: Cultural Impacts of Renewable Energy Investments

Introduction

This chapter explores the extent to which culture impacts renewable energy investment decisions for Native American tribes. According to the Oxford Extended English Dictionary (Stevenson 2010, 425), "*Culture*, comes from the Latin *colore*, meaning to tend or nurture, as in the planting of seeds into soil to produce fruit, and later to 'training or education', as into planting ideas into the fertile soil of the mind, to the modern description of the ideas, social behavior and ideas of a group of people. In all of these contexts, culture arises from a place, be it a physical space, a mental space, or a sociological space. Culture has connotations with the structure of human behavior and the human growing and tending of crops. According to Kassam (2009, 18), "Nature is a foundation from which possibilities of culture emerge." Because cultures emerge from their environment, one cannot separate culture and nature because they are in constant interaction. In a very real sense, as a person plows furrows into the land for planting crops, the land plows furrows into the people. Due to this connection to the environment, cultures are diverse and in order to discuss what a culture is, one needs to also discuss how one distinguishes one culture from another. According to Harmon (2002, 46) , there are several indicators of cultural diversity: 1) the nature and manner in which a people obtains food (i.e. hunting, planting, etc.), 2) the nature and manner in which a people express themselves (i.e. language, art, etc.), and 3) the nature and manner in which a people identify themselves (i.e. religion, ethnicity, etc.). Harmon's first indicator is interesting because it both acknowledges that cultures emerge from a people's interaction with nature, but also incorporates the concept of cultivation of plants to acquire food. The second indicator is also interesting in the framework of this dissertation because it shows how culture, ties together technology, which is an expression of a people, and language, which is also an expression of a people. The third indicator is important to this research because it frames culture as the political identification of a people, which as I will go into further depth in Chapter 3.

How a community uses technology is an expression of culture, but the introduction of a new technology also changes that culture. A renewable energy project on a reservation would introduce a new technology to the community, which may have both positive and negative impacts on that community's culture. New technologies that are aligned with the cultural values of a community are more likely to be embraced and used by the people (Dreveskracht 2011, 145). An example of how a new technology changed an Indigenous community's culture is the introduction of firearms to the Copper Inuit. The Copper Inuit subsisted on seal meat as a staple, but with the introduction of hunting rifles, they shifted to mainly hunting caribou and foxes (Condon and Ogina 1996, 92). This change led to hunters not having to travel as far to acquire food, and a surplus of meat. The meat surplus meant that hunters could share their bounty with the community as a whole and not just with their close family members. The rifle changed the type of meat and the amount of time to acquire it, but it also strengthened the cultural value of sharing food. Cultures are dynamic, but they are based in the cultural values of the community and as such community action may change a community's behavior, but that change will still be grounded in the cultural values of that community.(Kassam, Golshani, and Krasny 2018, 79-81). Hunting is a strong component of the Copper Inuit's culture, and rifles aligned with that cultural value, by making the hunt more efficient, but the cultural value of sharing that food remained a key component of hunting. However, it is also important to highlight that not every introduction of a technology leads to positive cultural expressions. Again, in the case of the Copper Inuit, the introduction of the rifle has also led to an increase in hunting animals for their pelts. This also led to the exploitation of the Copper Innuit by European traders. In 1923, a fox pelt could be bought in London for $40, but in order to trade for a $25 rifle, members of the Copper Innuit had to trade 20 fox pelts (Condon 1994, 115). Thus, the goal of introducing a new renewable energy system is to build one that is already in line with that community's cultural values and be done in a way that the tribe is not exploited. However, the question then becomes, how can a community evaluate the extent to which a renewable energy project aligns with cultural values? This chapter will use a combination of linguistics and Geographic Information Systems (GIS) to demonstrate the connections between culture, place and renewable energy technologies.

Conceptual Framework

Language can be a bridge amongst culture, the environment and technology. Culture is influenced by the environment. Furthermore, renewable technology, intrinsically ties the resources to the place in which they are refined (Domínguez and Amador 2007, 324). For the purposes of this reasearch, language is used as as a means to quantify cultural expression. Word frequency analysis is a method that uses the concepts from semiotics to quantify the importance of different concepts within a language. The basis of the analysis comes from semiotics. In semiotics, one looks for a sign, a signifier, and the significance, and to differentiate these things, we turn to the work of Umberto Eco. According to Eco, a sign, is a thing, either physical like a street sign, or ethereal like a spoken word. The signifier is the means to interpret and give meaning to the signs, which is partially based on the culture of the creator of the signs. Thus, the significance is the larger cultural context which the sign and signifier is formed and larger inferences can be drawn from (Eco 1976). A more specific example, a stop sign. Examining the sign itself, we can see the color, the shape, and the word written on it, but that is a limited perspective. The signifier of the stop sign is the laws that govern driving, which give rise to a specific behavior, one must stop when they come to a stop sign. The significance of the stop sign is that if there are laws that govern driving, then there is a governing body that creates the laws and some way to enforce the laws. With semiotics, the bigger or more frequent a sign, the more important or greater the significance of the sign (Wood and Fels 1986, 79). Bringing these ideas back to the concept of linguistic analysis, if a language has a high number of words for the sun for example, then one can infer that the sun is highly significant to that language's culture. This concept will be further applied in

Chapter 3.

This analysis of Indigenous languages has - weaknesses that I would like to address. First, there has been a sharp decline in the number of living Indigenous language speakers in the past decade (Schwartz and Dobrin 2016, 202). This means that words are being lost. Thus, if there were a high number of words for the sun in an Indigenous language, those words may be lost because they were not passed down to the next generation before a living language speaker passed away. Second, words can change meaning over time. This means that words that may have once referred to the sun, may not now. This is especially important because Indigenous cultures have changed with the interaction of European cultures, and that Indigenous languages have changed with the interaction the lingua franca, for example how Native American languages have changed because of their interaction with English as the dominant language (Haynes 2010). Neither of these issues are addressed in this analysis, however, one of the components of validating the research within an Indigenous community is meeting with living language speakers to get a better sense of the number of words that are key to this analysis.

The second element of this research is a spatial analysis of tribal language families and their connection with the environment. The cultural impact of a particular environmental element (i.e. sun, wind, trees, etc.) can be measured by evaluating the number of synonyms for an element in a tribe’s language (Eco 1976, Wood and Fels 1986). Going back to the example of the stop sign, if there was only one stop sign in the United States, then one could infer that a stop sign has little significance within the arena of driving. However, since there are a high number of stop signs, one can conclude that a stop sign is has a high significance within the arena of driving. By extension, Indigenous communities in colder climates tend to have more words for snow than the ones that are in warmer climates (Regier, Carstensen, and Kemp 2016, 5). Another counter example of language being influenced by the environment is the Slavic Homeland. The arrival of the Slavs into Europe in the fifth century caused much discussion concerning where they came from. An examination of the Slavic words for different trees and those names that were appropriated from other cultures created a picture of the Slavic Homeland; the Pripyat Valley in the Ukraine is the only place that has the trees with Slavic names and were not appropriated from other cultures (Alinei 2003). As such, Native American cultures emerge from the environments of the Tribal homelands and an examination of the number of words for specific environmental elements can provide insights into those cultures.

Methods

The analysis of the cultural appropriateness for wind, solar, and biomass technologies will is limited to the Yakama, St. Regis Mohawk, and the Standing Rock Sioux tribes. First by looking at the frequency of environmental words in a tribal language, the linkage between that culture and its environment can be demonstrated. Secondly, an analysis of tribal language families using GIS coupled with the relevant biome maps can show to what extent the tribal culture has been influenced by the predominant biome. Finally, by comparing the linguistic and geographic analyses, the links between culture, the environment and renewable technologies can be better understood.

The relevant biomes for the traditional homelands (pre-contact areas inhabited by and in which the tribes tended to migrate) are forests, prairies and deserts based on the three maps of the traditional homelands for Native American tribes (Sturtevant 1991, Goddard 1999, Powell 1890) and the three biome maps (North American Ecoregions (2010), Terrestrial Ecoregions of the World (2001), and Ecoregions (2017). Forests tend to have high biomass density, which is largely concentrated in trees, along with moderate wind and solar density (Milbrandt 2005, 11, Draxl, Hodge, and McCaa 2015, Sengupta et al. 2018). Prairies tend to have high wind density, with moderate solar and biomass density (Milbrandt 2005, 11, Draxl, Hodge, and McCaa 2015, Sengupta et al. 2018). And, deserts tend to have high solar density, moderate wind density and low biomass density (Milbrandt 2005, 11, Draxl, Hodge, and McCaa 2015, Sengupta et al. 2018). By examining the number of words for sun, wind and trees (which relate to the highest sources of solar, wind and biomass resource technologies), one can examine the relative likelihood that a renewable technology aligns with a tribe's cultural values. In theory, a tribe that has a lot of words related to the sun, would have a culture in which the sun in an important element.

The linguistic analysis is based on calculating the number of words that are in the linguistic families of the Yakama, St. Regis Mohawk and Standing Rock Sioux tribes. The Yakama speak a Sahaptin dialect which is in the Penutian language family that includes Nez Perce, Molalla and Klamath languages (DeLancey and Golla 1997, 172). The St. Regis Mohawk speak an Iroquoian dialect which includes the Seneca, Cayuga, Onondaga and Oneida languages

(Mithun 2000, 398). Furthermore, the Standing Rock Sioux speak Lakota, which is a dialect of Siouan which includes Dakota and Assiniboine languages (Cumberland 2005, 2). For this analysis several linguistic dictionaries from each of the language families were gathered and examined for words that related to sun, wind and trees. For example, with this analysis was not just looking for the number of words for the “sun”, but also counted associated words like “sunlight”, descriptions of the sun at different times of day or year or the quality of sunlight under different conditions (like sunlight through dust). Examples of words related to the wind are words like wind from a specific direction, wind relating to weather conditions (like a wind that carries a storm) or sacred wind directions. The words relevant to trees are specific species of trees, groups of trees, or even parts of trees (like treetops or limbs). In some cases, words referred to two elements (like the sound of wind in the forest, or light rays through leaves) in those cases the word was counted as a full word for each element. In the example of a word meaning sound of wind in the forest, that word would be both counted as both one full word for wind and one full word for trees. The number of words is then averaged and approximated to the whole number of words.

However, merely evaluating the number of words related to wind, sun and trees is not enough to demonstrate the cultural importance of those elements. First, language is only one element of culture. Language may be a quantifiable proxy for culture, but it excludes other expressions of culture, such as art, ceremony, food gathering, etc. (Harmon 2002, 46). Second, one of the major issues facing current Native American cultures is the loss of language, which includes a lack of original speakers, linguistic appropriation and the misinterpretation of words by people from outside of the tribe (Wilder et al. 2016, 504). Finally, cultures evolve over time, and as such, words that had their original basis in the environment, may have changed their meaning (Field 2009, 45). To limit the impacts of the factors, analyzing the number of words for environmental factors across the language family can provide a more accurate assessment of the cultural appropriateness of different renewable technologies. However, an analysis across a language family may not be enough to accurately assess the cultural appropriateness of a renewable technology on its own. Which is why the spatial analysis is needed to provide a broader perspective on the relationship between culture and geography.

GIS is used to show the connections between Native language families and the biomes of the Native homelands to provide another layer of analysis concerning tribal culture and their homelands. The prevalent biome for each language family can be assessed by analyzing that biome and the relevant Native language families' maps. The foundation of this analysis is based on the concept that the more an environmental element is prevalent throughout a homeland and as a result the more that element influences the culture (Regier, Carstensen, and Kemp 2016, 5) . For example, if a tribal language family emerged from mostly forest biomes, one would expect that there would be an abundance of words for trees. GIS can be used to isolate areas of specific language families and then calculate the area of all the represented biomes in that area. Thus, the biome with the largest area has the largest impact.

There are several issues with this type of analysis that need to be taken into account. First, both biomes and cultures have fuzzy diffuse boundaries, in other words, the lines between different regions gradually transitions (Kent et al. 1997, Buchanan et al. 2019). GIS sets hard boundaries that represents both cultural and biome boundaries as a sharp definite shift (Frank 1996, 31). In addition, GIS maps are a snapshot in time, where the data is temporal set. However, both cultures and biomes shift over time and do not have fixed temporal boundaries. Finally, the language maps are representative of Native cultures before European contact, and in order to evaluate the environmental impact to those cultures, the biomes have to be assessed from the same time period. That period pre-dates GIS and relies on estimates and hand-drawn maps and may not represent the biomes or linguistic family areas accurately (Wing and Bettinger 2003, 6). To limit these issues, this analysis will examine several language maps along with several biome maps. The fuzziness of this data is made clearer by conducting a cross-analysis of the maps.

The final aspect of this analysis is comparing the linguistic and spatial analyses to see if the both show the same relationship between tribal culture and their homelands. Next, using that cultural relationship to a renewable resource to demonstrate a technology's cultural compatibility. A "cultural match" is the degree in which a development project and a tribe's culture align; development projects are more likely to succeed when they reflect a tribe's culture (Cornell and Kalt 2006, 16). The success of the project is only one aspect of the "cultural match." A tribe's culture is the foundation in which development projects can be built; the tribe can define its own terms of success as well as express their culture through the implementation of the project itself (Dreveskracht 2011, 145). Both Kassam (2015) and Wildcat (2010) agree that a fundamental factor of technological appropriateness is how well it aligns with the community's culture. To this end, tribes with a strong connection to the sun would most likely to find that solar energy projects are a cultural match. It is important to note that this would cover all solar technology (like passive solar) and not just photovoltaic panels that are the focus of this research. In addition, wind based renewable energy technologies would most likely be a cultural match for tribes with a strong cultural relationship with the wind. These technologies would include large scale wind farms, but also household scale wind projects and windmills for mechanical processes. Biomass technologies would align with a tribe that has strong cultural ties to trees or forests. Biomass technologies include biodiesel, which this research is focusing on, as well as bioethanol or even wood burning stoves.

Data and analysis

Table 1. Word Frequency Analysis of the Sahaptin (Yakama) Language Family

Yakama	sun	wind	trees
Sahaptin Noun Dictionary(2019)	6	6	13
Dictionary of the Klamath language(1890)	18	19	23
Klamath dictionary (1963)	11	24	18
Nez Perce dictionary (1994)	6	13	20
Average (Approximated to the nearest whole number)	**10**	**16**	**19**

The Yakama reside in Washington State and speak Sahaptin which is a dialect of the Penutian language family. According to Table 1, the Sahaptin have an average of ten words for sun or types of sunlight. In addition, the Penutian languages have an average of sixteen different words for wind or types of wind. Finally, there are an average of nineteen different words for trees and tree types in the Penutian languages. Thus, it is logical to assume that biomass renewable energy projects would be most in line with the culture of the Yakama, followed by wind and solar projects. It logically follows that the Yakama have the most abundant biomass resources available of the three tribes and moderate wind and solar resources.

Table 2. Word Frequency Analysis of the Siouan (Standing Rock Sioux) Language Family

Sioux	Sun	Wind	Trees
New Lakota Dictionary Online (2019)	9	15	11
Dakota Dictionary Online	11	9	9
Lakota Translation (2019)	9	4	6
Plains Cree: Online Dictionary (2019)	9	8	5
Omaha-Ponca Words (2019)	7	14	13
Grammar and Dictionary of the Dakota Language (1874)	7	16	11
Average (Approximated to the nearest whole number)	**9**	**11**	**9**

The Standing Rock Sioux are on the border between North and South Dakota and speak Lakota and Dakota which is a dialect of the Siouan language family. According to Table 2, the Sioux have an average of nine words for sun or sunlight. Furthermore, there are an average of eleven words for wind or associated with the wind within the language of the Sioux. Furthermore, the Sioux dialects have an average of nine words for trees. This would suggest that the Standing Rock

Sioux would likely be open to wind-based technologies.   Furthermore, the Sioux also have the highest wind density of the three tribes, and only moderate solar and biomass resources.

Table 3. Word Frequency Analysis of the Iroquoian (St. Regis Mohawk) Language Family

Mohawk	sun	wind	trees
KANIEN'KÉHA LANGUAGE INITIATIVE (2019b)	5	6	8
The Ojibwe People's Dictionary (2019)	5	11	12
Cayuga Digital Dictionary(2019a)	10	9	22
Seneca Dictionary (2019)	15	13	30
Average (Approximated to the nearest whole number)	**9**	**10**	**18**

The St. Regis Mohawk reside across the borders of New York, Quebec and Ontario, and they speak a dialect of the Iroquoian language family. According to Table 3, the Iroquois have an average of nine words for solar elements of their environment. They also have an average of ten words for different types of wind. Finally, there are an average of eighteen words referencing trees in the Iroquois languages. The St. Regis Mohawk would be more likely to embrace biomass because there is a large linguistic difference in the number of words for trees over the others. The high frequency of the number of words for trees suggests that the St. Regis Mohawk’s culture would be more likely to align with biomass technologies, like biodiesel refining or burning wood for heat.

According to the linguistic data in this chapter, the Yakama are more likely to be culturally aligned with biomass technologies, the Standing Rock Sioux are have a higher likelihood of being culturally aligned with wind technologies, and the

St. Regis Mohawk might be most culturally aligned with biomass. In addition, the resource abundance maps from the NREL (Milbrandt 2005, 11, Draxl, Hodge, and McCaa 2015, Sengupta et al. 2018) demonstrate that there is a high resource density for biomass in forest biomes (which are prevalent for the Yakama and the St. Regis Mohawk) and wind density in prairie biomes (which are prevalent for the Standing Rock Sioux). In English, the sun and wind are not classified as species, as trees are, however, based on this analysis, the variation in the types of trees did not appear to overwhelm the number of words for sun and wind. In order to verify the relationship between culture, resources and technology, the biomes need to be related to the language families. Although, there is an opportunity for future research to find words that would not be common to any of the tribes as a control variable to put the frequency of the words for sun, wind and trees into a broader context. The next step in this chapter is to use GIS to show which biomes had the most impact on the Yakama, Standing Rock Sioux, and the St. Regis Mohawk language families.

The spatial analysis uses three separate biome maps (North American Ecoregions (2010), Terrestrial Ecoregions of the World (2001), and Ecoregions (2017)) and three separate Native American linguistic maps (National atlas. Indian tribes, cultures & languages (1991), Map of North American Indian languages (1999), and Map of linguistic stocks of American Indians (1890).The biomes are isolated by the language families of the Yakama, Standing Rock Sioux, and the St. Regis Mohawk (Sahaptin, Siouan, and Iroquoian respectively). Each biome map is analyzed based on each language map (see appendix 1), providing nine data points per tribe. Tables 4,5, and 6 only show the data for the largest biomes for each tribes' homelands because the emphasis of this analysis is focused on the biomes that are the most prevalent to show the relationship between the biomes that had the most impact on tribal languages. However, the maps in Appendix 1 provide all of the biome data for each tribe so that in the future a more in depth analysis can be done on the biomes that had comprised smaller areas of tribal homelands and how that may also be reflected in their languages. The biomes are measured as a percentage of the total tribal homeland areas, then averaged to demonstrate the predominant biomes for each tribe's language family. As such, the biomes that impacted the tribes' cultures can be assessed.

According to Table 4, the Yakama's language family has an average of 67% forest and 26% prairie biomes. Since the forest biomes are the largest biome for the Yakama, biomass energy sources are the most aligned with their culture. In addition, the prairie biomes occupy a substantial area for the Yakama as well, which means that wind technologies would also be appropriate for their culture. The linguistic analysis showed that the Yakama have the most words for trees. In addition, the resource availability conducted in chapter three showed the most biomass resources. Given these analyses combined, biomass is the most culturally appropriate renewable technology for the Yakama.

