

MAPPING BOLIVIA'S SOCIO-POLITICAL CLIMATE:
EVALUATION OF MULTIVARIATE DESIGN STRATEGIES

A Thesis
by
CHERYL A. HAGEVIK

Submitted to the Graduate School
Appalachian State University
In partial fulfillment of the requirements for the degree of
MASTER OF ARTS

August 2011
Department of Geography and Planning

MAPPING BOLIVIA'S SOCIO-POLITICAL CLIMATE:
EVALUATION OF MULTIVARIATE DESIGN STRATEGIES

A Thesis
by
CHERYL A. HAGEVIK
August 2011

APPROVED BY:

Dr. Christopher A. Badurek
Chairperson, Thesis Committee

Dr. Kathleen A. Schroeder
Member, Thesis Committee

Dr. James E. Young
Member, Thesis Committee

Dr. Kathleen A. Schroeder
Chairperson, Department of Geography and Planning

Dr. Edelma D. Huntley
Dean, Research and Graduate Studies

Copyright by Cheryl A. Hagevik 2011
All Rights Reserved

ABSTRACT

MAPPING BOLIVIA'S SOCIO-POLITICAL CLIMATE: EVALUATION OF MULTIVARIATE DESIGN STRATEGIES

Cheryl A. Hagevik, B.S., Appalachian State University

M.A., Appalachian State University

Chairperson: Christopher A. Badurek

Multivariate mapping can be an effective way to illustrate functional relationships between two or more related variables if presented in a careful manner. One criticism of multivariate mapping is that information overload can easily occur, leading to confusion and loss of map message to the reader. At times, map readers may benefit instead from viewing the datasets in a side-by-side manner. This study investigated the use of multivariate mapping to display bivariate and multivariate relationships using a case example of social and political data from Bolivia.

Recent changes occurring in the political atmosphere of Bolivia can be better visualized, understood, and monitored through the assistance of multivariate mapping approaches. In 2006, Evo Morales became the first fully indigenous Bolivian Head of State, with the first ever majority victory by a single party in a Bolivian Presidential election. Regional divides associated with these relatively abrupt political changes were illustrated through relationships that occurred between the results of the Bolivian Presidential election of 2009 and location of indigenous populations. The effectiveness of four approaches to

multivariate mapping (combined sequential color schemes, separable graduated circles, choropleth with proportional symbols, and pair of sequential color schemes) in communicating this relationship was evaluated.

A paper map survey in English and Spanish was administered to a group of thirty-four people in the United States and thirty people in Bolivia by the researcher, using four multivariate maps (each displaying a different approach) and one control (separate maps of each variable). Survey results were analyzed using comparison of means, Pearson's correlations, paired *t*-tests, and independent samples *t*-tests. Based on percentage of correct responses and preference ratings, significantly higher results showed that viewing the datasets displayed in separate maps best transmitted the map message. The multivariate mapping approaches that yielded the lowest scores suggested that it is best to avoid the use of two ratio datasets and the use of graduated circles. The pair of sequential schemes approach received the highest scores when considering the multivariate mapping methods only. This approach also yielded higher scores from the Bolivian sample, suggesting that readers lacking map experience can benefit from this form of multivariate mapping.

Results revealed no significant differences between demographic groups, including age, gender, political activeness, and map experience. Cultural differences were revealed among the two sample groups of Bolivia and the United States, which related to familiarity with map reading and conception of the word "north". When creating a study that utilizes a map based evaluation, it is best to fully investigate cultural characteristics that surround map reading prior to creating the evaluation tool. While this study did reveal benefits of certain approaches to multivariate mapping, these approaches should be further investigated based on regional and characteristic differences among groups.

ACKNOWLEDGEMENTS

This thesis would have not been possible without the guidance and support of several individuals. I would like to express my gratitude to my advisor and the chairperson of my committee, Christopher Badurek, who offered invaluable guidance and assistance. My deepest gratitude is due to the other members of my supervisory committee. Without Kathleen Schroeder, my international research in Bolivia would not have been possible. Through her wonderful social contacts, the administration of the Bolivian study was achievable. I would like to thank James Young for his support in the creation and fine tuning of the maps used in this study, as well as his generosity in the editing of this thesis.