Table 4. A synthesis of the data from the maps in Appendix 1 for the Yakama

Yakama	% Forest		% Forest
Map1	61%	Map6	64%
Map 2	71%	Map7	70%
Map3	75%	Map8	64%
Map4	64%	Map9	67%
Map5	81%	**Average**	**67%**

According to Table 5, the Standing Rock Sioux's homeland has an average of 70% prairie biomes and 27% forest biomes. The plains biomes have high winds, which means that wind technology would be the most appropriate technology based on the spatial analysis. The forest biomes are the second largest biome, which means that biomass technologies would be appropriate to a lesser extent as well. The language analysis showed that the tribe's language family had more words for wind than sun or trees. In addition, the resource availability analysis showed that the Standing Rock Sioux had the highest wind density of the three tribes. Combining these analyses shows that wind renewable energy technologies are the most culturally appropriate for his tribe.

Table 5. A synthesis of the data from the maps in Appendix 1 for the Sioux

Sioux	*% Prairie*		*% Prairie*
Map 1	*76%*	*Map 6*	*68%*
Map2	*73%*	*Map 7*	*76%*
Map 3	*73%*	*Map 8*	*70%*
Map 4	*67%*	*Map 9*	*65%*
Map 5	*65%*	***Average***	***70%***

According to Table 6 on, the St. Regis Mohawk' homeland has an average of about 100% forest biomes. Thus, the St. Regis Mohawk's culture was heavily affected by the forests. Hence, biomass technologies would be the most culturally appropriate of the three technologies. In addition, the linguistic analysis showed that there was an abundance of words for trees compared to the words for sun or wind. However, the resource analysis did not show high densities of solar, wind nor biomass resource. The linguistic analysis and the spatial analysis showed that biomass technologies are the most culturally appropriate.

Table 6. A synthesis of the data from the maps in Appendix 1 for the Mohawk.

Mohawk	*% Forest*		*% Forest*
Map1	*100%*	*Map6*	*100%*
Map2	*100%*	*Map7*	*100%*
Map3	*96%*	*Map8*	*100%*
Map4	*100%*	*Map9*	*100%*
Map5	*80%*	***Average***	***100%***

Discussion/conclusion

The linguistic analysis and the spatial analysis clearly showed that the biomass technologies would be the most appropriate for the Yakama, wind technologies would be the most appropriate for the Standing Rock Sioux, and biomass technologies are the most culturally appropriate for the St. Regis Mohawk. This research supports the assertion that cultural edges are related to ecological edges (Turner, Davidson-Hunt, and O'flaherty 2003). The analysis demonstrated that culture and technology are intertwined through the land; furthermore, this relationship needs to be a vital element of tribal renewable energy decisions. Quantifying the cultural relevance of development decisions can be difficult for tribal members to express.

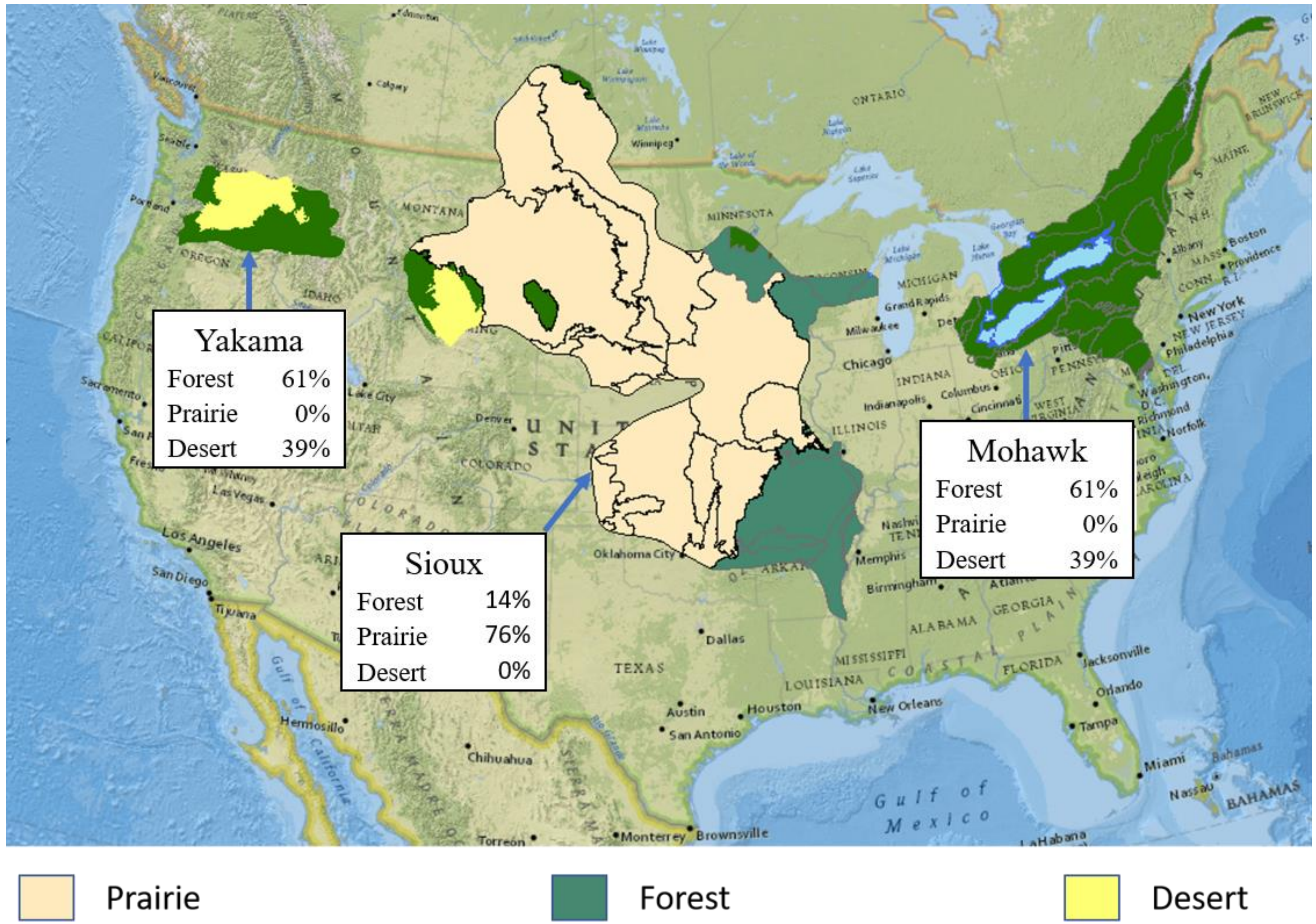
One way that this research can take the next step is to present these findings to tribes and discuss the accuracy of them. Furthermore, validating the number of words for different environmental elements with tribal language speakers is key to the future of this research. This research avenue is important because languages, meanings, and connotations of words evolve over time, especially in the case of tribal languages that are in danger of being replaced with the lingua franca of English. One way that this research can be an asset to a community beyond collaborating to build a renewable energy project is to work with living language speakers to share their language to younger tribal members. This is an important element of future research because it can be a means to revitalize tribal languages and provide a mechanism for tribal languages to define a tribe’s development agenda. Another advantage is providing a practical function for tribal language preservation as a means of discussing the cultural appropriateness of renewable energy projects. Tribal cultures are diverse and so are tribal development agendas, by discussing language through the lens of renewable energy development, tribes can both strengthen their development agenda and their cultural distinctiveness, which is imperative to retaining cultural diversity.

Another way that this research can move forward is by implementing a renewable energy project with a tribe. Presenting this research can be useful for tribes to decide what type of renewable energy project is a cultural match for their tribe. Examining and collaborating with the tribal decision-making process can show the extent in which culture plays a role in the technological appropriateness in comparison with economic, environmental and technological factors. For example, if a tribe would like to invest in a renewable energy project, culture is one element that they will take into account along with other aspects of technological appropriateness, like technical efficiency. By presenting the cultural analysis along with all of the other analysis from the other chapters, a researcher can begin to evaluate to what extent culture plays a role in renewable energy investment decisions. A researcher collaborating with a tribe's decision-making process can interview tribal members, observe the process, and encourage a dialogue to better understand how a tribe's cultural values their development decisions. Working with a tribe to articulate how their cultural values influence their actions can have broader ramifications for the tribe's future economic development agenda. Sharing this understanding with the tribe provides a more complex perspective which tribes can implement for a variety of future economic development projects, not just ones concerning renewable energy.

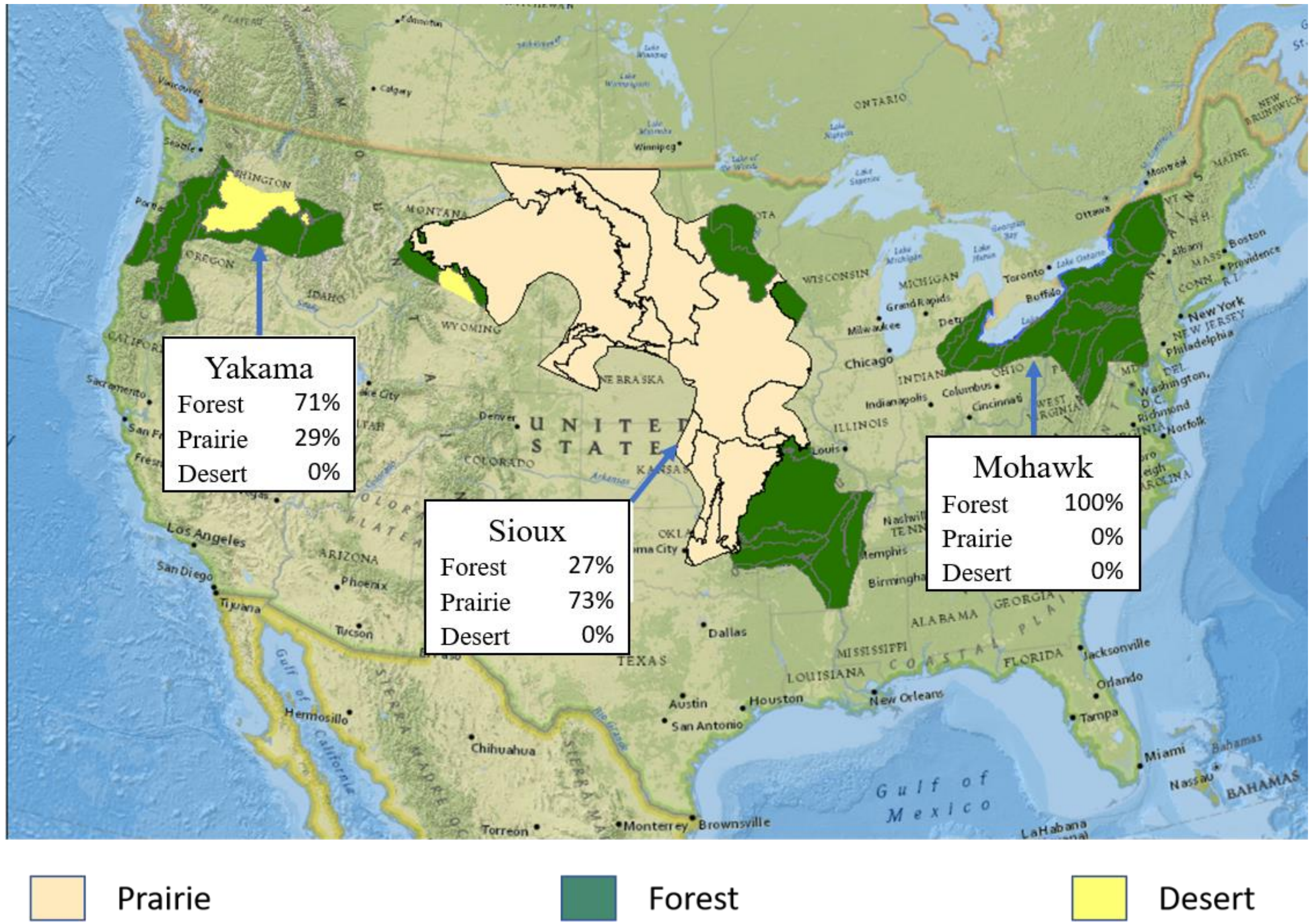
APPENDIX 1

The maps with the biome data for each of the Yakama, Standing Rock Sioux, and the St. Regis Mohawk's traditional homelands.

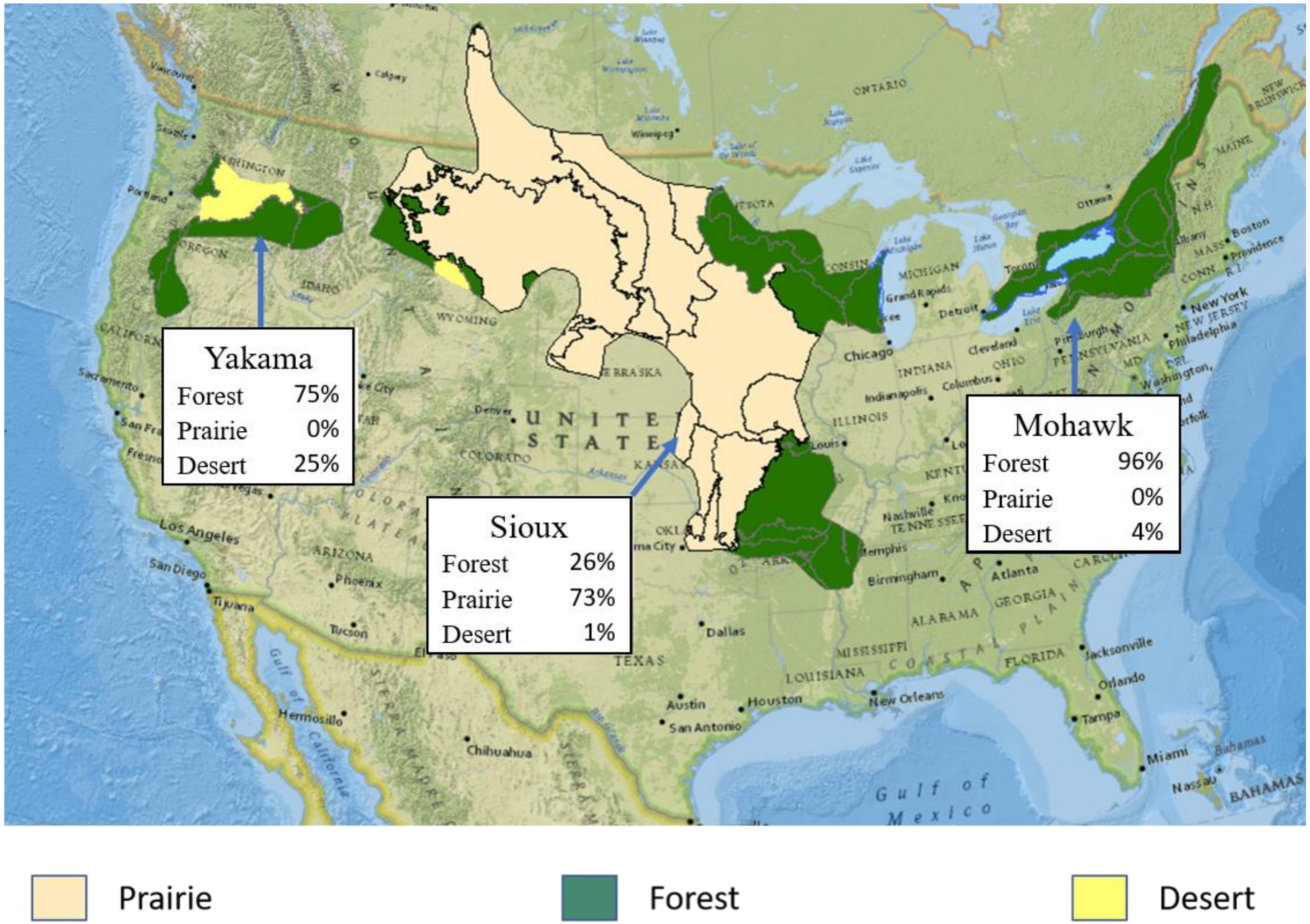
Map 1. North American Ecoregions (2010) defined by National atlas. Indian tribes, cultures & languages (1991)



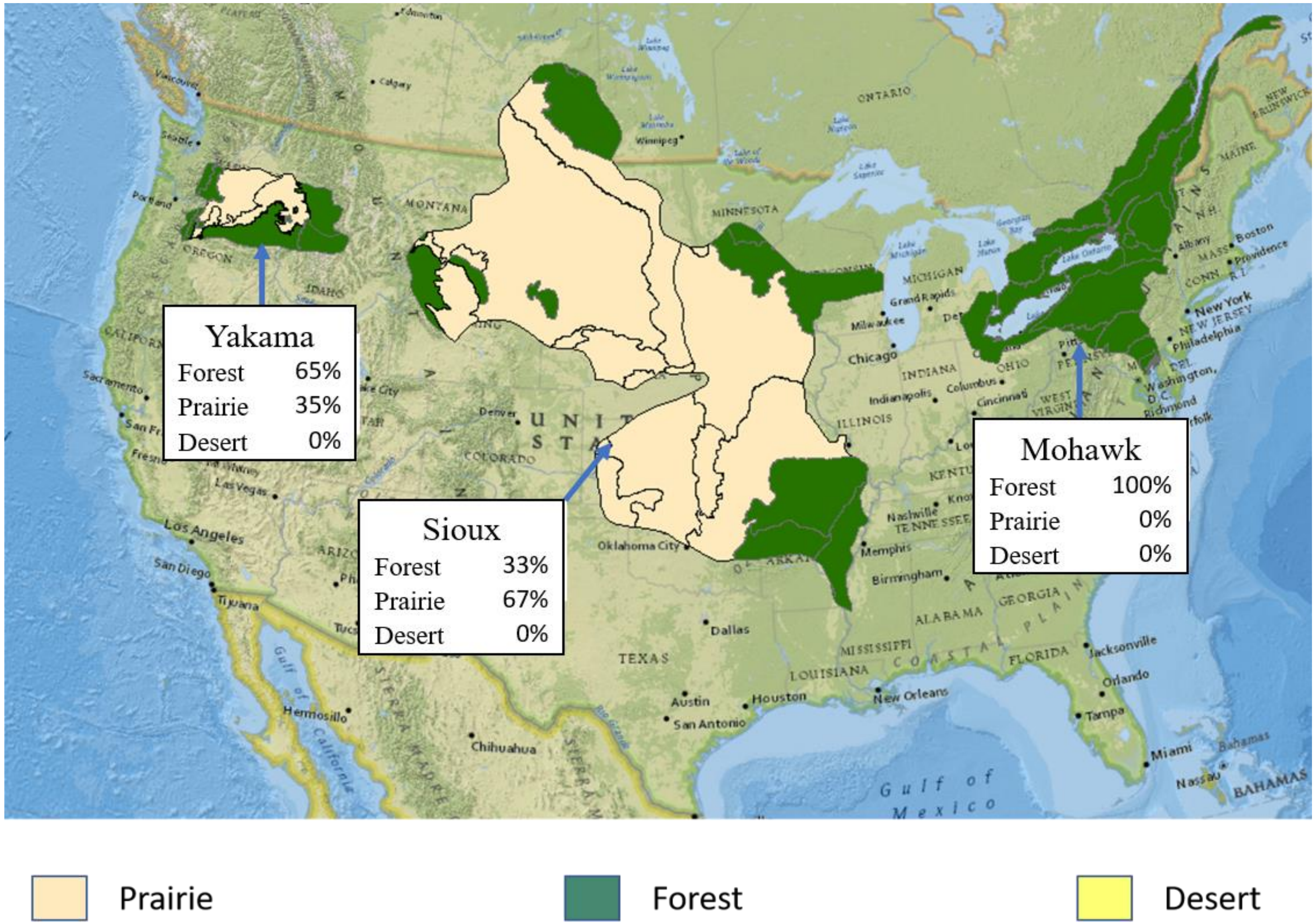
Map 2. North American Ecoregions (2010) defined by Map of North American Indian languages (1999)



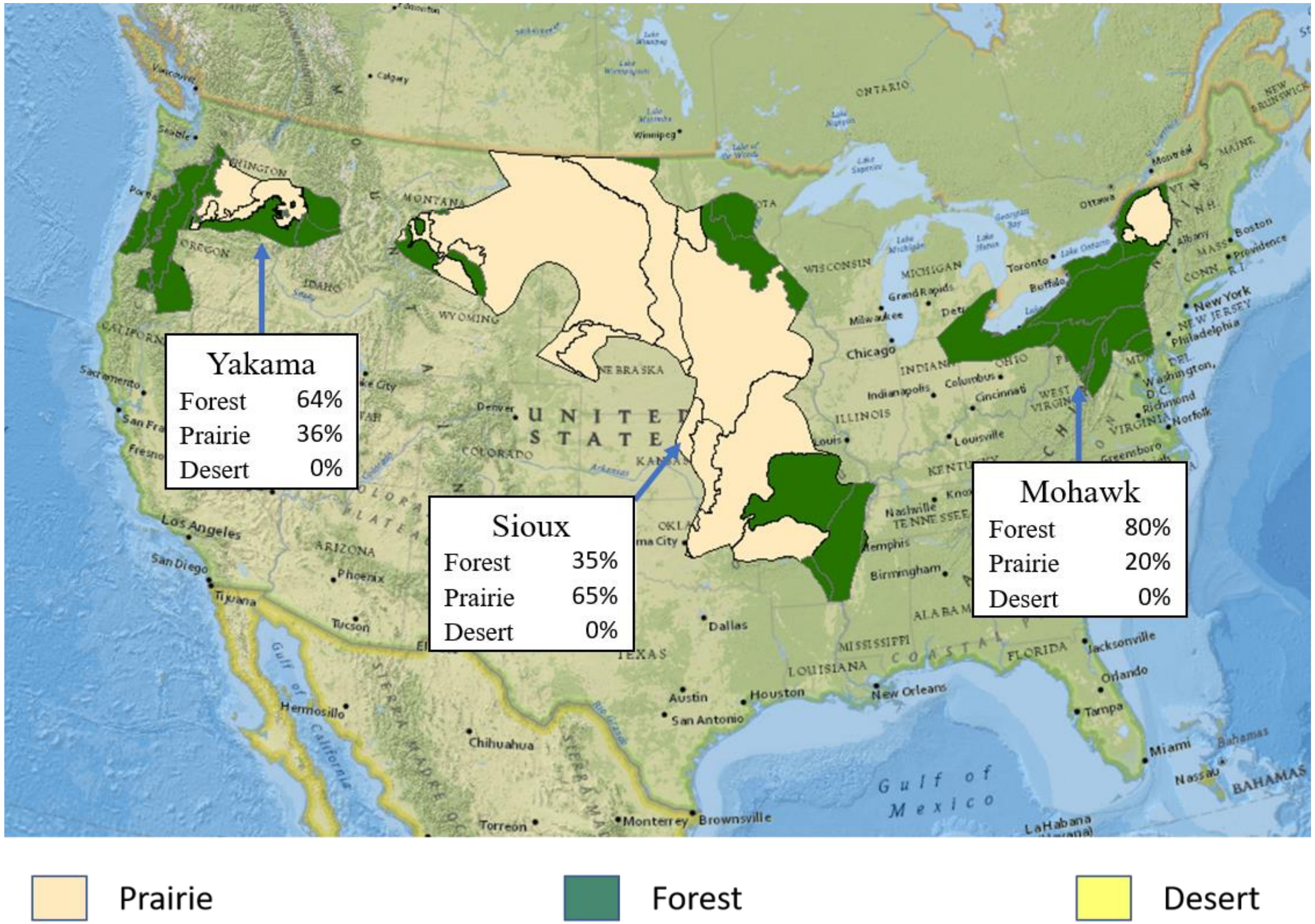
Map 3. North American Ecoregions (2010) defined by Map of linguistic stocks of American Indians (1890)



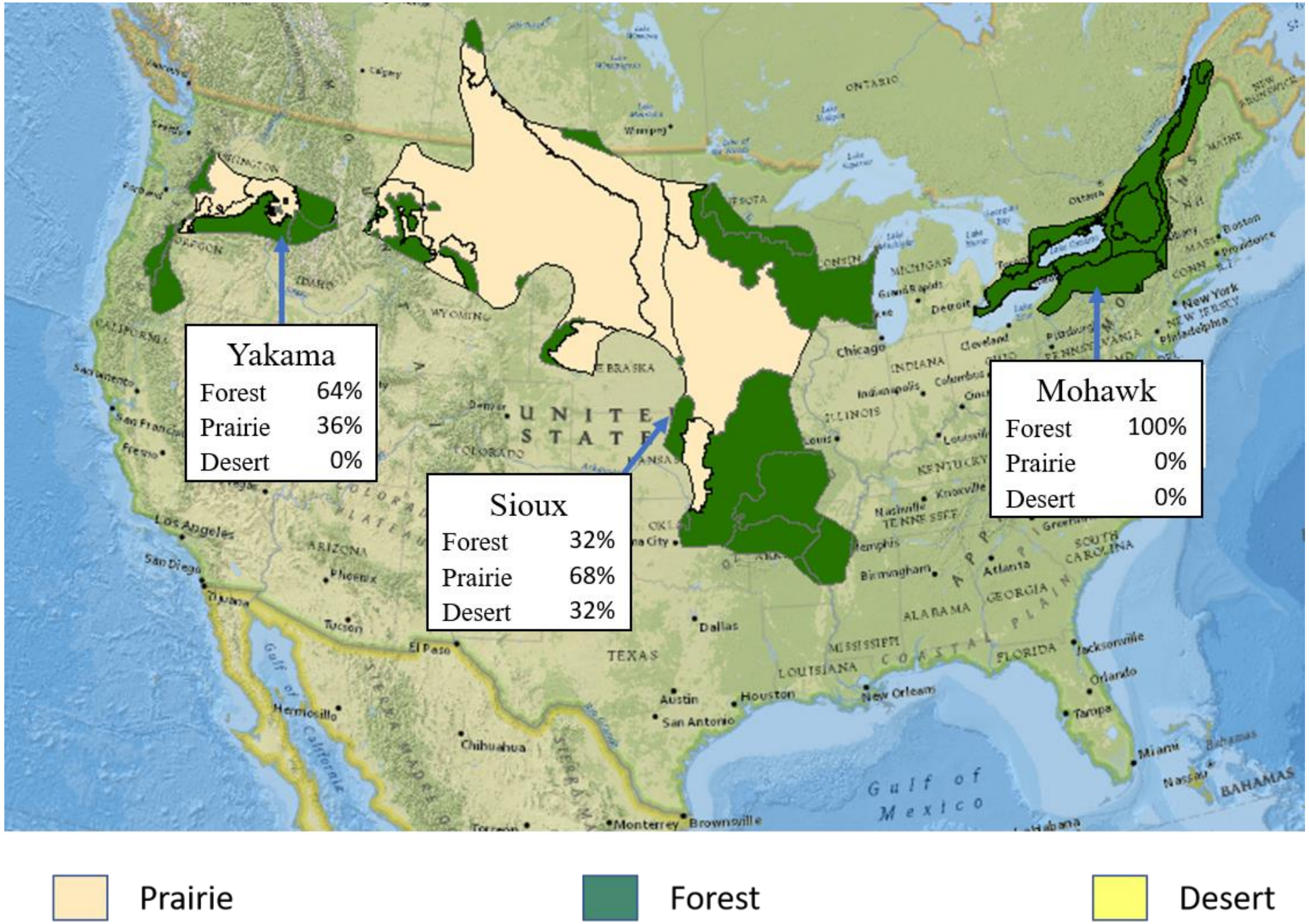
Map 4. Terrestrial Ecoregions of the World (2001) defined by National atlas. Indian tribes, cultures & languages (1991)



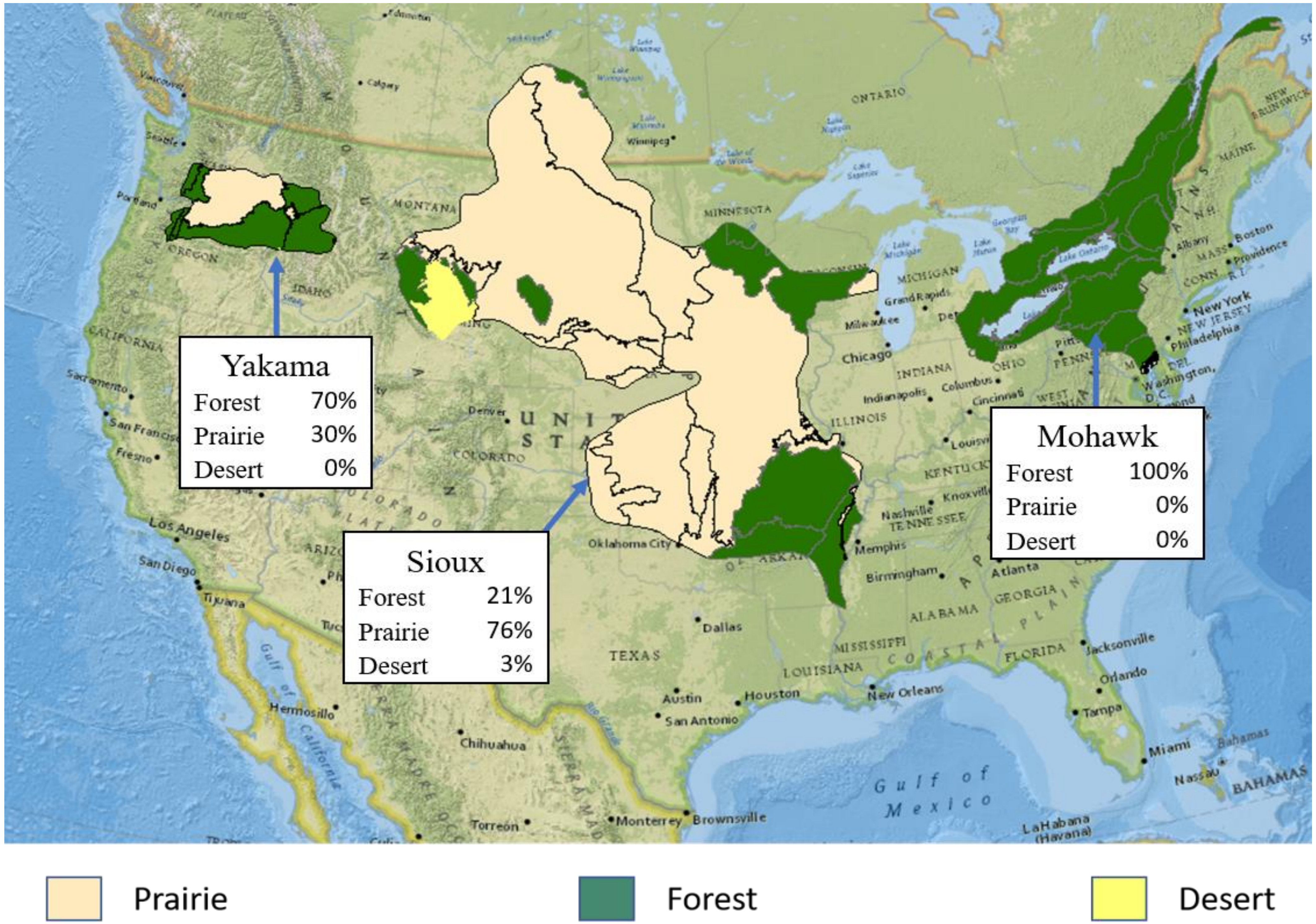
Map 5. Terrestrial Ecoregions of the World (2001) defined by Map of North American Indian languages (1999)



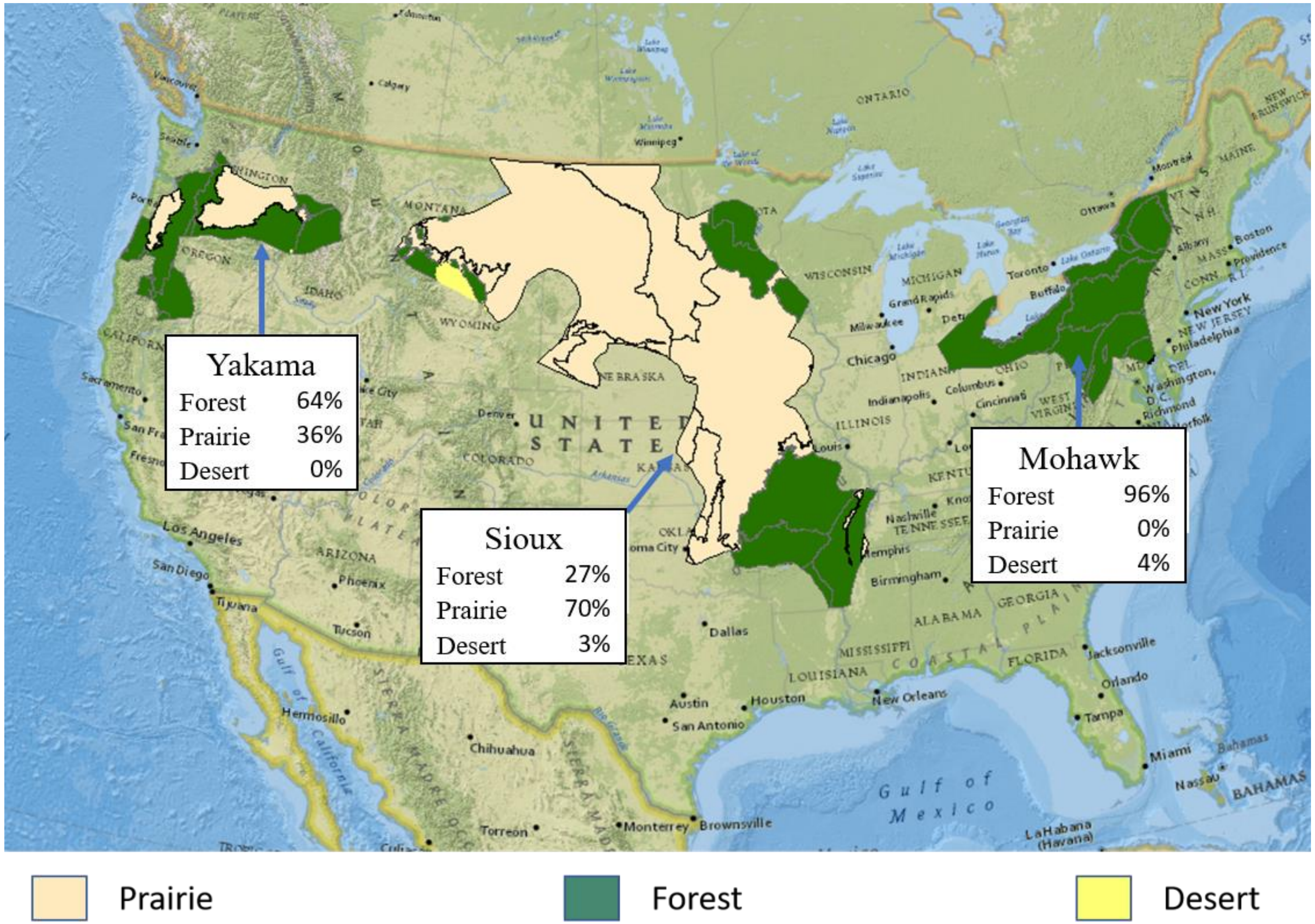
Map 6. Terrestrial Ecoregions of the World (2001) defined by Map of linguistic stocks of American Indians (1890)



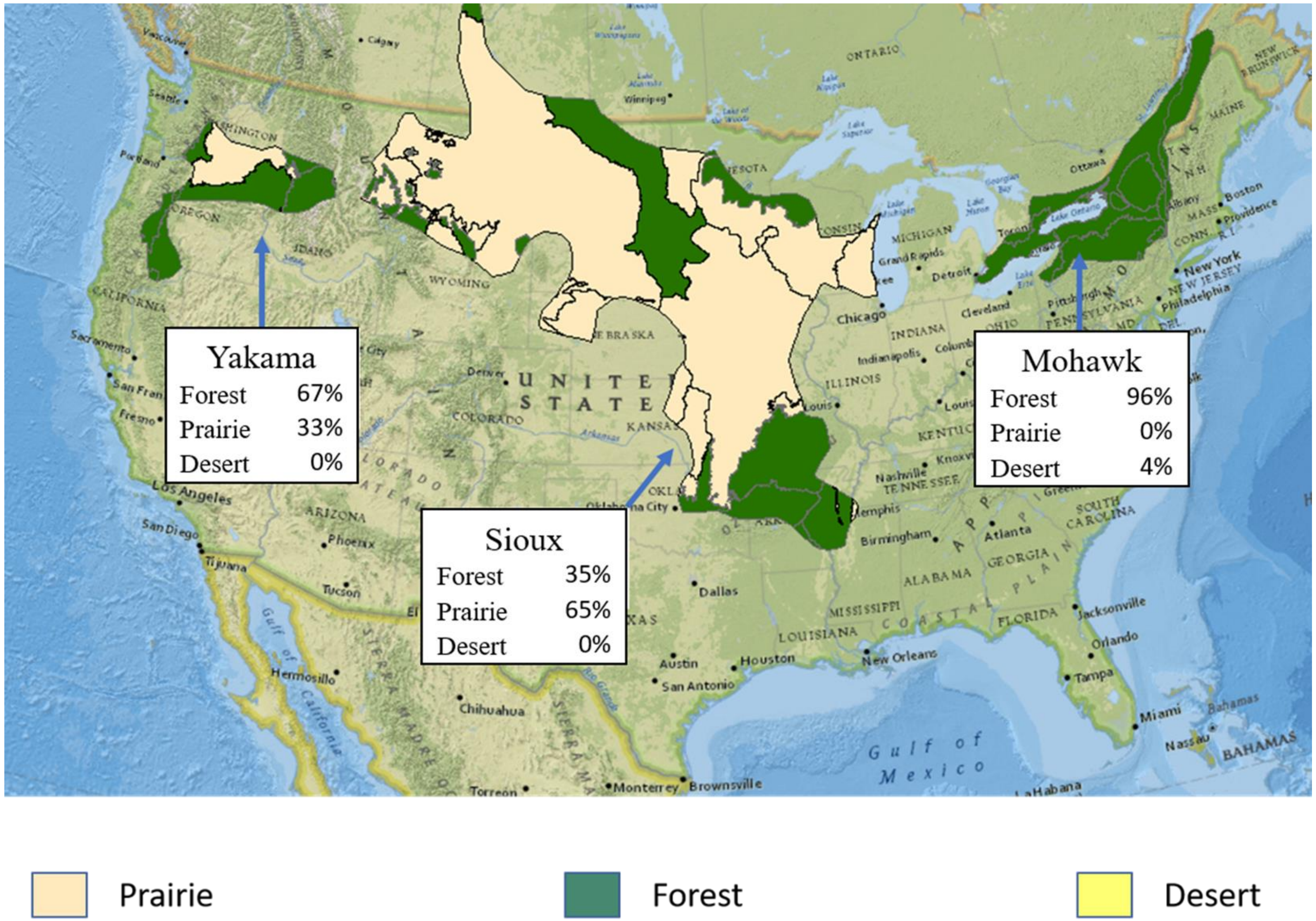
Map 7. Ecoregions (2017) defined by National atlas. Indian tribes, cultures & languages (1991)



Map 8. Ecoregions (2017) defined by Map of North American Indian languages (1999)



Map 9. Ecoregions (2017) defined by Map of linguistic stocks of American Indians (1890)



Chapter 3: Ways Policies Can Affect Renewable Energy Development

Introduction

Renewable energy projects are a mechanism for tribes to strengthen their sovereignty. Tribes have already begun partnering with academics and policy makers to invest in economic development projects (Dreveskracht 2011, Cornell, Kalt, and University of California 1992).The foundation of those partnerships is communication that creates policies favorable for tribal renewable energy projects. Policymakers have the ability to provide funding and write policies that make it easier for tribes to build, maintain and manage renewable energy projects. As such, tribes can strengthen their energy sovereignty by collaborating with policymakers. Policies promote education and training of tribal members to effectively build and maintain renewable projects. Furthermore, policies establish new funding sources for projects and incentives like carbon credits. Academics have the expertise to help construct and maintain those projects by bringing their expertise to tribal members so that those tribal members can eventually have the knowledge to construct and maintain projects on their own. Chapter 5 further discusses how researchers can strengthen tribal sovereignty through research partnerships with tribes. How can tribes communicate with these groups more effectively to promote the technological appropriateness of renewable energy projects on tribal lands?