I offer my special thanks to Carmen Scoggins who graciously assisted in the translation of the survey from English to Spanish. Thank you to my graduate peers Ginger Kelly, Chris Coffey, Chip Haden, Kelly Renwick, and Dylan Philyaw, who assisted in the pilot study of the survey and offered their feedback which resulted in an improved evaluation tool. The voluntary assistance of each of the 64 survey participants is of course greatly appreciated.

I am indebted to Carmen Lindefjeld and Marcello Jillanvena, who organized the Bolivian sample and assisted in administration and translation of the survey. I would like to thank Hostal El Carmen in Tarija and Patricia and Javier Castellanos Z. for providing the location for survey administration in Bolivia. A special thanks is owed to John, Sidney, and

Joe Wiswell for welcoming me into their family while visiting and completing my research in Bolivia. This study would not have been possible without funding provided by the Office of Student Research at Appalachian State University. The Conference of Latin Americanist Geographers in addition played a key role in the realization of this study through funding provided as a result of a 2011 Field Study Award.

TABLE OF CONTENTS

Abstract	iv
Acknowledgments	vi
List of Tables	x
List of Figures	xii
Chapter 1: Introduction	1
Chapter 2: Literature Review	6
Multivariate Mapping	6
<i>Map comparison</i>	7
<i>Separable proportional symbols</i>	7
<i>Superimposition of symbolization</i>	10
<i>Multivariate choropleth color schemes</i>	11
Socio-political Climate of Bolivia	16
<i>Brief Political History of Bolivia</i>	17
<i>People and Culture of Bolivia</i>	18
<i>Bolivia and Natural Resources</i>	22
<i>The Rise of Evo Morales</i>	23
Summary	28
Chapter 3: Methods	29
Research Objectives	29

Data Collection	30
Map Design	30
Survey Design	40
Data Analysis	43
Summary	45
Chapter 4: Results and Discussion.....	47
General Questions	47
Specific Questions	50
Rating Scales	59
Overall Ranking	62
Demographic Groups	63
Observations from Bolivia	73
Confounds	77
Summary	78
Chapter 5: Conclusion.....	80
References	86
Appendix A: English Survey Map Book	90
Appendix B: English Survey Questions	103
Appendix C: Spanish Survey Map Book	113
Appendix D: Spanish Survey Questions	126
Vita	136

LIST OF TABLES

1. Summary of research questions.	44
2. Summary of sample size.	47
3. General questions (section 2) descriptive statistics.	48
4. Results of general questions independent samples <i>t</i> -test.	49
5. Summary of general question (section 2) incorrect responses.	49
6. Pearson's Correlation: General and specific questions.	50
7. Summary of specific question (section 3) descriptive statistics.	50
8. Results of specific questions independent samples <i>t</i> -test.	51
9. Summary of specific question (section 3) scores in percent.	53
10. Results of specific questions paired <i>t</i> -tests by mapping approach.	53
11. Results of paired <i>t</i> -test for Bolivian sample only.	54
12. Pearson's Correlation: Multiple choice and fill-in questions.	55
13. Summary of section 3 multiple choice incorrect answers.	57
14. Summary of section 3 fill-in incorrect answers.	57
15. Detail of specific question (section 3) incorrect responses.	58
16. Summary of visual pleasantness ratings.	59
17. Results of visual pleasantness ratings paired <i>t</i> -tests by mapping approach.	60
18. Summary of readability ratings.	62
19. Results of readability ratings paired <i>t</i> -tests by mapping approach.	62

20. Summary of overall ranks by mapping approach.	63
21. Summary of population demographics.	64
22. Summary of descriptive statistics by sex.	65
23. Results of independent samples <i>t</i> -test by sex group.	65
24. Summary of visual pleasantness ratings by sex.	65
25. Summary of readability ratings by sex.	66
26. Summary of descriptive statistics by age group.	67
27. Summary of visual pleasantness ratings by age group.	69
28. Summary of readability ratings by age group.	69
29. Summary of first spoken language percentage by sample.	70
30. Summary of first language spoken groups.	70
31. Pearson’s Correlation: Political activeness and map understanding.	72
32. Pearson’s Correlation: Map experience and map understanding.	73
33. Summary of incorrect answers from questions including “north”.	75
34. Summary of results by mapping approach.	81

LIST OF FIGURES

1. Comparable choropleth maps.....	8
2. Separable graduated circles map.	9
3. Layering of proportional symbols and choropleth map.	10
4. Color scheme examples.	12
5. Bolivian political party logos.	13
6. Pair of sequential color schemes map.	14
7. Combined sequential color schemes map.	16
8. Physical landscape of Bolivia.	19
9. Distribution of political datasets.	32
10. Distribution of language dataset.	32
11. Separate maps for survey in English.	33
12. Separate maps for survey in Spanish.	34
13. Combined sequential color schemes map for survey in English and Spanish.	36
14. Separable gradated circles map for survey in English and Spanish.	37
15. Pair of sequential color schemes map for survey in English and Spanish.	38
16. Choropleth with graduated circles map for survey in English and Spanish.	39
17. Summary of section 2 scores by sample.	48
18. Summary of section 3 scores by sample.	51
19. Total section 3 scores by mapping approach.	52
20. Summary of section 3 incorrect answers by question type.	55

21. Summary of section 3 multiple choice responses by mapping approach.	56
22. Summary of section 3 fill-in responses by mapping approach.	57
23. Summary of visual pleasantness ratings.	60
24. Summary of readability ratings.	61
25. Summary of overall ranking.	63
26. Summary of map approach ratings by sex.	66
27. Summary of map approach ratings by age group.	68
28. Relationship between map understanding and political activeness.	71
29. Relationship between map understanding and map experience.	72
30. Visual depiction of the Bolivian sample understanding of “north”.	74
31. Summary of incorrect responses from “north” questions.	75
32. Direction compass from survey maps.	75
33. Section 3 scores excluding direction questions by mapping approach.	76

CHAPTER 1: INTRODUCTION

Visual tools, such as charts, graphs, and maps, can be used as assistance in the identification of connections between different types of data. The combination of multiple datasets into one static cartographic display can be achieved through multivariate approaches (Slocum et al. 2005). Multivariate mapping is a cartographic approach which holds promise in assisting with the visualization of dataset connections when presented in a careful manner. One criticism of multivariate mapping is that information overload can easily occur, leading to confusion and loss of the map message to the map reader (MacEachren 1995; Robinson et al. 1995; Dent, Torguson, and Holder 2009; Tyner 2010). The map reader often can benefit more fully from viewing single datasets in side-by-side maps (MacEachren 1995; Dent, Torguson, and Holder 2009; Tyner 2010). Complex mapping approaches that combine datasets are often avoided by mapmakers due to the increased effort that is associated with the creation of multivariate information products.

While information overload is a criticism of multivariate mapping techniques, a possible benefit is that the amount of information a map carries can be increased, providing the visual opportunity for variable comparison (Robinson et al. 1995). Using a single map to display multiple datasets can actually reduce confusion related to the comparison of varying map scales, projections, and orientations. By following basic visual guidelines for the manipulation of symbolization, multivariate approaches can be optimized in the transmission

of information and relationships. It is important that approaches to multivariate mapping be studied so that the full potential of multivariate symbolization can be realized in the communication of complex data relationships, such as in case of connections between social and political data.

Over the past five years, the political atmosphere of Bolivia has changed relatively drastically. By monitoring the emerging political structures of Bolivia, the driving factors behind these changes can be better understood. In studying Bolivia's recent election outcomes, social indicators of poverty can help describe regional divides reflected in the support of presidential candidates. The physical landscape of Bolivia is divided into two main regions, the western *altiplano* of the Andes and the tropical eastern lowlands. These regions are paralleled by the two main populations of the country, indigenous groups and *mestizos* of European descent. Bolivia's presidential election in 2005 was historic in that Evo Morales became the first indigenous head of state with the first ever majority victory by a single party. As Morales has been dedicated to protecting indigenous rights, racial and economic divides between the indigenous population of the west and the non-indigenous population of the eastern lowland have become emphasized.