It is important to acknowledge that the history of the U.S. government's policies concerning Native American resources has not always been in the best interests of the tribes; the United States has heavily regulated tribal resources, which has prevented tribes from fully exercising their sovereignty. United States' policies towards renewable energy projects on tribal lands are notable recent exceptions. By analyzing the energy policies documents written by the tribes, academics and policymakers, one can discern areas of opportunity which can facilitate tribal renewable energy projects. This chapter examines documents to determine the frequency of words utilized by tribes, policymakers and academics. The details of how this analysis was conducted is detailed in the methods section. Using this process one can identify lexicographic gaps which can become opportunities for tribes to be able to communicate better with both groups.

Background

The United States policies towards Native Americans have tended to favor the interests of the United States rather than the interests of the tribes. Since its conception, the United States has had several different policy eras regarding Native American resources. These policy shifts have had a significant impact on the tribes' ability to use their resources to assert their independence. Understanding this policy history is important when discussing how tribes can use renewable energy projects to assert their sovereignty because decisions that were made over two-hundred years ago still impact tribes today.

The first US policy era regarding tribes is the treaty making era that lasted from 1789 to 1828. This era was marked by the US government establishing treaties with tribes with a nation to nation relationship. The treaties tended to include land succession by tribes in exchange for concessions like military protection or monetary compensation (Lehman 1990). The United States government entered over five hundred treaties with tribes during this era. The United States Constitution's Supremacy clause states that treaties are the "supreme law of the land" (U.S. Const.).

However, the United States has violated every treaty that it entered into with tribe (Deloria 2010, 48). These violations range from failure to provide the concessions of a treaty to taking more land or resources than was agreed to in the treaty.

The next policy era was the Removal Era that ran form 1829-1886. One of the major shifts in United States policy was the Indian Removal Act (1830). The Removal Act forced several tribes to be moved from their homelands to land east of the Mississippi River. Another major shift occurred with the "Marshall Trilogy". The Marshall Trilogy were the first three Supreme Court cases that affected Native American tribes. There were several impacts of the Marshall Trilogy including depicting tribes as "domestic dependent nations" (1831). Tribal sovereignty emerged from the land itself (Corntassel and Primeau 1995, 355). However, as "domestic dependent nations," tribes' sovereignty was now defined by the United States government. The term "dependent" by the court is used for those who are unable to take care of themselves, (i.e. children, the elderly, the mentally incompetent), and placed the U.S. government as guardians over the tribes with the ability to make choices for the tribes because they were decreed "unable" to take care of themselves otherwise. Tribes were then defined as wards of the United States, establishing that the U.S. government had a "trust responsibility" to act in the best interest of the tribes (1831). With tribes considered to be wards of the United States and not having the same status as nations, the U.S. Congress decided to quit relating to tribes through treaties and instead set out how tribes would be treated through acts of congress (Rice 1977, 42). This meant that the United State government could change how they related with tribes without any consultation or negotiation with the tribes themselves.

Another major impact of the removal era was the establishment of the reservation system. The reservation system had two main impacts. First, the reservations had much less land than the tribes originally had (Heart and DeBruyn 1998, 62-63). This represented a huge loss of land for the tribe and they received little to no compensation for the loss. Second, many tribes were removed to new ecosystems and had little to no knowledge of how to survive in the new places (Akers 1999). In addition, the reservation land was low quality that had few natural resources. Many tribes refused to be moved onto reservations and took up arms against the United States government (Cave 2003, 1350). These Indian wars included many tribes including the Sioux, Cheyanne and the Apache. The Indian wars lasted for several years ending with the last of the Apache raids in 1924 (White 1978, 132). The tribes that resisted the most were treated the harshest by the United States government's subsequent policies.

The Assimilation Policy Era was from 1887-1932. The assimilation era was marked by policies that forced Native Americans to become more like Europeans. The assimilation period was marked by several major impacts to Native American sovereignty and their ability to access and control natural resources. The first aspect was the allotment of tribal lands. The General Allotment Act (1887) or the Dawes Act parceled tribal land into individual allotments. These allotments were plots of land that were assigned to individual tribal members. Allotments impacted tribal control over their resources in several ways. The first impact was that it privatized the majority of tribal land, most of which was originally held as communal property by the tribe (Anderson and Lueck 1992, 429). The second impact was that it encouraged individual improvements to the land, such as farming or ranching (Carlson 1983, 33). The third impact was that tribal members could sell their land, eroding the land base of tribal nation (McChesney 1990, 309). But the largest impact was that it created a surplus of land that the United States gave or sold very cheaply to non-native settlers, further eroding the land-base of the tribes (Bobroff 2001, 1564). A land-base is fundamental to sovereignty and control over the resources.

In addition to allotments, the United States attempted to assimilate tribal members by sending their children to boarding schools. This was an effort to "kill the Indian and save the man" (Pratt 1892). The education included having their hair cut, being forbidden to speak their language, and wearing European style clothing (Margolis 2004, 8). The boarding schools effectively cut the children's ties to their communities (Davis 2001, 21). Culture is an essential aspect of sovereignty. The education of the Indian children changed the way that tribes came to view and use resources. After the children grew up in the boarding schools, they returned to the reservations as strangers with diminished cultural ties to the community.

The third aspect of the assimilation period was that the United States government ended its policy of making treaties with tribes and started dealing with them solely through acts of congress. This meant that tribes were no longer able to negotiate or compromise with the United States government over issues of sovereignty or resources. The most significant act of Congress, from a resource standpoint, was 25 U.S. Code § 396 (1909) which gave the Secretary of the Interior the ability to negotiate leases for mining resources on the behalf of allotment owners. Furthermore, the United States added 25 U.S. Code § 396a (1938) which gave the same authority for unallotted tribal lands. The Secretary of the Interior, considered to be the guardian of the allotment owners, did not have to give notice, receive input or get permission from the allotment owners (Gross 1981, 315). However, there was nothing to ensure that the Secretary of the Interior was held to their "trust responsibility" (the legal obligation of a guardian to act in the best interest of their wards) and as a result resource leases were heavily skewed to the detriment of tribal members.

The Termination Era of U.S. policies towards Native Americans is from 1932-1960. This era was defined by the United States terminating their relationship with tribal nations; if a tribe was seen as being able to take care of itself, it was not dependent on the United States and was no longer considered a tribe. This policy encouraged tribes to remain dependent on the United States in order to remain being a tribe (Deloria 1992, 44). This represented a large loss of tribal sovereignty over their resources. House Concurrent Resolution 108 (1953a) began the process of terminating the U.S. government's relationship with several tribes. In the following years, the government terminated their relationship with over 100 tribes, giving the policy era its name (Wilkins and Stark 2017, 10). The Indian Claims Commission Act (1946) established a mechanism for tribes to file grievances over and resources. This included the Black Hills for the Sioux (Newton 1993, 472). In addition, Public Law 280 (1953b) handed the United States' authority over several tribes to the states California, Minnesota, Wisconsin, Oregon, and Nebraska, to the states. Until this time, the U.S. government was the only authority over tribes and by increasing the authority of the states over the tribes, the U.S. government fundamentally reduced the ability of tribes to make their own decisions within their own borders This era represented a loss of tribal sovereignty for several tribes, including the loss of land, of control of their resources, and legal jurisdiction.

The self-determination era (1961-present) was marked by several policy changes that shifted away from terminating tribal relations back towards strengthening tribes' ability to govern themselves. The 1960s saw a resurgence of tribes pushing to strengthen their sovereignty (Deloria's 2010, 22). The American Indian Movement was one of the main groups pushing for Native American sovereignty. The Trail of Broken Treaties March in 1972 had several demands, including a return to the treaty making process with tribes and the U.S. government, repealing laws that allowed states to have jurisdiction over tribes and the United States not inhibiting the tribal trade, commerce or transportation of goods (American Indian Movement 1972). The protest ended with tribal members occupying the Department of Interior headquarters building (Banks, Means, and Mitchell 2013, 249). The Native American civil rights movement led to the passing of the Indian Self-Determination and Education Assistance Act (1975). The act created a mechanism for tribes to contract with the United States Government for services, which meant that tribes could negotiate for services instead of being told what services that they would receive. However, the act only affected contracting for services (like health care) and did not affect the Secretary of the Interior's authority to issue mineral right leases without consulting the tribes. In addition, the Indian Tribal Energy Development and Self-Determination Act (2005a) created a mechanism for tribes to negotiate Tribal Energy Resource Agreements (TERA). TERAs are contracts between tribes and the Secretary of the Interior that lay out what needs to be included in agreements with tribes and outside entities concerning energy development and production. However, these TERAs do not include anything covered in 25 U.S. Code § 396 (1909) which gave the Secretary of the Interior the ability to negotiate leases for mining resources on the behalf of allotment owners or 25 U.S. Code § 396a (1938) both of which allowed the government to negotiate mining leases on tribes' behalf.

These policies have created the possibility for tribes to explore and control their renewable energy resources. The St. Regis Mohawk removed one of the hydroelectric dams on their land in order to restore the flow of the river and allow fish to swim further upstream (McKenna Jr et al. 2015, 1). In addition, their housing authority has been investing in solar power (Cole 2019). The Standing Rock Sioux recently protested the building of the Dakota Access Pipeline (Whyte 2017, 155). Additionally, other bands of Sioux have been investing in wind power (Zi 2019). The Yakama have developed their own hydropower production from the profits from their casino (Rigdon 2016, 7-9). They are looking to invest in solar, but also to take advantage of the abundant biomass resources on their land (Rigdon 2016, 6). Renewable energy investment for these tribes is a means to strengthen their sovereignty despite the colonizing efforts of the United States. The tribes are working to become more independent, but they have to work within the confines of the United States government's policies.

Methods and Framework

Forensic linguistics critically examines what is important within a set of documents by determining the frequency of specific words used in those documents. Word choices are a direct consequence of communicative activity and purpose (Coulthard, Johnson, and Wright 2016, 41). The activities and purposes can be differentiated by examining groups of texts and comparing them against each other. Forensic linguistics can be used to identify an unknown author based on known written works (Coulthard 2004). In addition, forensic linguistics can also be used as evidence in criminal trials or catching unknown subjects. The first use of this in a criminal investigation was the Unabomber. Investigators had several Unabomber writings but did not know who the suspect was. By examining the suspect's writings, the investigators were able to identify several things that were important to the writer (Coulthard 2005, 14-15). This technique only looks at the frequency of the words used, not the context in which they are used, however, this analysis does provide the opportunity to conduct a more contextual analysis in the future. This chapter will use a similar technique to identify word patterns that are important to tribal leaders, policymakers and academics documents about energy.

Tribal leaders are key to setting energy policies for their tribe and to partnering with other groups to invest in renewable energy projects. U.S. policymakers set the energy policy for the United States and through those policies make the process of building a renewable energy project on a reservation easier. Academics analyze polices and create research opportunities that tribes can partner with to invest in renewable energy technologies. By investigating what is important to each group through word count analysis, one can delineate opportunities for these groups to better communicate with each other. For example, tribes can frame why a renewable energy project is important to them in terms that reflect what is important to U.S. policymakers and encourage academics to become involved with renewable energy projects by discussing those projects in terms that align with academic priorities.

This word count analysis was conducted using a computer program called Wordle. Wordle was designed to take large amounts of text and create a word cloud that had the words with the largest word counts have the largest font size. This is an easy way to visualize what words are repeated the most in a block of text. In addition, Wordle has the capacity to provide an overall word count for all of the words in a block of text. This is a way to use word frequency analysis to go through large blocks of text, but does not account for their context (McNaught and Lam 2010, 631). This analysis is designed to demonstrate the differences and similarities of important words to tribes, policymakers and academics. Even though a word may have a high frequency, that does not mean that it is necessarily used in a positive context, only that it is a frequently used word in the text. However, it can point to areas of future conversation and deeper more context-based analysis. Through some experimentation it appeared that Wordle had a word limit of about 3 trillion words that it could analyze at one time. This created a limitation in the size of the overall text that could be analyzed at one time. Google search algorithms were used to search tribal websites looking for any documents referring to energy, renewable, solar, wind, biodiesel, etc. After searching over 125 tribe's documents, there were only about eight documents specifically referring to energy policies for the tribe. These documents were collected using google searches through each tribal website looking for key words like "energy" or "renewable" and focused on documents produced by tribal legislators. The earliest document dates back to 2009. These documents came to a total of about 2.2 trillion words and was easily within the capacity of Wordle. A search was conducted through the Congressional record specifically looking for documents concerning United States energy policy. This search was conducted through the federal register and focused specifically on any legislation that pertained to U.S. energy policy. That search resulted in seven documents that were created in the past 30 years. These documents came to about 2.8 trillion words and as such was near the upper range for Wordle to be able to analyze. As such, the scope of this analysis became 30 years, which encompasses all tribal policies and the most recent U.S. policies. Furthermore, the U.S. policies were limited to documents that were specifically about energy policy, and no other polices (like environmental policies) to reduce any extraneous words that might be counted but not about energy (like the words climate or change). A separate analysis would need to be conducted to see what words are important to U.S. environmental policy, and as such were beyond the scope of this analysis. Finally, with the limit of 30 years established, there were thousands of academic articles concerning energy policy. These documents were collected through google scholar and focused on academic journal articles that related to U.S. energy policy. The first reduction in the scope was to limit the included articles to those that were cited by over 200 other articles. This ensured that the highest impact articles were included. However, there were too many articles over the past 30 years for Wordle to be able to accommodate. To that end, the articles were divided up by decade, which kept each block of text under the 3 trillion word limit, and provided the opportunity to see how what was important to academics changed over the course of 30 years, and what remained important. By limiting the scope of this analysis, there were between 10 and 15 articles for each decade to analyze.

Wordle has the ability to exclude small common words like “a”, “an”, “the”, “this”, etc. However, some other common words were removed from the word count list that pertained to the type of document and not the content. For example, words like “section”, “article”, “whereas”, etc. were excluded because they are common to all policy documents and not specific to energy policies. Furthermore, words that are common to the groups themselves were also removed. For example, “congress” was removed from U.S. policy word counts and “tribe” or “tribal” was removed from tribal documents because they again would be common to any document produced by those groups. Finally, plurals of words, like model and models, were combined in the word count because they represent the same concept, instead of being treated like two different words. Limiting the scope of the word list in these ways prioritized words that were specific to the documents regarding energy policy.

Data/Analysis

Tribal energy policies demonstrated several important factors. First, there are several high frequency words that focused on economics, like *development, economic*, and *costs* (Table 7). This demonstrates that tribes are more inclined to invest in energy projects that are economically viable. In addition, future-oriented words, like *strategy, plan, change,* and *future* had frequent usage (Table 7). One could conclude that this demonstrates tribes’ commitment to develop their energy resources. *Water, land,* and *climate* were among the most frequent words used in tribal energy policies (Table 7). The energy policies showed a variety of energy sources. *Coal, natural* and *gas* ranked higher than r*enewable, solar* and w*ind; solar* and *wind* were not even in the top 50 most frequent words used; however, *biomass* and *biofuel* were highly ranked (Table

7). This implies fossil fuel-based energy solutions are frequently discussed, but current U.S. policy puts the control of those resources in the government's hands, which could be an interesting avenue for future research with a more context-based analysis. Furthermore, there is a higher usage of "biomass" compared to "solar" or "wind", thus in addition to a more in-depth context based analysis, biomass solutions are an important aspect to discuss with tribes as this research progresses.

Table 7. Word frequency of tribal policies

Rank	Word	Frequency	**Rank**	Word	Frequency
1	energy	872	**26**	work	154
2	development	582	**27**	future	153
3	water	470	**28**	community	150
4	economic	437	**29**	total	150
5	tribe	413	**30**	biofuel	149
6	reservation	332	**31**	harvest	149
7	resources	318	**32**	natural	146
8	plan	274	**33**	species	145
9	biomass	254	**34**	environmental	141
10	nation	253	**35**	national	141
11	power	245	**36**	oil	140
12	project	245	**37**	business	136
13	study	238	**38**	state	136
14	production	222	**39**	section	135
15	land	207	**40**	well	135
16	potential	194	**41**	coal	134
17	feasibility	186	**42**	council	134
18	strategy	183	**43**	change	134
19	system	179	**44**	report	133
20	costs	178	**45**	one	133
21	program	166	**46**	renewable	132
22	cost	163	**47**	current	132
23	band	157	**48**	department	131
24	climate	157	**49**	plant	129
25	wood	154	**50**	government	128

Scope of the analysis:
Biofuel Feasibility Study Bois Forte Band of Chippewa (2009a)
Strategic Energy Plan created by Mescalero Apache (2011)
Strategic Plan created for Eastern Shoshone & Northern Arapaho Tribes (2012b)
Strategic Launch Plan created for Hualapai Tribe (2012a)
Climate Plan For The Quileute Tribe Of The Quileute Reservation (2017)
Resolution Of The Navajo Nation Council Relating To Resources And Development And Naabiki'iyati; Approving The Navajo Nation Energy Policy (2013)
Yakama Nation Renewable Energy Plan (2018)
Hopi Comprehensive Economic Development Strategy (2018)

The word frequency analysis of U.S. energy policies (see Table 8) showed several areas where it complimented tribal energy policies. First, U.S. energy policy had several economic words that were used to a high degree. However, they tended to focus on funding projects: words like *funds, assistance, credi*t and *grant* (table 8). This shows that the U.S. government is committed to funding energy projects. Furthermore, words that focused on people, including *health*, *respect*, and *individuals* (Table 8). Issues like health and security are frequently discussed the U.S. policymakers and is an element of U.S. energy policy that tribes will need to discuss when partnering with U.S. policymakers. In addition, the future-oriented high frequency words tended to focus on people. *Plan* and *Program* had a high frequency as well as *security* and *training* (Table 8). U.S. policies seem to focus on being a funding source for projects that impact people's lives in positive ways.