This study involves the evaluation of differences in understanding among four approaches to complex or multivariate mapping. Four different design strategies were used in the display of political and social data from Bolivia: choropleth with proportional symbols, separable proportional symbols, pair of sequential color schemes, and combined sequential color schemes. The positive connection between Bolivia's indigenous population and supporters of Evo Morales in the 2009 presidential election allowed for the creation of maps in which a visually evident relationship is seen through symbolization.

Multivariate mapping strategies manipulate and combine different forms of symbolization to display multiple datasets. By displaying choropleth shading with graduated circles in one map, a layering of symbolization is achieved. The separable proportional symbols approach uses color and size to create contrast. Patterns between the two schemes can be identified by pairing color schemes with different hues into one visual display. In the combined color schemes approach, different schemes are merged to create new colors which represent the combined datasets. All of these approaches can be successfully achieved by following guidelines that aim to prevent information overload.

These approaches were evaluated through a paper survey designed to determine the effectiveness of these four types of static multivariate mapping to illustrate and communicate the relationship between the changing political structures in Bolivia and the populations associated with this movement. The political data used for this study describes the outcome of the 2009 presidential election of Bolivia, based on the two dominant parties at the time of the election: *Movimiento al Socialismo* (MAS) and *Plan Progreso para Bolivia* (PPB). Social data was collected from the 2001 Census of Bolivia, which described first spoken language, an indicator of population characteristics. These two datasets were displayed at the province scale using the four multivariate approaches, as well as individually in separate maps. The paper survey evaluated each participant's ability to understand the information contained within each map through a series of questions, including multiple choice, fill-in, rating scales, and ranking.

The survey was administered to a population of sixty-four participants, with thirty-four in the eastern United States and thirty in Tarija, Bolivia. The final survey was translated to Spanish and reviewed in Tarija before administration. The two sample groups included

participants from varying age groups and backgrounds. Both samples were heavily influenced by a university atmosphere with participants from educated middle class social groups. Surveys administered in the eastern United States were collected in February 2011 in multiple locations. The survey responses from Tarija, Bolivia were collected by the researcher during a two week field study in March 2011 with the help of residents from this city. Survey responses were analyzed using descriptive statistics and statistical tests to reveal patterns and trends associated with each multivariate mapping approach. Observations made during survey administration and verbal feedback provided by participants helped in the investigation of these patterns and trends.

This research is significant in an increasingly complex and interconnected world affected by the process of globalization. Decisions in one country are no longer isolated from others, natural resources are distributed globally, and economic inequalities exist within and between countries. A more integrated strategy, such as multivariate mapping, is needed in the illustration of these complex relationships. Yet, multivariate mapping strategies have not been fully investigated (Robinson et al. 1995; Dent, Torguson, and Holder 2009). Through evaluating various forms of multivariate mapping, optimal design strategies can be redefined to ensure effective communication of complex social structures. Comparing the effectiveness of different approaches to multivariate mapping will allow cartographers to gain knowledge necessary for mapping complex and varied relationships such as those found in political and social data.

Following this introduction, a review of past literature is provided in Chapter 2 explaining preceding research in multivariate mapping strategies, focusing on guidelines which were developed to improve symbolization techniques. A socio-political history of

Bolivia is then summarized in a brief description of cultural and economic influences. Chapter 3 describes the research objectives and evaluation methods of this study, which took place in the stages of data collection, map design, survey design, and data analysis. In Chapter 4, the results of the survey collection are discussed during an analysis of the responses divided by survey section: general questions, specific questions, rating scales, overall rankings, and demographic groups. Observations specific to cultural influences in Bolivia and possible confounds are then noted. The conclusion in Chapter 5 reflects on the implications of the observations made during this study and discusses the need for further research. The Appendices show the final survey design in both English and Spanish and include the multivariate and separate maps designed for this study.

2. LITERATURE REVIEW

The four approaches to multivariate mapping techniques used in this study will be reviewed, followed by a description of the social and political culture of Bolivia. Connections between multiple social and political variables can be illustrated and possibly understood through the use of multivariate mapping. Bolivia's current political climate has been shaped through a long history of indigenous traditions along with influxes of migrating populations. Today Bolivia's population is composed of many varying cultures with differing agendas. The strong relationship between Evo Morales and his indigenous supporters can be easily visualized through the use of multivariate mapping techniques.

Multivariate Mapping

The cartographic display of multiple phenomena is known as multivariate mapping (Slocum et al. 2005). Multivariate mapping is used as a means to analyze and display functional relationships between related variables. The manipulation of symbolization through color, geometry, and size allows for the display of several sets of data in a static environment. Suggested design guidelines for multivariate maps aim to create a simple message that is easily identifiable. However, simply placing the maps side by side can often transmit a clearer message (MacEachren 1995; Dent, Torguson, and Holder 2009; Tyner 2010).

Map comparison

When considering the creation of a multivariate map, a decision must be made about whether the datasets should be displayed through individual maps or should be combined into a single display (Robinson et al. 1995). Before creating any multivariate map, one should always consider if patterns and relationships presented can be shown more effectively with separate comparable maps, especially in the case of multiple sets of ratio data (MacEachren 1995; Dent et al. 2009; Tyner 2010). A single map can be created for each attribute and then compared visually. Just as in univariate map creation, choropleth shading is the most common choice for symbolization in map comparison (Figure 1). The ability of the map reader to interpret the map message is heavily reliant on data classification in this case (Slocum et al. 2005). A comparison between maps is most easily interpreted when the mapping method is held constant, such as using choropleth shading for both maps (Figure 1).

Separable proportional symbols

The proportional symbol map is one of the most common quantitative mapping techniques for bivariate mapping. This type of symbolization is known as multivariate point symbolization, which can be used with either point or areal data (Slocum et al. 2005). Multivariate proportional symbols have not been extensively researched and have disadvantages that can lead to loss of the map message, but can be optimally designed by following a few general guidelines (Dent Torguson, and Holder 2009). Proportional symbols can be used with base map information to display two datasets by using two different hues or shades to fill the symbolization (Figure 2).