Table 8. Word frequency for U.S. Federal energy policy

Rank	Word	Frequency	Rank	Word	Frequency
1	funds	751	**26**	training	172
2	state	678	**27**	national	170
3	amount	653	**28**	coverage	169
4	health	834	**29**	property	167
5	Provided	526	**30**	taxable	167
6	available	483	**31**	requirements	163
7	information	469	**32**	activities	162
8	federal	391	**33**	law	151
9	respect	391	**34**	public	147
10	assistance	384	**35**	provisions	135
11	purposes	379	**36**	report	135
12	payment	331	**37**	trade	134
13	individual	273	**38**	programs	134
14	fiscal	254	**39**	payments	133
15	united	252	**40**	person	133
16	credit	249	**41**	standards	132
17	program	248	**42**	benefits	132
18	entity	227	**43**	Indian	131
19	plan	224	**44**	administration	255
20	services	200	**45**	application	126
21	grant	199	**46**	public	124
22	technology	199	**47**	amounts	124
23	projects	196	**48**	costs	123
24	grants	182	**49**	local	122
25	security	177	**50**	community	121

Scope of the analysis:
Public Law 111–5 (2009c)
Energy Independence And Security Act (2007)
H.R. 6049 (2009b)
Public Law 110–232 (2008a)
Public Law 110–234 (2008b)
Public Law 109–58 (2005b)
Public Law 102-486 (1992)

Analyzing academic journal articles highlight important policy factors that can shift over time, as well as those factors that continue to be relevant. In the 1990's *fuel*, *vehicle(s)*, and *efficiency* were at the top of the most frequently used words by academics (table 9). Vehicles and fuel efficiency were a primary focus of academic writings on energy policy during this time. In addition, during the 2000s, *wind*, *turbines, solar* and *renewable* were among the most used words by academics (table 10). There was a clear attention shift to renewable energy during this period. In the 2010s, high frequency words included *jobs, employment*, and *industry* (table 11). Renewable energy was still important, however, concern over energy economics is evident. Across all three decades, academics showed that data analysis was of constant concern. In the 90s, *data, analysis* and *models (referring to statistical or mathematical models)* were among the top academic words (table 10). *Models (referring to statistical or mathematical models), studies* and *research* were also highly utilized during the 2000s (table 11). During the 2010s *models (referring to statistical or mathematical models*, *studies* and *data* were frequent. Academic journal articles about energy policy may shift over time, but a commitment to research and examining data remains constant.

Table 9. Word frequency for 1990s academic journal articles on energy policy.

Rank	Word	Frequency	**Rank**	Word	Frequency
1	energy	1294	**26**	economy	144
2	water	465	**27**	prices	143
3	fuel	354	**28**	policy	142
4	technology	328	**29**	table	136
5	power	282	**30**	coal	131
6	demand	244	**31**	costs	127
7	vehicle	237	**32**	analysis	126
8	price	216	**33**	dynamics	123
9	system	209	**34**	economic	120
10	data	204	**35**	studies	116
11	other	198	**36**	research	116
12	model	196	**37**	turbines	114
13	efficiency	183	**38**	time	114
14	cost	179	**39**	income	112
15	change	169	**40**	industry	109
16	gas	168	**41**	government	108
17	electricity	167	**42**	plants	108
18	estimates	167	**43**	information	107
19	models	160	**44**	gasoline	107
20	elasticity	154	**45**	changes	104
21	used	154	**46**	systems	103
22	electric	152	**47**	total	103
23	effect	148	**48**	states	102
24	level	147	**49**	oil	102
25	market	145	**50**	household	101

Scope of the analysis:

Gasoline Demand Revisited: An International Meta-Analysis Of Elasticities (Espey 1998)

Market Barriers to Energy Efficiency (Howarth and Andersson 1993)

Fuel Economy Rebound Effect for U.S. Household Vehicles (Greene, Kahn, and Gibson 1999)

Water And Energy (Gleick 1994)

Aggregation And The Role Of Energy In The Economy (Cleveland, Kaufmann, and Stern 2000)

Policy Networks and Policy Analysis: Scrutinizing a New Analytical Toolbox (Kenis and Schneider 1991)

Social Cost of Environmental Quality Regulations: A General Equilibrium Analysis (Hazilla and Kopp 1990)

System Dynamics and the Electric Power Industry (Ford 1997)

Sources Of Change In Energy Use In The US Economy, 1972–1982: A Structural Decomposition Analysis (Rose and Chen 1991)

Measuring The Energy Savings From Home Improvement Investments: Evidence From Monthly Billing Data (Metcalf and Hassett 1999)

Creating Incentives for Environmentally Enhancing Technological Change: Lessons From 30 Years of U.S. Energy Technology Policy (Norberg-Bohm 2000)

Closing The Efficiency Gap: Barriers To The Efficient Use Of Energy (Hirst and Brown 1990)

Table10. Word frequency for 2000s academic journal articles on energy policy

Rank	Word	Frequency	**Rank**	Word	Frequency
1	energy	2188	**26**	coal	249
2	policy	1770	**27**	table	248
3	states	582	**28**	urban	243
4	power	558	**29**	political	236
5	emissions	516	**30**	research	233
6	change	497	**31**	natural	226
7	environmental	432	**32**	tax	221
8	climate	406	**33**	fuel	220
9	consumption	396	**34**	total	214
10	renewable	382	**35**	industry	212
11	data	382	**36**	plants	211
12	wind	359	**37**	study	208
13	electricity	352	**38**	growth	203
14	gas	344	**39**	oil	195
15	efficiency	344	**40**	time	187
16	economic	317	**41**	studies	181
17	national	312	**42**	areas	173
18	carbon	587	**43**	solar	167
19	development	301	**44**	cost	165
20	public	289	**45**	generation	165
21	analysis	274	**46**	results	165
22	nuclear	264	**47**	forest	164
23	sources	253	**48**	technologies	162
24	models	250	**49**	government	160
25	technology	249	**50**	jobs	160

Scope of the analysis:
The Age Of Non-polarity: What Will Follow U.S. Dominance (Haass 2008)

Is There Life After Policy Streams, Advocacy Coalitions, And Punctuations: Using Evolutionary Theory To Explain Policy Change? (John 2003)

Performance Analysis Of US Coal-Fired Power Plants By Measuring Three DEA Efficiencies (Sueyoshi, Goto, and Ueno 2010)

Energy Sources, Public Policy, And Public Preferences: Analysis Of US National And Site-Specific Data (Greenberg 2009)

American Policy Conflict In The Greenhouse: Divergent Trends In Federal, Regional, State, And Local Green Energy And Climate Change Policy (Byrne et al. 2007)

Energy Security And Climate Change Concerns: Triggers For Energy Policy Change In The United States? (Bang 2010)

State Renewable Energy Electricity Policies: An Empirical Evaluation Of Effectiveness (Carley 2009)

State Renewable Energy Electricity Policies: An Empirical Evaluation Of Effectiveness (Mowery, Nelson, and Martin 2010)

Modeling Energy Consumption And CO2 Emissions At The Urban Scale: Methodological Challenges And Insights From The United States (Parshall et al. 2010)

The Relationship Between Disaggregate Energy Consumption And Industrial Production In The United States: An ARDL Approach (Sari, Ewing, and Soytas 2008)

Putting Renewables And Energy Efficiency To Work: How Many Jobs Can The Clean Energy Industry Generate In The U.S.? (Wei, Patadia, and Kammen 2010)

States On Steroids: The Intergovernmental Odyssey Of American Climate Policy (Rabe 2008)

Controllable And Affordable Utility-Scale Electricity From Intermittent Wind Resources And Compressed Air Energy Storage (CAES) (Cavallo 2007)

Punctuating Which Equilibrium? Understanding Thermostatic Policy Dynamics In Pacific Northwest Forestry (Cashore and Howlett 2007)

Embodied Environmental Emissions In U.S. International Trade, 1997-2004 (Weber and Matthews 2007)

The Incidence Of A U.S. Carbon Tax: A Lifetime And Regional Analysis (Hassett, Mathur, and Metcalf 2007)

Table 11. Word frequency for 2010s academic journal articles on energy policy.

Rank	Word	Frequency	**Rank**	Word	Frequency
1	energy	5768	**26**	new	395
2	motor	1560	**27**	solar	376
3	efficiency	1346	**28**	sector	366
4	policy	1190	**29**	study	365
5	consumption	1108	**30**	production	348
6	renewable	1091	**31**	cost	346
7	power	1000	**32**	plants	344
8	emissions	925	**33**	policies	341
9	electricity	801	**34**	models	341
10	systems	659	**35**	fuel	337
11	economic	643	**36**	results	328
12	electric	616	**37**	states	322
13	water	576	**38**	nuclear	307
14	growth	548	**39**	global	307
15	wind	541	**40**	carbon	306
16	table	496	**41**	world	305
17	technology	496	**42**	analysis	299
18	countries	483	**43**	gas	286
19	development	479	**44**	change	286
20	industry	461	**45**	demand	285
21	environmental	432	**46**	united	282
22	total	430	**47**	sources	273
23	system	411	**48**	national	272
24	industrial	410	**49**	international	270
25	data	397	**50**	climate	267

Scope of the analysis:

Renewable And Non-Renewable Energy Consumption-Growth Nexus: Evidence From A Panel Error Correction Model (Apergis and Payne 2012)

The Nexus Across Water, Energy, Land And Food (WELF):Potential For Improved Resource Use Efficiency?(Ringler, Bhaduri, and Lawford 2013)

Review Of Policies And Measures For Energy Efficiency In Industry Sector (Tanaka 2011)

Energy Security And Climate Change Concerns: Triggers For Energy Policy Change In The United States? (Bang 2010)

Methods Of Dealing With Co-Products Of Biofuels In Life-Cycle Analysis And Consequent Results Within The US Context (Wang, Huo, and Arora 2011)

A Review On Global Wind Energy Policy (Saidur et al. 2010)

A Review On Global Solar Energy Policy (Solangi et al. 2011)

Non-Renewable And Renewable Energy Consumption And Co2 Emissions In OECD Countries: A Comparative Analysis (Shafiei and Salim 2014)

On The Causal Dynamics Between Emissions, Nuclear Energy, Renewable Energy,

And
Economic Growth (Apergis et al. 2010)
Providing All Global Energy With Wind, Water, And Solar Power, Part I: Technologies, Energy Resources, Quantities And Areas Of Infrastructure, And Materials (Jacobson and Delucchi 2011)
Energy-Efficiency Policy Opportunities For Electric Motor-Driven Systems (Waide and Brunner 2011)
The Energy-Water Nexus In Texas (Stillwell et al. 2011)
Opportunities And Barriers To Pumped-Hydro Energy Storage In The United States (Yang and Jackson 2011)

Discussion/Conclusion

The goal of this chapter is to find ways that Tribal leaders can communicate more effectively with academics and policymakers so that it will make collaborating on renewable energy projects easier. The United States has consistently and historically used policies to colonize tribal lands and resources. Revisiting this history is not about resurrecting wounds of the past but to inspire hope for the future. U.S. policies have been used as a tool of colonization, but every tool of colonization can be a tool of decolonization. The historical colonization of tribe through policies has left very few avenues for tribes to assert their sovereignty. Investing in renewable energy is one of those opportunities. In addition, U.S. policies have provided opportunities for tribal renewable energy projects to be funded through grants. Tribes would have a better chance of getting their projects funded if they spoke about their priorities in terms that align with the granter's priorities. Furthermore, they are more likely to access funding if they can show that they are partnering with academics to further research goals.

Forensic linguistics was chosen because one can identify the priorities of people or groups of people. Word frequency analysis effectively assesses those priorities in a block of given text. Thus, if one wants to know what concepts that policymakers find important for energy policy, word frequency analysis is a way to do this. In addition, this type of analysis across different types of text can show similarities and differences in the concepts that are important. This is key for tribes because they can frame what is important to their development agenda in terms that align with the priorities of policymakers and academics. This creates the opportunity for tribes to use the policies that have historically hindered tribal sovereignty as a means to strengthen it.

This analysis showed how tribes can diversify their methods of communication with policymakers. First, policymakers want to fund projects, but their priority is people over environmental concerns. Thus, tribes can frame renewable energy projects in terms of education and job creation. In addition, tribes can show how their renewable energy projects support the goal of U.S. energy security by demonstrating that their desire for diverse energy sources can be a model for other communities. Finally, Tribes can frame environmental concerns in terms of public health. For example, higher clean air standards has led to a reduction in the incidence of asthma in children (Sheppard et al. 1999). By reframing how they discuss their priorities, tribes can build a dialogue with policymakers that will help both groups reach their goals.

Tribes can also build stronger alliances with academics to build renewable energy projects. Tribes can frame renewable energy projects as sources of data that is of interest to several fields of study. Even though the focus has shifted away from fuel efficiency in the 1990s, energy efficiency is still an academic focus. Another method tribes can implement to interest academics is by being open to experimental energy projects. Furthermore, they can invite academics to explore increasing the efficiency of existing projects. An alternative way that tribes can create opportunities to collaborate with researchers is to explore the economic impacts of renewable energy projects for tribal members. Finally, the social impacts of a new technology on a reservation can provide insight about the implications of projects for other communities. There are numerous ways that tribes can work with academics to facilitate renewable energy projects, through creating new policies or even labor and logistical support.

Tribes are heavily impacted by U.S. policies, and as such the technological appropriateness of a project is tied to those policies. Most tribes are not able to invest in renewable energy technologies without outside funding. The U.S. government has created to fund tribal renewable energy projects (Office of Indian Energy Policy and Programs 2020). Therefore, tribes can access those funds by framing their priorities to align with the ideals of the policymakers. Funding can range from exploring the environmental impact of a project, which would increase the environmental suitability of a project, to funding training that would increase a project's economic efficiency. Collaboration with academics is another way to increase a project's technological appropriateness. Experiments with new technologies or increasing the efficiency of an existing technology, can increase a project's technological efficiency. Finally, data produced by tribal projects can influence both policymakers and tribal members, which would in turn increase a project's social and cultural compatibility. Tribal renewable energy projects can be technologically appropriate for their land, but by communicating effectively with both policymakers and academics, tribes can increase a project's technological appropriateness, even after it has been implemented.

Chapter 4: The Accessibility of Renewable Resources on Reservations

Introduction

The accessibility is a crucial factor for Tribal Nations who are considering investing in renewable energy technology. Tribal Nations will want to choose an abundant resource to maximize both the economic efficiency and the technical efficiency of their development projects. The National Renewable Energy Laboratory (NREL) has already created maps that show renewable resource availability. The NREL maps focus on national data which was not designed to represent resource density on tribal lands (National Renewable Energy Laboratory 2018a, b). Tribal Nations have already begun investing in renewable energy projects (Grossman 2008, 13). However, for Tribal Nations to invest wisely in renewable energy projects, they need information that best suits their development agendas. To that end, this study seeks to provide Tribal Nations with data and information, so they can make the renewable energy project investment that accurately aligns with their development agendas. Depending on a Tribal Nation's values, they have different priorities as it concerns renewable energy investment.

The first perspective that may be of interest to Tribal Nations is the amount of time to recover their initial investment for each technology. This payback period is important for Tribal Nations who want to recover their initial investment as quickly as possible. A quick recovery time for their investment is important because after they recover their investment, the project will start gaining net profits. Those net profits can be used for other tribal projects, investing in more renewable energy projects, or used for anything that the Tribal Nation considers important enough to apply those funds to.

For a project to be viable, it needs to be profitable enough for Tribal Nations to invest in. Even though the payback period is an important aspect for Tribal Nations to consider, Tribal Nations may primarily be concerned with maximizing their energy production for the least amount of capital investment.

The second area of concern for Tribal Nations is the amount of energy that can be produced for the least amount of initial capital investment. Maximizing energy output would be important to Tribal Nations who want to supply the most amount of energy for the smallest investment. This differs from focusing on the payback period because the goal would be to produce the most amount of energy regardless of the costs associated with producing it. For example the cost of maintaining the system would not be included for this objective. Therefore, profit would not be prioritized. A high energy output may be important for Tribal Nations that have a lower standard of living and can provide energy for free or at a reduced cost, freeing up household income for other monthly bills, like food or medication.

The third perspective focuses on the amount of carbon that can be offset by different renewable energy systems. Investing in renewable energy is one way for Tribal Nations to mitigate climate change impacts. To that end, Tribal Nations will want to know how much carbon that is offset per initial investment. Each technology has its own Energy Return on Investment or EROI. EROI is a way to measure the amount of carbon that is released during the construction of each technology in comparison to the amount of carbon it can offset. EROI is displayed as a ratio, for example 5:1, which means five units of carbon offset for every unit of carbon that is released during the construction of the system. Wind has an EROI of about 18:1, solar about 7:1, and biodiesel about 2:1, however, with biodiesel, that includes everything that goes into the production of the oil before it is used as cooking oil (Murphy and Hall 2010). EROI can be impacted by the abundance of a resource. Because the more efficiently a system produces energy, the lower the impact of the initial carbon emitted during construction.

The fourth area of concern is maximizing energy production for a limited amount of space. This issue would be of interest to Tribal Nations that have a smaller land base or limited land to invest in a renewable energy project. Each technology has its own spatial requirement. Renewable energy production is a function of the abundance of a resource, so what might be the most efficient technology with the smallest footprint on the; land base varies from reservation to reservation. This study examines which technologies would produce the most energy on a single acre of land on each reservation.

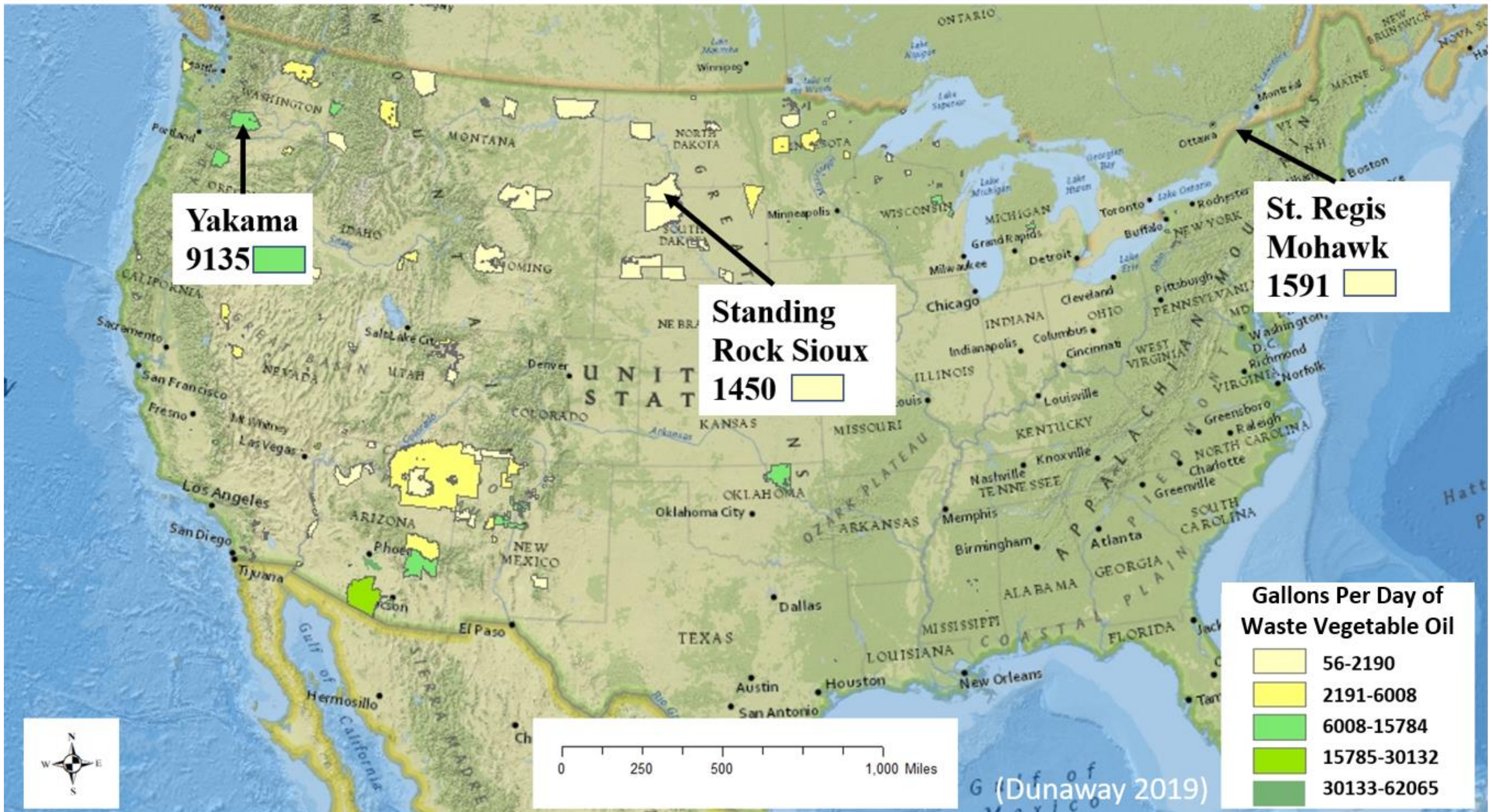
The final area of focus examines maximizing the energy production per person on a reservation. This would be of concern for reservations with higher populations or are the ones who are asking their members to bear the cost of the energy project. This study will first determine the amount of energy that each reservation will need based on their population. The next step is to focus is on maximizing each technology to supply enough energy for the entire reservation. The final step is to determine the cost per person for each technology.