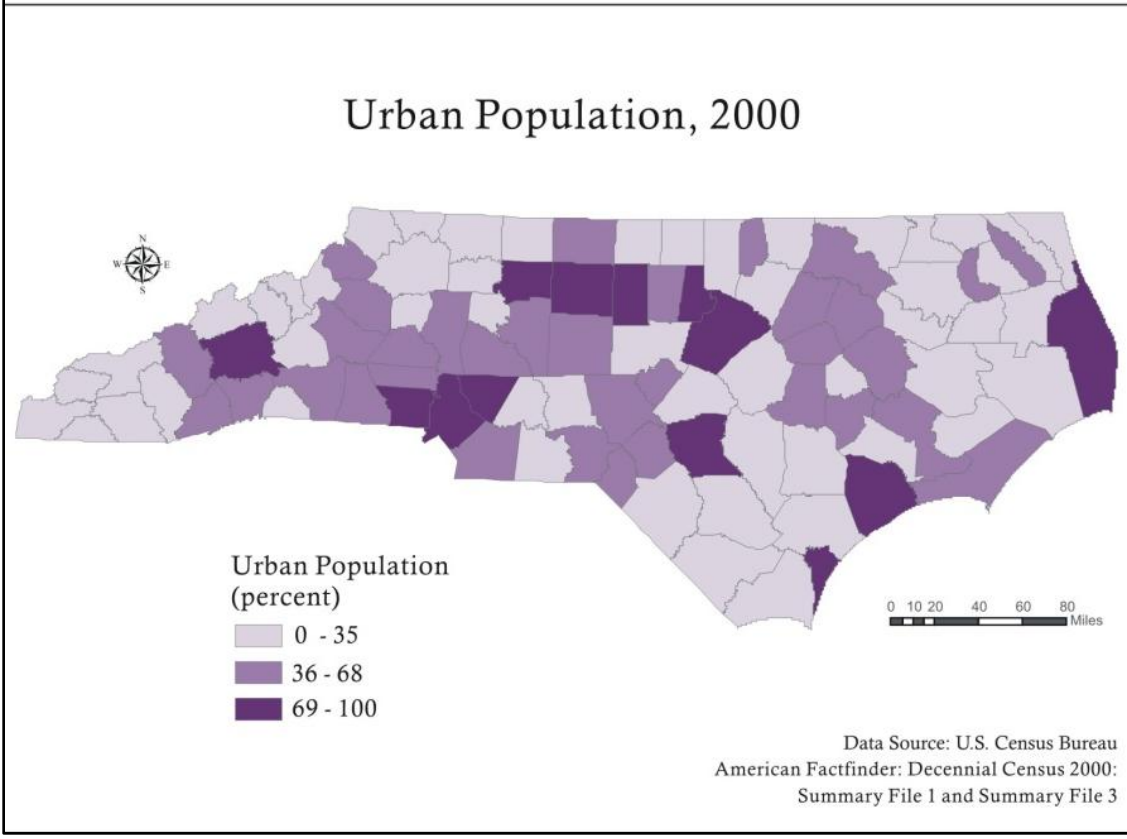
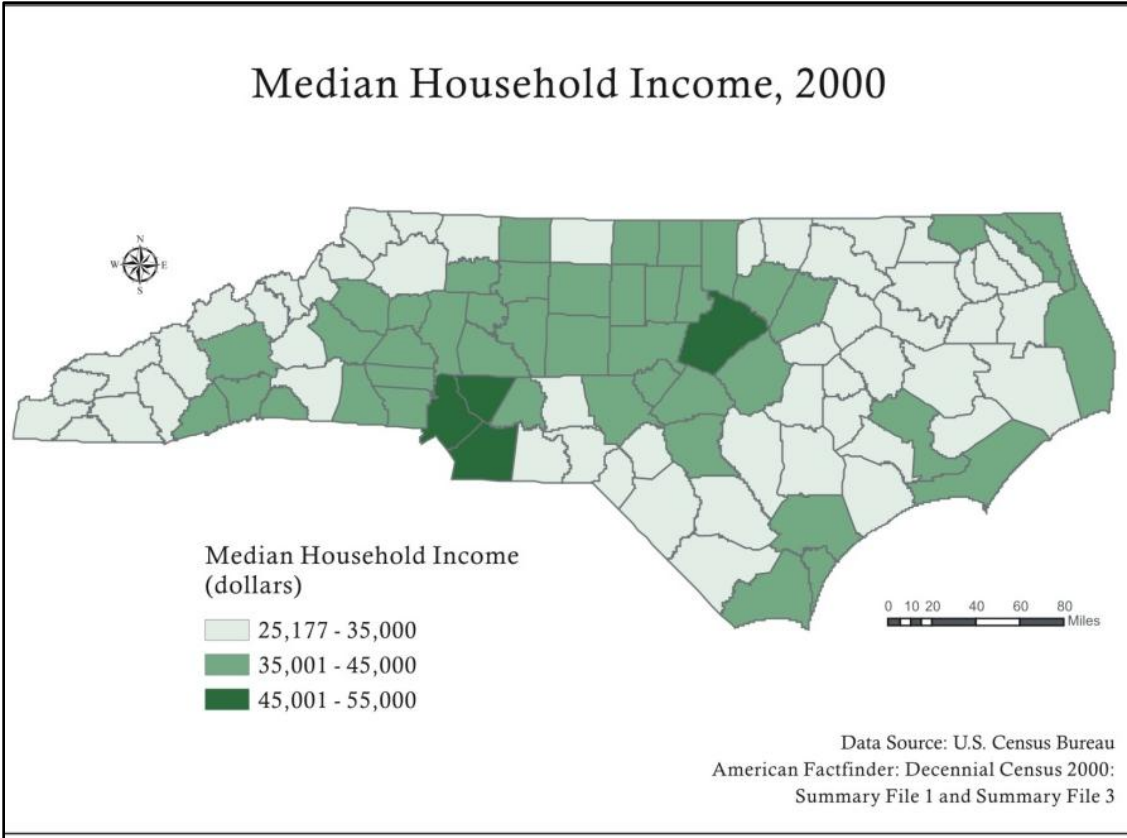


Figure 1: Comparable choropleth maps.