Methods/Data

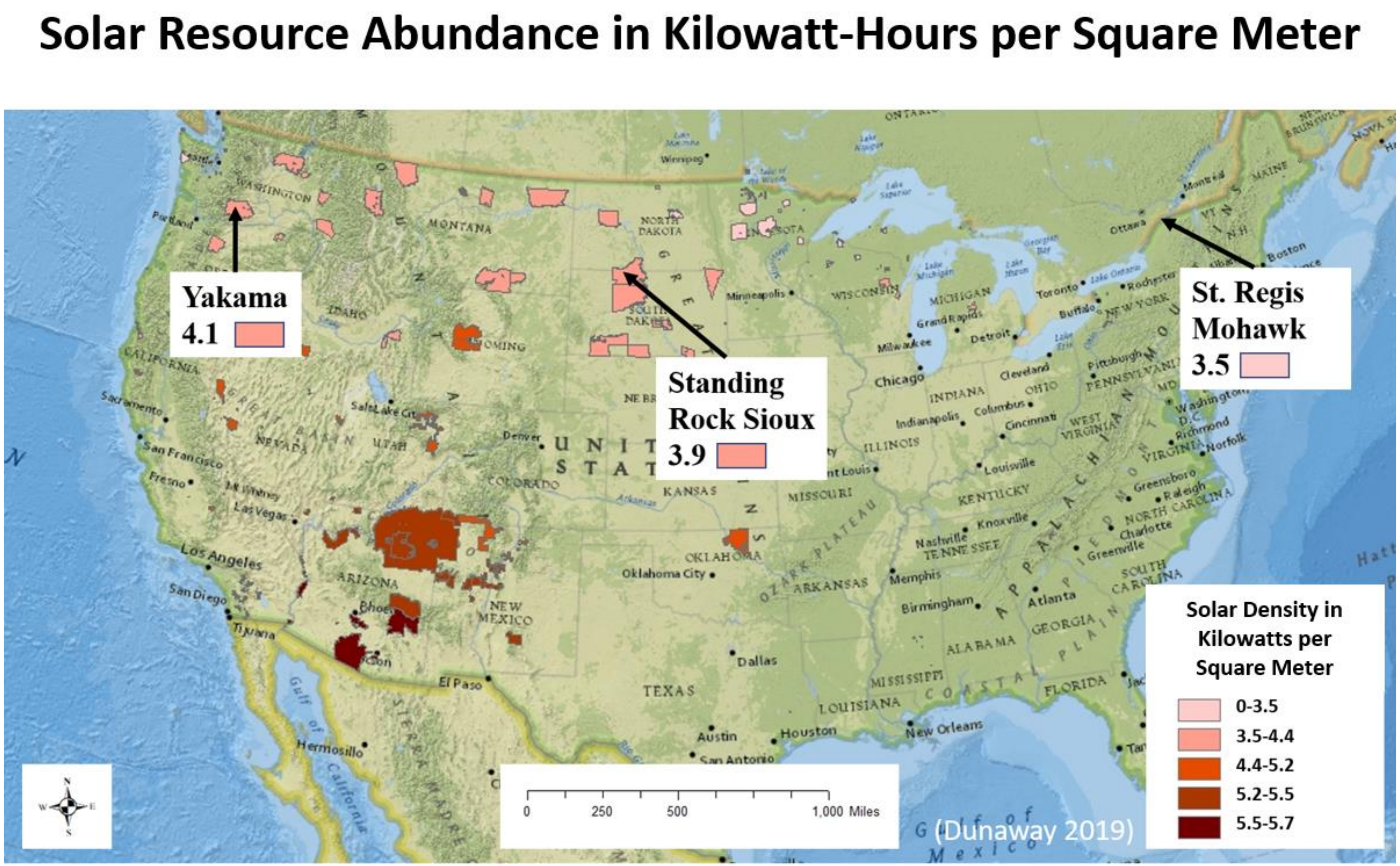
The data for the spatial analysis comes from various United States' government sources. NREL has solar density maps that use several factors to determine how much solar radiation is available in a place on an annual basis (National Renewable Energy Laboratory 2018a). For the purposes of this dissertation, the solar panels will be assumed to be American-made, community scaled systems that have an efficiency of 20%. NREL also has wind density maps that take into account the factors that determine how much consistent wind exists at 50 meters (the height of a wind turbine) (NREL 2007, 6). The U.S. Census's TIGER dataset shows the population density by area. Since about 3 gallons of waste vegetable oil (WVO) is produced per person every year, population is a can be a proxy for the amount of WVO available near a reservation (Wiltsee 1998, 3). All the datasets are for the entire United States, so this study used spatial averaging, which both gave a single value for each reservation based on the spatially weighted averages for the values comprising that area and eliminated all data that outside of each Tribal Nation's lands.

Map 10. Tribal Biodiesel Resource Abundance

Biodiesel Resource Abundance in Gallons per Day



Map 11. Tribal Solar Resource Abundance



Map 12. Tribal Wind Resource Abundance

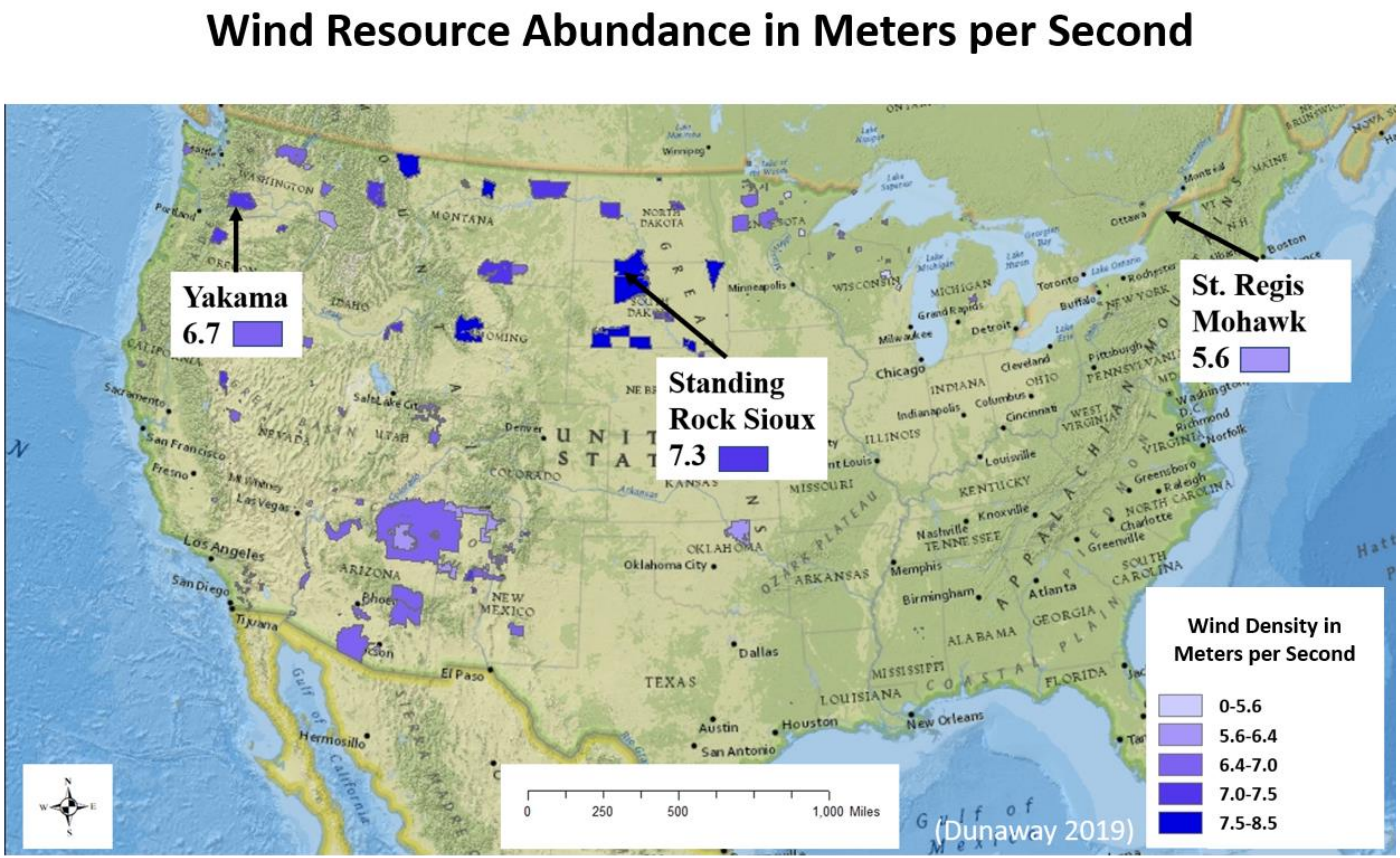


Table 12. A summary of renewable energy resources available for each example Tribal Nation collated from Maps 10,11 and 12.

Reservation Name	**Waste Vegetable Oil (gallons per day)**	**Average Solar Density (kilowatt-hours per square meter)**	**Average Wind Speed (Meters Per Second)**
Saint Regis Mohawk	1591	3.542	5.6
Standing Rock Sioux	1450	3.948	7.3
Yakama	9135	4.111	6.7

Payback period is determined by taking the initial investment and dividing it by the annual profits while accounting for the operational costs. The formula is:

payback period = initial investment/(revenue from energy production- operational costs)

For example with biodiesel, the initial investment of a single unit is about $12,000 and each 50 gallon batch requires about 2 hours of labor (Rochester Institute of Technology 2012, 34). According to the Department of Labor (2018), the minimum wage for New York for the Mohawk, an average of South and North Dakota for the Sioux, and Washington for the Yakama are $10.40, $8.85, and $11.50 respectively. Furthermore, according to the Energy Information Association (2018) as of September 2018 the price of diesel in New York, South Dakota and Washington states are $2.92, $2.84, and $3.20 per gallon, respectively. The material costs come to $1.14 per gallon for raw materials, e.g. cooking oil, methanol, lye, etc. (Rochester Institute of Technology 2012, 34). As of September of 2018, the taxation of diesel is $0.24 for federal and for New York, an average of North and South Dakota and Washington states is $0.42, $0.30, and $0.49, respectively. Using the formula initial investment ((50 gallons per day multiplied by the price of diesel- material costs and taxes) – 2 hours of labor multiplied by the minimum wage), the payback period is about 227 days for the Yakama, about 296 days for the Standing Rock Sioux, and 383 days for the St. Regis Mohawk.

The payback period for solar energy production can be figured in a similar fashion as biodiesel. According to NREL (2018), the initial capital investment is $3,782 for a 1 Kw, which would produce roughly 1,750 kilowatt-hours per year, and an annual maintenance cost of $24. According to the EIA (2018a), the average price for electricity in New York. North and South Dakota, and Washington states is $0.19, $0.12, and $0.10 per kilowatt-hours. Given this data, the payback period of solar energy for the St. Regis Mohawk, the Standing Rock Sioux, and the Yakama to about 4.8 years, 5.4 years, and 6.7 years, respectively.

The final technology that will be assessed for the example Tribal Nations is wind power generation. According to NREL (2018), the maintenance costs are about $100,000 per year with an initial investment for wind turbines in New York, North and South Dakota and Washington States are about $3.4 million, $3.2 million, and $3.2 million per turbine. A 2mW turbine would produce in New York, North and South Dakota, and Washington states about 4.4 million kilowatt-hours, 6.4 million kilowatt-hours, and 5.5 million kilowatt-hours per year, respectively. Again using the EIA (2018a), the average price for electricity in New York, North and South Dakota, and Washington states is $0.19, $0.12, and $0.10 per kilowatt-hour. The payback period for a wind turbine for the St. Regis Mohawk of 4.6 years, The Standing Rock Sioux is 4.8 years and the Yakama is 7 years.

Table 13. Payback period for each technology for the example Tribal Nations.

Reservation	Biodiesel	Solar	Wind
Saint Regis Mohawk	1.05 years (383 days)	4.8 years	4.6 years
Standing Rock Sioux	.81 years (296 days)	5.4 years	4.8 years
Yakama	.62 years (227 days)	6.7 years	7 years

The environmental impact of a renewable energy system is another factor that would be of interest to Tribal Nations. Carbon offsets can be profitable for tribes as a way to produce energy in a culturally appropriate way, while working within the U.S. government's regulations to the advantage of the tribes (Dreveskracht 2011, 153-155). One way to assess that impact is by looking at the amount of carbon that a system can offset. This can be determined by taking the amount of energy produced by a system over its lifetime and multiplying it by the average of 7.44 × 10-4 metric tons CO2/kilowatt-hour (EPA 2018). This comes to about 3,200 tons per biodiesel refinery, 240 tons per 1 kilowatt-hour solar array and 90,000 tons per wind turbine (see Table 14). But the systems produce different amounts of energy, a more accurate way to compare them would be to divide the amount of carbon offset by the initial capital investment. The cost per ton of carbon offset is about the $3.70 for both wind and biodiesel and about $16 for solar (See Table 14). If the Tribal Nations are interested in investing in a renewable energy system for environmental reasons, then they can also take advantage of carbon credits. Carbon credits are highly volatile ranging from less than $1 per ton to $139 per ton (The World Bank 2018, 17). For the purposes of this study, $15 per ton has been assumed and is a reasonable price within the United States, and much less than world bank estimates of about $40 per metric ton of carbon (The World Bank 2018, 57). If Tribal Nations take advantage of carbon credits, then they can earn close to four times their initial investment in biodiesel, close to the same amount as their initial investment in solar, and about half of the price of a wind turbine.

Table 14. Carbon offsets for each of the technologies.

	Biodiesel	**Solar**	**Wind**
Carbon Offset	3,258.72 tons per refinery	238.08 metric tons per array	89,280 tons per turbine
Cost Per Ton of Carbon	$3.68	$15.89	$3.70
Potential Carbon Credits	$48,880.80	$3,571.20	$1,339,200.00

It is critical to note that some Tribal Nations have a small land base, and even if a Tribal Nation has a larger land base, they may have a limited amount of land that they can devote to a renewable energy project. Wind has the largest spatial footprint, and for the purpose of this study it is used as the unit of study to compare with the other technologies. A wind turbine needs 10,000 m^2, which can contain 2,000 solar arrays and 1,000 biodiesel refineries. Biodiesel produces a liquid form of energy while wind and solar produce electricity directly. However, the biodiesel can produce electricity when used to power a generator and the amount of electricity produced is about 12 kilowatt-hours per gallon of biodiesel (Goldman, Thresher, and Hock 1999, 574). When comparing the electricity produced from the 10,000 m^2 biodiesel produces about 219 million kilowatt-hours per year, solar and wind produce about 6 million kilowatt-hours per year (see Table 4). Investing in enough technology to make use of the entire footprint would bring the startup cost for biodiesel to about $12 million, solar to about $7.5 million and wind to about $3.3 million (See Table 15). But, 1,000 biodiesel refineries would require 50,000 gallons of waste vegetable oil to produce, so this is not really an accurate comparison. To create a more balanced comparison, this study normalizes the data so that all the technologies produce 6 million kilowatt-hours per year. This normalization means that 28 biodiesel refineries with a footprint of 280 m^2 would produce the 6 million kilowatt-hours per at year at a cost of about $330,000 (table 16).

Table 15. Spatial factors for each technology.

	Biodiesel	**Solar**	**Wind**
Number of Units	1000	2000	1
Energy Produced	219 million kilowatt-hours	6 million kilowatt-hours	6 million kilowatt-hours
Initial Cost	$12 Million	$7.5 Million	$3.3 Million

Table 16. Spatial factors for each technology with equivalent energy production.

	Biodiesel	**Solar**	**Wind**
Number of Units	**28 or 280 square meters**	2000	1
Energy Produced	**6 million kilowatt-hours**	6 million kilowatt-hours	6 million kilowatt-hours
Initial Cost	**$0.33 Million**	$7.5 Million	$3.3 Million

The final factor that may affect a Tribal Nation's decision to invest in a renewable energy system is the amount of energy that the Tribal Nation needs to provide for each of its tribal members. According to the U.S. Census, the St. Regis Mohawk have a population of 2,788, the Standing Rock Sioux have 6,540, and the Yakama have 7,259 (US Census 2018). For the purposes of this study, the assumed consumption of biodiesel is 1 gallon of biodiesel per person per day. The average energy usage for New York is 7,451 kilowatt-hours each year per person, an average of North and South Dakota's energy usage per person is 19,285 kilowatt-hours per year, and for Washington State 12,208 kilowatt-hours a year per person (EIA 2018b). The tribal population is divided by the 50 gallons of biodiesel produced each day by a single refinery in order to find how many biodiesel refineries a reservation requires. Finding the maximum number of refineries per reservation can be calculated in a similar fashion by taking the total available waste vegetable oil for a reservation and divide it by the 50 gallons of biodiesel that each refinery can produce. The St. Regis Mohawk need 130 refineries, but only have enough resources for 30. The Standing Rock Sioux need 164 refineries but can only build 29 refineries. The Yakama need 146 refineries and have the availability for 182 refineries (see table 17). Each 1 kilowatt-hour solar panel array produces about 3,000 kilowatt-hours per year. Given that, the required number of solar arrays can be calculated by multiplying the population by the average electricity consumption per person and dividing by the 3,000 kilowatt-hours that each array can produce. The St. Regis Mohawk need about 6,700. The Standing Rock Sioux need about 42,000 arrays. The Yakama need about 30,000 arrays (see table 6). The number of wind turbines that a Tribal Nation needs can be determined in a comparable way to solar, except instead dividing by the 6,000,000 kilowatt-hours that a wind turbine produces each year. The St. Regis Mohawk require 4 turbines, while the Standing Rock Sioux require 21 turbines, and the Yakama need 15 turbines.

Table 17. Needed size of energy projects based on reservation population.

Reservation Name	Biodiesel	Solar	Wind
Saint Regis Mohawk	130 refineries/ 30 refineries max	6,700 arrays	4 turbines
Standing Rock Sioux	164 refineries/ 29 refineries max	42,000 arrays	21 turbines
Yakama	146 refineries/ 182 refineries max	30,000 arrays	15 turbines

Tribal Nations need to take into account a number of factors when investing in a renewable energy system, including the amount of a resource that is available, the payback period for each technology, how much carbon a system can offset, the space required for a system, and the energy requirements of the Tribal Nation. A Tribal Nation may want to prioritize one of these factors or take all of them into account. The most key factor is that Tribal Nations have the information to decide to invest in a renewable energy system that is right for them.

Discussion

Each technology has its strengths and weaknesses that Tribal Nations need to consider before investing in them. There is no silver bullet technology that will always work for every Tribal Nation. First, Tribal Nations have different development agendas that will affect renewable energy investment decisions. In addition, Tribal Nations have a large variation in the amount of investment capital that they can use for investing in renewable energy. In addition, some reservations can have spatial limitations that they would need to consider when investing in a renewable energy system. Finally, Tribal Nations have vastly different populations and energy needs to be able to accommodate all their tribal members.

Biodiesel has many advantages. It has a low startup cost and a quick payback period. It also has a small footprint for the amount of energy that it produces. The cost per ton of carbon offset is similar to wind, but the carbon credits can pay for the refinery many times over. However, biodiesel is a liquid fuel and is not a good source of electricity production. It is better to be used in vehicles and machinery. This means that biodiesel is an excellent source of revenue, but not an excellent source of electricity.

Solar also has significant advantages. Solar has the cheapest start-up cost ($4,000) and can be invested in incrementally to expand into a larger renewable energy project. In addition, the carbon offsets can pay most of the startup cost during the lifetime of the system. However, solar is the most expensive source of these renewable energy technologies per kilowatt-hours produced and carbon offset. Solar has the same size footprint as wind for a comparable amount of energy produced. However, the land in the solar footprint can only be used for solar panels, while the land around a wind turbine can be used for farming or ranching. In the end, solar is a reliable source of electricity, but with a high initial cost and low energy production compared to wind or biodiesel, a Tribal Nation will not make much money investing in solar energy.

Finally, wind has its own advantages. The largest advantage is that wind turbines produce a lot of electricity. The payback period is much less than solar, however if a tribe takes advantage of monetizing the carbon offsets, they can recover about a third of the initial investment. The biggest downside of wind is that a turbine is expensive to build and requires a full capital investment all at once. Wind turbines are a terrific way to produce electricity on a larger scale, but it is an expensive technology to invest and support.

However, a diversified energy portfolio can use the advantages of each technology to offset the negative aspects. One of the key components of energy security is diversified sources of energy (Yergin 2006, 70). A diversified energy portfolio creates a more stable energy investment because it protects against catastrophic failure. Because energy sovereignty is a process towards energy security, Tribal Nations should be investing in a diversified energy portfolio (Li 2005, 2243). An example of a diversified energy portfolio would be if each Tribal Nation invested to build enough biodiesel refineries to use half of the available waste vegetable oil, half of their energy need in solar and a single wind turbine. The St. Regis Mohawk can produce about 95% of their needed electricity at a cost of about $11.6 million with a payback period of about 4.2 years. The Standing Rock Sioux can achieve 57% of their required energy with an investment of about $43 million and a payback period of 5.3 years. The Yakama can produce about 68% of their energy with an investment of about $32 million and a payback period of 6.6 years. It is important to note that the payback periods for a diversified portfolio are similar to the payback periods of just investing in wind, this means that the revenue of biodiesel can almost completely offset the cost of investing in the solar part of the portfolio. It is also important to know that a Tribal Nation can invest in each of the technologies over time.

Table 18. Factors for a diversified energy portfolio that invests in half the available biodiesel resources, one wind turbine and half of the tribes' energy needs addressed with solar energy.

Reservation Name and Yearly Energy Needs	Energy Produced	Initial Investment	Payback Period
Saint Regis Mohawk 20,773,388 kilowatt-hours per year	19,671,694 kilowatt-hours per year (95% Energy Need)	$11,671,450	4.2 Years
Standing Rock Sioux 126,123,900 kilowatt-hours per year	72,346,950 kilowatt-hours per year (57% Energy Need)	$42,907,267	5.3 Years
Yakama 88,617,872 kilowatt-hours per year	60,295,942 kilowatt-hours per year (68% Energy Need)	$31,940,453	6.6 Years

If these tribes invest in a diversified energy portfolio, the payback periods are similar and in most cases the technologies will pay for themselves quicker than investing in wind or solar alone. In the case of the St. Regis Mohawk, they can pay for a diversified energy portfolio in 4.2 years while it would take 4.6 years for wind and 4.8 years for solar. The Standing Rock Sioux can pay for a diversified energy portfolio in 5.3 years while solar and wind would take 5.4 years and 4.8 years, respectively. The Yakama can pay for a diversified energy portfolio in 6.6 years, solar 6.7 years and wind in 7 years. By continuing to invest in a diversified energy portfolio at the same rate as is described in this dissertation, the St. Regis Mohawk can be energy secure in 4.4 years, the Standing Rock Sioux in 9.2 years and the Yakama in 9.7 years. These reservations utilizing this investment plan would be able to produce all their energy through renewable energy within a decade.

Table 19. Comparing a diversified renewable technology investment payback period to wind and solar.

Reservation Name and Estimated Time to Become Energy Secure Using Diversified Technology	Payback Period (Diversified Technology)	Payback Period (Solar Only)	Payback Period (Wind Only)
Saint Regis Mohawk ~4.4 Years to Energy Security	4.2 Years	4.8 years	4.6 years
Standing Rock Sioux ~9.2 Years to Energy Security	5.3 Years	5.4 years	4.8 years
Yakama Reservation ~9.7 Years to Energy Security	6.6 Years	6.7 years	7 years

A Tribal Nation could begin with small investments. If they started with biodiesel and used it to produce revenue, they could build refineries one by one until the Tribal Nation found a natural maximization of the usage of the available waste vegetable oil. They can then begin using the profits to invest in solar arrays. The Tribal Nation could use the solar arrays to offset the energy costs for the Tribal Nation's most vulnerable households. Finally, over time use the money from the biodiesel and solar projects to invest in wind turbines that could supply electricity on a larger scale. Once the technologies are paid off, there is the potential for the technologies to produce a profit. Those profits could then be reinvested in educational initiatives, new or more efficient renewable technologies, and/or to lobby for Native American energy policy reforms in the United States Congress. In the end, a diversified energy portfolio can create more profit, offset negative aspects of each technology, and maintains a more stable energy production system, and Tribal Nations should be very serious about investing in them.

Conclusion

Each of the factors that this chapter examined are important for Tribal Nations to consider. The amount of a renewable energy resource that is available for the Tribal Nations is key because if there is not enough of a resource the technology will not function efficiently. Payback period is important for several reasons: 1) it is the time to recover the initial investment, 2) after that time the revenue generates a net profit, 3) it is the amount of time that you can double the amount of a technology through reinvestment. Most Tribal Nations are concerned about the environmental impact of a technology, so the amount of carbon is important for two reasons, it helps to combat climate change and the carbon credits can help offset the initial capital investment shortening the payback period. Many Tribal Nations also have spatial concerns, so knowing the size of the footprint of a technology and how to maximize their investment for the least amount of space required for a technology is of interest. Finally, the goal for most Tribal Nations is to supply enough energy to provide for all their tribal members, which is why this study examined the number and limitations of each technology based on the tribal populations. All these elements come together in this study to assess the assess ability of the renewable resources on the example reservations.

Tribal Nations are not limited to only investing into a singular resource. Moreover, investing in multiple technologies provides a more stable means of energy production, and thus a more secure investment. By investing in all three of the technologies, the downsides of each can be mitigated. This study demonstrated how moderately investing in all of the technologies can increase the profit potential of a Tribal Nation's investment, keeps the payback period similar to just investing in wind, and can provide for the majority of a Tribal Nation's energy needs. This means that the Tribal Nation can have more profits made in less time than investing in a single renewable energy system alone. The additional profits can be used to address other energy concerns of the Tribal Nation, like infrastructure improvements, or social concerns, like education. In the end, a diversified energy portfolio does the most good for the highest number of tribal members and can help with issues like elders being able to afford their bills and pay for food.

A Tribal Nation that invests in energy sovereignty can use that to strengthen other sovereignty issues. Biodiesel can strengthen food sovereignty. First, it can be used to run farm equipment and increase crop yields. In addition, it can be a fuel source to transport livestock. Furthermore, the revenue biodiesel sales can help fund community gardens and locally sourced foods. Decreasing energy costs can help with health sovereignty concerns. Tribal Nations can provide energy at a lower cost if they produce their own electricity. This can reduce monthly energy costs to tribal members, so that can more easily afford medications or visits to the doctor. Being in control of their own energy, Tribal Nations can invest in lobbying for other issues with Congress, buy back tribal land that was lost, and strengthen their own laws and authority, all of which can help deal with political sovereignty issues. On tribal lands, nothing happens in a vacuum. If one element of sovereignty is strengthened, the other elements of sovereignty can do so as well.

Accessibility of the renewable resources is also important in the context of this dissertation. The availability of a resource is fundamentally tied to the land, in a similar way that tribal culture is tied to the land. Because some Tribal Nations have been relocated away from their homelands, it is important to address both the accessibility of a resource and the cultural relevance of renewable technology to a Tribal Nation. Resources on reservations are heavily subject to U.S. laws and policies. Any resource above or below tribal lands is subject to management by the United State government. As of now, renewable resources are not subject to those laws, and so understanding the accessibility of the renewable resources is key to Tribal Nations being able to make their own policies and lobby against federal involvement in the management of those resources. Finally, as Tribal Nations become more interested in investing in renewable resources, researchers need to know how to work with Tribal Nations to create mutually beneficial outcomes. One way to do that is for researchers to be able to provide Tribal Nations with data about their renewable resource accessibility, so they can come to Tribal Nations with something to offer, and not start out with what they want to take from Tribal Nations. Accessibility of a resource serves as a primary driver of decisions that strengthen energy sovereignty and is fundamental to the technological appropriateness of renewable energy projects.

Chapter 5: Methodology for Working with Indigenous Communities

Introduction

This chapter focuses on examining the best practices when conducting research with Indigenous communities as a pathway for this research to take its next steps. Ethical research empowers Indigenous communities. Furthermore, there are multiple pathways that empower Indigenous communities because each has its own history, culture, and social issues. And as such, ethical research needs to be flexible, community-oriented, and decolonizing (Smith 1999, 118). Within the academy, Indigenous methodologies incorporate concepts of Participatory Action Research (Denzin, Lincoln, and Smith 2008, 157-173). Furthermore, Indigenous methodologies specifically focus on strengthening Indigenous communities. Indigenous methodologies serve to erode the foundations of colonization and rebalance the power dynamics between researchers and Indigenous communities (Wilson 2008, 55-56). This chapter uses the *AAG Indigenous Peoples Specialty Group's (IPSG) Declaration of Key Questions About Research Ethics with Indigenous communities* as the foundation to discuss conduction research with Indigenous Communities. The IPSG's Declaration (2010) has six key focus areas: 1) Formulating the Project, 2) Identities of Researchers, 3) Partnerships, 4) Benefits, 5) Findings, and 6) Deepening Relationships. Each focus addresses issues that researchers may encounter when working with Indigenous communities, even before the research is conducted and continues after the research is concluded.

Researchers who use Indigenous Methodologies need to begin with planning their research by keeping in mind the communities' priorities. The researchers need to build community capacity, create a collaborative research agenda, and work with the community to get their consent to do the research. Next, researchers need to be transparent about who they are and what their motives are. Researchers, institutions, and funders all have their own interests that need to be disclosed to the community. In addition, effective research with Indigenous communities requires the researchers to build strong relationships with community members; they need to be allies that rely heavily on community advisors to inform the research process, as well as, work within the community to develop the most appropriate methods for them. Moreover, for research to be sustainable, researchers must not only focus on their data, but also on how the data can be of use to the community. If researchers prioritize the goal of being invited back to the community, then they should focus on the reciprocity of the benefits and creatively become an asset beyond simply conducting their research.

Working with tribes when producing findings can reduce misinterpretation and ensure accurate representation for the community. Researchers need to continue strengthening their relationships with the community long after their research has been concluded and should explore how they will to be of service in the future, and in doing so they can further their research goals as well as empower the community.

Formulating the Project

Formulating the project may be the most crucial step when conducting research with an Indigenous community. It is the step that Linda Smith (1999, 120) refers to as having the researcher's face seen by the community. The researcher needs to build trust to facilitate their research by being seen in person or through technology. It is essential to work with the community to create a collaborative research agenda that can accomplish both the researcher's and the community's goals (Kassam and The Wainwright Traditional Council 2001, 206-207, Kassam and The Soaring Eagle Friendship Centre 2001, 3-5). Therefore, the researcher can conduct a more in-depth study while being of service within the community. A vital part of creating a collaborative research agenda is getting informed consent. For example, researchers should find approaches that go beyond the Institutional Review Board (IRB) process to work with the communities to develop standards that work for the community as well as the researcher's institution. In addition, the researcher can create collaborative methods that reflect the community's values while adhering to academic rigor.

Institutional Review Board (IRB) requirements are founded in medical research which prioritizes the physical wellbeing of the subjects, and do not consider social or cultural harm. Successful collaborative research informs the community of the research methods and creates a dialogue about their implementation with the community. Some Indigenous community members have felt that the IRB process does not adequately protect them from harm leading to some communities to develop their own review processes that are more rigorous than the standard academic IRB process (Louis 2007, 137). These community review processes can be formal or informal ways to assess the risk of possible cultural or societal harm to the community (Kelley et al. 2013, Jengan et al. 2016, Brugge and Missaghian 2006). If the Indigenous community does not have their own review process, the researcher can be a benefit by discussing how the community can design their own process and establish a precedent for how they can collaborate with researchers in the future. It may seem that creating community research protocols impedes the research process, but if done correctly, the research can be enriched by community collaboration in the IRB process and it can facilitate building relationships between the community members and the researcher (Kelley et al. 2013, 2150). Working with Indigenous communities to develop their own review process is another way for researchers to build community capacity.

Building *community capacity* requires the researcher to spend time with the Indigenous communities building relationships. Building community capacity at a fundamental level when a researcher develops multiple types of networks, both between the researcher and the community and between community members themselves, to increase both the ability to conduct research, but also to strengthen the community overall (McDonald and Raderschall 2019). It may require the researcher to meet with community members doing community activities, participating in local customs, and honoring traditional rites (Castleden, Morgan, and Lamb 2012). Through these types of experiences, the researcher can contextualize their own research as well as build an understanding for community values and worldviews. These insights can align the research with the community's ideals, while supplying the researcher a context in which to discuss their research. Spending time in the research location makes it easier to negotiate how the research will be conducted and gives the people an opportunity to voice their concerns about the research. By doing this, the researcher can better understand what is important to the people, and as a result, prioritize the community's goals equally with their own research agenda. By prioritizing what is important to the people the power dynamic is rebalanced which forges a stronger research partnership (Kassam and The Wainwright Traditional Council 2001, 207, Robinson, Kassam, and Rantala 1998, 39-49). Strong partnerships reduce the chance that the Indigenous people will feel exploited by the researcher and shows how research can be conducted with the community's needs in mind. In addition, those partnerships are the foundation for building collaborative research agendas co-creates new knowledge that can shared by the both the Indigenous and academic communities.

Both the researcher and the community reach their goals by co-creating a research agenda. The first step in the process is discussing the community and researcher's goals. This can be done through a method like Cognitive Mapping, Visual Charting, or through a workshop that focuses on the Gallery Walk exercise. Cognitive Mapping is a process the community members draws on a large paper that demonstrate the important aspects of the area which gives the researcher a foundation to discuss how their research can align with the values of the community (Kitchin and Freundschuh 2000). The discussion encompasses both the similarities and differences between what the researcher thinks is important for the community and what the community members think is important to them. Visual Charting is similar to Cognitive Mapping, however, the charting process can focus on concepts, attitudes, or even as a means to create a common vocabulary, which is important when working in communities with people who speak different languages (Jengan et al. 2016). A Gallery Walk is similar to Cognitive Maps, but the researcher with the collaboration of community leaders compose broad questions at the top of large pieces of paper, and then the community members write their responses beneath them (Shallwani and Mohammed 2007, 5). The Gallery Walk exercise includes either small groups walking from paper to paper and discussing the questions, and/or the papers presented to the group to articulate common themes. In both methods, the goal is to create a vibrant discussion where the community learns more about the research components and the researcher learns more about the community. As a result, the researcher can explore common ground, so that the outcome of the research is an empowering experience to ease future community interactions with researchers. Furthermore, to carry this out, the researcher needs to be flexible enough with their research and methodology to be able to accommodate the community's needs.

Identity of the Researcher

Understanding the identity of the researcher is a key element of informing the community about the research. When working with Indigenous communities, researchers need to confront their own deep colonization and recognize that the process of their own institutionalized education may have created biases that have gone unnoticed (Rose 2002, 182). Respecting local customs is a process that makes the researcher more accessible and helps to rebalance the power dynamic between the researcher and the community members. This means that the researcher must be willing to self-reflect, and their interactions, on multiple levels. An example of a multiple layered reflection would be transparently reflecting on one's self, their close relationships within the community, and the community as a whole in a larger context (Nicholls 2009). Discussing the researcher's identity can include sharing their family lineage, places that they have lived, why they went into their field, and should not be limited to talking about their academic credentials (Robinson, Garvin, and Hodgson 1994, 6). With many Indigenous communities, there are limited educational opportunities, so simply discussing who they are academically may create a divide between the researcher and the community members. The researcher may include inviting community members to participate in the researcher's hobbies or learning new skills from the community members (Brody 1981). The researcher needs to break with an objective observational model and need to become a part of the community because there are insights that cannot be understood from just watching the community as an outsider. In addition, by working within the community, the researcher refines their own identity and worldview (Nicholls 2009, 25). The benefits of this are threefold. First, a more complex worldview can drive the research in unanticipated directions. Second, the researcher constantly refines their identity, which will be shared with new communities. Third, as the research evolves, so does the researcher's identity.

Another key element of the researcher's identity focuses on the universities that are supporting their research. Universities have their own goals when supporting researchers in their field, and community members need to understand those goals. Researchers need to discuss what is important to their field and what are the field's fundamental principles. Discussing one's discipline with Indigenous community members creates the opportunity for researchers to find ways beyond the thinking in their own field and expands the conversation both within the community and within the field (Denzin, Lincoln, and Smith 2008, 140). Including communities in that discussion can enrich academic priorities in the future as well as creating a greater understanding between a researcher and the community. In addition, the community leadership may want to check the credentials of the researcher and their institution by scrutinizing their record of work with other communities (Kassam and The Wainwright Traditional Council 2001, 207). Moreover, merely saying that a researcher is supported by a specific university, assumes that the community members know the history of that university. Discussions about the researcher's institution may include its history, founding principles, and acknowledging the Indigenous community of whose lands the University was built. Furthermore, each department has their own goals that can influence the type of research conducted by its faculty, so it is important for the researcher to discuss their department's ideals. Discussing the departmental interests also provides a means for community members to contact other members of that department to advocate for their own research agendas or to assess the researcher's academic reputation (Chambers 1997, 1746). By being transparent with the ideals of their department, the community can address any potential issues that may arise from the research process.

The source of a researcher's funding is the final element that needs to be discussed with the community. In having this discussion, the community members can address any potential conflicts of interest. For example, if the researcher's funding comes from the U.S. Military, the community members may feel betrayed if that source of funding is not disclosed (Bryan and Wood 2015). Even if a researcher adheres to the all the other elements of ethical research and does not disclose their source of funding, their reputation, trust, and community relationships can be damaged. Indigenous community do not exist in a vacuum, the researcher's funding source will most likely be discovered, and even if that does not occur during the research process, it will be exposed when they publish their findings. The community's reaction to that betrayal of trust, makes the research process more difficult for the researcher and subsequent researchers. There is a greater benefit to being honest with the community and addressing their concerns that far outweighs the cost of not being transparent and losing a research partnership. Sustainable research means that the research is continuously viable and creates an environment in which other researchers can conduct future research.

Partnerships

Ethical research with Indigenous communities depends on creating strong partnerships with the community members. To create those partnerships a researcher needs to work with a group of community advisers. Community advisers collaborate with researchers to establish a research agenda that meets the community's and researcher's goals, can help resolve misunderstandings between the researcher and the community and assist in validating the data throughout the research process (Kassam and The Wainwright Traditional Council 2001, 207-208, Robinson, Kassam, and Rantala 1998, 32). Community advisers can be political leaders, elders, or anyone that maintains the respect of the community. While working with community advisers it is important to discuss the issues that the community if facing and find ways that the research can benefit the community. Respecting the community's agenda can include community action projects or creating spaces within academic institutions for the community's voice to be heard (Smith 1999, 125). Research that is practical for the community is paramount to ethical research, otherwise there is little use of working within Indigenous communities. In addition, creating spaces in academia for community members creates the opportunity for Indigenous communities to build a cohort of their own researchers. Another issue that researchers need to work with community advisers on is formulating the methods that the researcher will use. Researcher's methods need to be diverse and pluralistic to be able to adapt different contexts (Chambers 2008, 13). Thus, a researcher needs to be flexible with regards to their methods because community members may not be receptive of certain methods. For example, a community may have had negative experiences with surveys, so a research may have to find a way to collect data that does not include using surveys. By working with a group of community advisers, researchers can avoid creating new negative experiences in communities and foster the trust that is the basis for effective research.

Benefits and Rewards

It is important for researchers to honestly examine the benefits that they will receive and attempt to reciprocate those benefits for the community. The researcher needs to work with community members to establish ways that their research agenda can align with the community's priorities. Even though the community and the researcher may have different goals, the research can be mutually beneficial to both groups and it is important to find where those there are opportunities can synergize. Ethical research needs to be sustainable, much in the same way that economic development in Indigenous communities needs to be sustainable. Therefore, research that is merely extractive damages the community just as resource management that is extractive damages the environment. The research itself needs to benefit by revitalizing the community while maintaining its culture (Denzin, Lincoln, and Smith 2008, 506). Beneficial research delineates the difference between research on an Indigenous community and research for an Indigenous community. Research is an appropriation of knowledge from the community and the community needs to adequately benefit from that appropriation (Louis 2007, 133). The researcher can compensate the community monetarily, however, there are several ways that the researcher can give back to the community that has longer lasting benefits.

Reciprocity of the community's generosity is key. Reciprocity can be small things, like honor gifts that are culturally appropriate for a community member hosting the researcher in their house or sharing a story about the researcher after a community member has shared one of theirs. It can also include larger things, like preforming good works around the community, establishing programs that will have long-term impacts, like a peer tutoring program for high school students. The concept of reciprocity is vital when it comes to the research and sharing the results.

Research can address the community's needs in many ways, including working with community members to collect data in culturally appropriate methods and sharing the research findings to the community. In addition, researchers should find creative ways to be of benefit to the communities in addition to the research itself. For example, researchers can advocate on behalf of the community's goals to other stakeholders, work with community members to provide new skills, and work to support the academic goals of younger community members (Chambers 1995, 201).

As my work continues, one of my main priorities when working with community members is creating academic opportunities for some of the community members that I work with to come back to my home institution to earn advanced academic degrees. This will help to rebalance the dynamic between myself as a researcher and those I work with, by creating a cohort of community researchers. There are many ways that researchers can be of value to communities, however the researcher can only effectively be of value if they work closely with the community members and innovate creative ways to become beneficial.

Sharing Results

One of the main goals of conducting research in Indigenous communities is for the research to be useful to the community. Thus, the research findings need to be shared with the community. The findings should not just be shared at the end of the research process, but the research needs to be validated throughout the research process (Kassam and The Wainwright Traditional Council 2001, 32, Robinson, Kassam, and Rantala 1998). Validating the data throughout the research process allows the community to give feedback about the data and reduces the likelihood that the researcher misinterprets the data. The group of community advisers is key to the validation process and should be consulted throughout the entire data collection and interpretation process. The final findings should be presented to the community. An example of this is by hosting several community dinners where the research can be presented. This creates a space for the community to see the research, to give final feedback and is a way that the researcher can give back to the community.

In addition to sharing the findings with the community, researchers need to discuss who owns the data. The community and the researcher need to agree on ethical practices, safe data management, ownership of data and authorship of publications (Robinson, Garvin, and Hodgson 1994, 7, De Crespigny et al. 2004, 9). Examples of this are a discussion about where the data storage: will it be housed at the home institution or with the community, will it be digital or on paper, who will have access to the data, etc. Several researchers chose to co-publish with the community or community members as a way to share their findings of the research including two members of my committee Dr. Karim-Aly Kassam (Kassam and The Wainwright Traditional Council 2001, Robinson, Kassam, and Rantala 1998, Kassam and The Soaring Eagle Friendship Centre 2001) and Dr. Shorna Allred (Jengan et al. 2016). This also acknowledges that the knowledge gained from the researcher belongs to the community as much as it does the researcher. It also rebalances the power dynamics between the researcher and the community. Furthermore, by co-publishing with the community, the researcher is effectively setting up co-ownership of the research data and the findings. The knowledge arises from the community and it is important that the research find ways to ensure that the knowledge stays tied to the community.

Deepening Relationships

The researcher's obligation to conduct ethical research does not end when the research is concluded. The mutual trust and respect initiated by the research project forged through strong alliances reinforce a sense of movement towards a positive future for the research and the community (Smith 1999, 104). Maintaining the research relationships provides the opportunity for continued research with the community. In addition, by building lasting relationships with communities, the researcher can open the door for other researchers. Furthermore, the researcher can be consulted by the community concerning future researchers and research opportunities. Staying connected with the community facilitates the opportunity that if there are negative impacts due to the research, the researcher can be held accountable and find ways to mitigate the harm. Researchers that build strong alliances reinforce a sense of movement towards a positive future for the research and the community (Kassam and The Wainwright Traditional Council 2001, 209, Kassam and The Soaring Eagle Friendship Centre 2001, 4-5). The researcher needs to not only create a positive research experience for the good of their own research, but to create a foundation for those who follow. By being an example of how researchers can have a positive impact on the community, the community will hold future researchers to that same mark and recognize when a research has the potential to cause harm to the community. If each researcher tries to leave the communities better off than they found them, Indigenous communities will continue to be empowered by research and will be more likely to build positive collaborations with researchers.

Conclusion

The focus of my research is to strengthen Indigenous energy sovereignty. However, that research is pointless if how I conduct my research disempowers the communities that I work with. For my research to be effective, I need to conduct it in an ethical manner. This chapter sets forth how I will conduct my research working in collaboration with Indigenous communities. Making explicit these protocols is important because Indigenous communities have been damaged by extractive research practices. Research conducted for the sole purpose of gathering data with no regard for the communities' values is not my objective. As such, as a researcher part of my responsibility is to remember the damage of the past and be an example of how researchers should conduct themselves in the future.

The first thing that I will do is spend time in the communities not directly conducting research but establishing relationships. This will allow the community to get to know me as a person and as well a researcher. Furthermore, it will allow me to get to know the community and their priorities. Understanding those priorities is the foundation for creating a collaborative research agenda and opens new avenues for research opportunities. In addition, it provides the time for me to strengthen the relationships with community members and create a community advisory board. The community advisory board serves as the point of contact for creating a collaborative research agenda, developing research methods that align with the community's values, and a mechanism to validate the findings throughout the research process.

The next priority for my research is sharing my findings with the community. I would like to share my findings at a community meal. Furthermore, it is important for me to co-publish with the community because it demonstrates that the knowledge was co-produced through a collaborative process that included the community.

Finally, I want to continue to support the relationships that I built during my research after it is concluded. The community needs to be able to communicate with me if there are any issues with the impacts of my research project, as well as be able to discuss future research directions. . My research focuses on sustainability, so the research itself should be sustainable. By creating a positive research experience for Indigenous communities, I hope to be a template for future researcher-community relationships that go beyond the acquisition of knowledge and is founded in the building long-term partnerships. Building and supporting those partnerships empowers the communities and makes me an effective collaborator and researcher.

Chapter 6: Conclusion

The main goal of this dissertation is to provide tribal leaders with the information that will allow them to make renewable energy development decisions that are most appropriate for their reservation. The goal was not to create a recommendation for tribal leaders to invest in a specific technology or a specific mixture of them. Any recommendation would promote binary thinking, to accept or not accept the recommendation. Tribes need to find their own creative solutions to solve energy sovereignty issues. They need to find a “third space”, or a space for solutions that are beyond binary constructs (Bruyneel 2007). In order to promote third space thinking, this dissertation has focused on how tribes can invest in the most technologically appropriate renewable energy projects. Strong technological appropriateness of a renewable energy project equates to better odds of success and an increase in the longevity of the projects. If a project is not technologically appropriate, then it is more likely to create more problems than it solves. This is doubly important for tribes who want to build and maintain renewable systems, because these projects are on their limited land base. Therefore, any energy project that degrades tribal land weakens their sovereignty.

Chapter 2 explored how academics may collaborate with Indigenous communities in ways that can empower the community. Academics can provide expertise and logistical support for tribes who want to invest in renewable energy systems. Furthermore, academics have a responsibility to find methods to reverse the trend of extractive research conducted on Indigenous communities. Without strong protocols, it does not matter how technologically appropriate a renewable energy system is, if the tribes feel exploited the project has a higher likelihood of failure.

Chapter 3 examined the availability of renewable resources for reservations. Tribes need to be able to refine renewable resources, but they need to know which resources are the most abundant on their lands. However, this dissertation examined the availability from various perspectives (i.e. economic, environmental, spatial). Tribes have different development goals, which means that they may prioritize one element of availability over others, or a combination of elements. Thus, this chapter did not seek to tell tribes what renewable energy projects that they should invest in, but focused on providing information that could further justify what types of projects they would like to invest in.

Chapter 4 focused on the cultural factors of technological appropriateness for Native American tribes. There were two main goals for this chapter: 1) to demonstrate that there is a relationship between culture and place, and 2) to examine how that relationship could indicate which renewable energy technologies are more likely to align what a tribe’s culture. The connection between culture and a tribe’s environment were associated by determining if their language family had more words for trees, wind or sun. Furthermore, maps were created through GIS to show which biomes were predominant for each tribe’s language families. The Yakama and St. Regis Mohawk had more words for trees, had homelands were in predominately forest biomes, and were in areas that had the highest biomass density. The Standing Rock Sioux had the most words for wind, had a homeland that was predominately prairie biomes, and had the highest wind density. Finally, this has shown that tribal culture (demonstrated through their languages) have a relationship with the biomes of their homelands. In addition, the high frequency of "wind" words for the Standing Rock Sioux and "trees" for the Yakama and the St. Regis Mohawk show that there is a cultural affinity for those elements of the environment. The biomes are well suited for different technologies, i.e. wind for prairie biomes and biomass for forest biomes. Thus, for the Yakama, Standing Rock Sioux and the St. Regis Mohawk, their cultures, the biomes of their traditional homelands, and their cultures are most likely to be aligned. Therefore, wind technology is not only well suited for the Standing Rock Sioux's biome, it is also more likely to align with their culture. In addition, biomass (in the context of this dissertation, biodiesel) is well suited for the Yakama and St. Regis Mohawk's biomes, it is also more likely to align with their cultures as well.

Chapter 5 focused on the role that policy has concerning the technological appropriateness of renewable energy projects on tribal lands. First, the chapter outlined the history of the United States' policies concerning tribal resources. The conclusion of which demonstrated how tribal natural resources have been heavily regulated by the United States government which limited tribes' ability to exercise their sovereignty. In addition, policies regarding tribal renewable energy development has not been heavily regulated and as such can be a mechanism for tribes to strengthen their sovereignty. Second, the chapter examined the documents produced by tribes, academics and U.S. policymakers to determine areas in which tribes can reframe their communication to build stronger collaborations with both academics and policymakers. Examples of this include tribes discussing their environmental concerns as public health issues with policymakers and/or tribes framing renewable energy projects as sources of data and innovation with academics. By building stronger partnerships with policymakers and academics, tribes can increase the technological appropriateness of a renewable energy projects. One of these ways is by working with policymakers to create initiatives that can increase the funding for renewable energy projects on tribal lands, thus increasing the economic efficiency of the project. Understanding the history of U.S. policies about tribal resources and effectively communicating with academics and policymakers, renewable energy projects are more likely to be successful for longer.

Synthesis

The assessment that this dissertation has outlined can be used for any tribal government to determine a pathway to strategically invest in renewable energy projects on their reservation. A synthesis of the assessment will be demonstrated using the three example tribes (Standing Rock Sioux, Yakama, and the St. Regis Mohawk), The protocol is fairly straight forward, each technology is ranked from 1 to 3, 3 being the highest for each category. If two categories are equally best suited for the reservation, both are given a 3, and if two categories are equally second best, they are both given a two. Next, by adding up all of the values for each technology, a tribe can determine which technology is best suited for their reservation, or the order in which to invest in multiple technologies. The Standing Rock Sioux have high wind density and moderate solar and biodiesel resources available. Although for this tribe, there is a high payback period for biodiesel, and a shorter payback time for wind than solar. Biodiesel and wind have comparable cost per carbon offset, while solar has a much higher cost to offset carbon. For all of the tribes, biodiesel produces the same amount of energy at almost 10% of the cost of wind and about 5% of the cost of a solar energy project. To accommodate the energy needs of the reservation the tribe would need 21 wind turbines with a startup cost of about $67 million, 42,000 solar arrays at a cost of $156 million, and is limited to 29 biodiesel refineries out of 164 needed at a cost of about $350,00. Culturally, the Sioux are more aligned with wind-based technologies, followed by solar, and biomass. Finally, the linguistic analysis of tribal policies showed that biomass technologies over both solar and wind technologies for all the tribes. Based on this information, wind is the most technologically appropriate for the Standing Rock Sioux, followed by biodiesel and the solar (see Table 20).

Table 20. The Standing Rock Sioux Technological Appropriateness Summary

	Culture	Policy	Density	Payback Period	Cost/ Carbon	Space Needed	Max Avail.	Sum
Solar	2	2	2	1	2	2	2	**13**
Wind	3	2	3	2	3	2	3	**18**
Biodiesel	1	3	2	3	3	3	1	**16**

The St. Regis Mohawk have moderate solar density and low wind and biodiesel resource availability. Biodiesel has the fastest payback period followed by solar and wind. The St. Regis Mohawk's technology is rated the same for the cost per carbon offset and the amount of energy produced within a limited land base. They require 130 refineries but can only build 30 at a total cost of $360,000, and need 4 wind turbines at a total of about $13 million, and 6.700 solar arrays at a cost of about $26 million. In addition, the St. Regis Mohawk come from a culture that is largely based in forested areas and have a high number of words for trees, and trees are a dense biomass resource, it is more likely that biomass technologies (in this case, biodiesel) are more in line with their culture, and with both wind and solar being equally less culturally relevant. Based on this information and the information regarding all of the technologies, biodiesel is the most technologically appropriate technology followed by wind and solar, respectively (See Table 21).

Table 21. The St. Regis Mohawk Technological Appropriateness Summary

	Culture	Policy	Density	Payback Period	Cost/ Carbon	Space Needed	Max Avail.	Sum
Solar	2	2	3	1	2	2	2	**14**
Wind	2	2	2	2	3	2	3	**16**
Biodiesel	3	3	2	3	3	3	1	**18**

The Yakama have high biodiesel resources along with high solar density and moderate wind density. The fastest payback period is biodiesel, followed by solar and wind. Due to the limitations of the current technology the cost per carbon offset and the amount of energy produced within a limited land based is the same for the other two tribes. In order to meet their energy demands, tribe needs 30,000 solar arrays at a cost of about $113 million or 15 wind turbines at a cost of about $50 million and can meet all of their biodiesel needs with 146 biodiesel refineries at a cost of about $1.8 million. Due to the high number of words for trees (a high biomass source) biomass technologies, like biodiesel, are also more culturally appropriate to the Yakama, followed by wind and solar, respectively. Thus, biodiesel is the most culturally appropriate technology followed by solar, and wind is the least technologically appropriate for the Yakama (See Table 22).

Table 22. The Yakama Technological Appropriateness Summary

	Culture	Policy	Density	Payback Period	Cost/ Carbon	Space Needed	Max Avail.	Sum
Solar	1	2	2	2	2	2	1	**12**
Wind	2	2	3	1	3	2	2	**15**
Biodiesel	3	3	3	3	3	3	3	**21**

This assessment is useful if a tribe is already interested in a technology and are looking for ways to justify investing in it. If a particular technology is more in line with a tribe's development plan, then they can look to the highest ratings for that technology to support their arguments for that technology. An example would be if the St. Regis Mohawk were interested in investing in wind technology they could focus on the fact that wind offsets the most carbon per dollar invested and they can provide enough energy for the tribe without committing a lot of land.

Next Steps

The next logical step for the research based on this dissertation is to work directly with a tribe to invest in a renewable energy project. The protocols set out in Chapter 5 will be useful for any researcher that desires to collaborate with an Indigenous community but are particularly salient with this research. The goal of Indigenous methodologies is to conduct research that strengthens the community. This goal is doubly important because the goal of a tribal renewable energy project is to empower the community. It is paramount to begin the methodology before working with the community and follow it through after the project is complete.

Another way that this research can move forward is ground-truthing the data. First by presenting the assessment in this dissertation to one of the example tribes and discussing its accuracy. In addition, ground measurements of the solar, wind and biodiesel resource density can be taken and used to adjust this dissertation's resource availability map data. The next step is to work with the tribe to determine a renewable energy that they would like to invest in. However, there are two main elements of this step. First, tribes need to make the choices base on the information I have provided, because making those decisions is fundamental to the process of energy sovereignty moving from energy poverty to energy security (Laldjebaev, Sovacool, and Kassam 2015, 107). Second, as the tribe creates their own "third space" by making their own decisions, creates an opportunity to examine the factors that affect those decisions. Examining those factors is important to understanding a tribe's cultural values. Understanding those values may help other tribes clarify their own thinking when it comes to creating "third space" solutions for their tribal issues. Another opportunity for future research is to engage with the process of acquiring the initial capital for a tribal renewable energy project. This will provide a means to put into practice the results of the word frequency analysis and determine to what extent reframing their communication with academics and policymakers. Furthermore, it is an opportunity to examine the impact of reframing their communications on forging stronger partnerships and their ability to acquire funding for a renewable energy project. In the end, partnering with a tribe to build a renewable energy project provides several different avenues for this research to continue.

At its heart, this dissertation is founded in pragmatism. Creating a way to assess the technological appropriateness of renewable energy systems on reservations is not a mental exercise. This information is meant to be used by tribes as a means to exercise and strengthen their sovereignty. As such, it is also primarily important that this information is disseminated as broadly as possible. The focus for publishing this dissertation will be in book form, so that it is easily accessible for tribes. Furthermore, the chapters will be submitted to journals that cross the natural and social science boundaries to reach an interdisciplinary audience. The nature of working with Indigenous communities is that they have complex problems and need people with expertise in several fields. This research, for example, draws on the fields of Natural Resources, Geography, Indigenous Studies, Linguistics, and Policy Analysis. Indigenous communities need allies who wear a lot of hats and build transdisciplinary research cohorts who focus on creative solutions to practical problems, as well as make room for ideas that might work in the future.

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