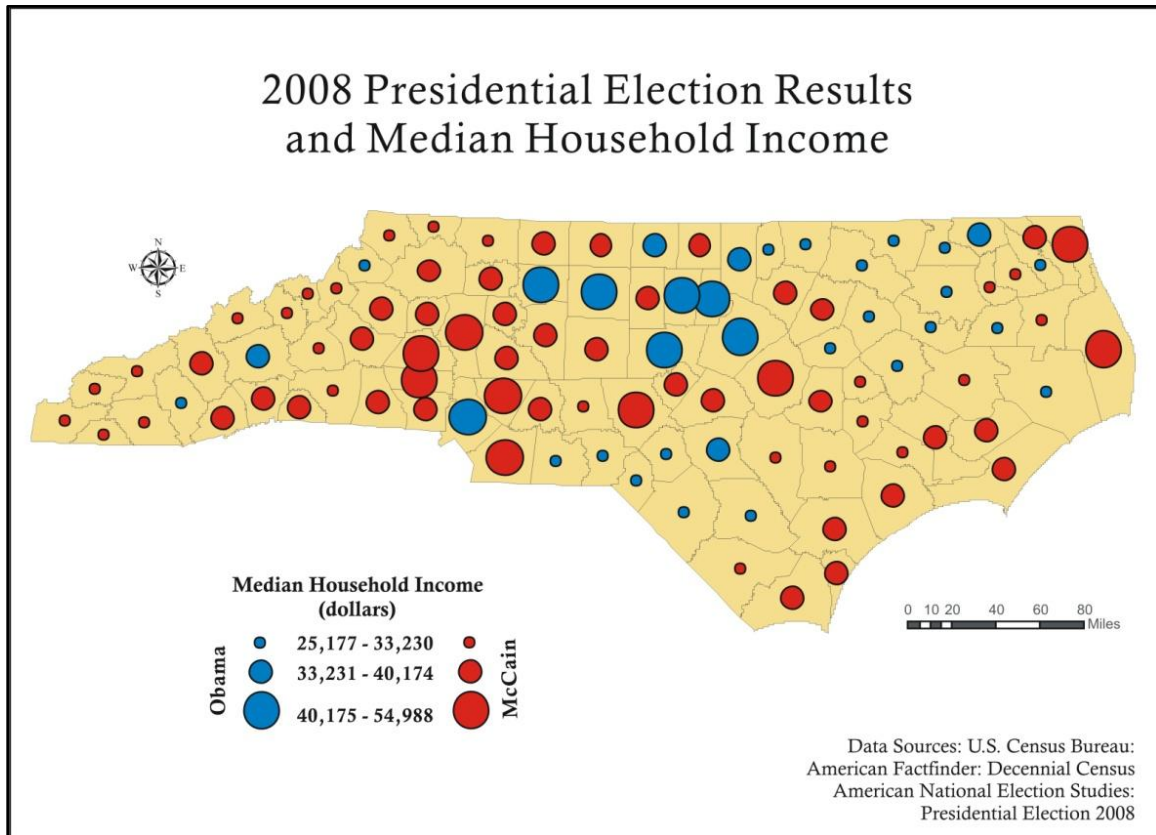


Figure 2: Separable graduated circles map.

This bivariate mapping approach is used with the quantitative-qualitative data combination. The proportional circles represent the ratio data while the nominal data is shown through different color hues. The hues utilized should be easily distinguished from each other and separable. With separable symbols, variation can be processed independently of all other dimensional variations, allowing the reader to focus on individual datasets (Nelson 2000). This example uses hues that are related to the data categories, in this case political party colors, which are easily distinguishable.

Superimposition of symbolization

The superimposition method uses separate symbolization schemes that are visually distinct and is the most common approach to multivariate mapping. An advantage of this method is that it is conceptually simple (Robinson et al. 1995). When displaying only two variables, there are many choices of compatible symbolization. For example, proportional symbols may be used in combination with choropleth symbolization to display multiple datasets (Figure 3). Although these two types of symbolization are visually distinct, there is potential for confusion when using proportional symbols with choropleth symbolization, especially in the case of two ratio level variables.

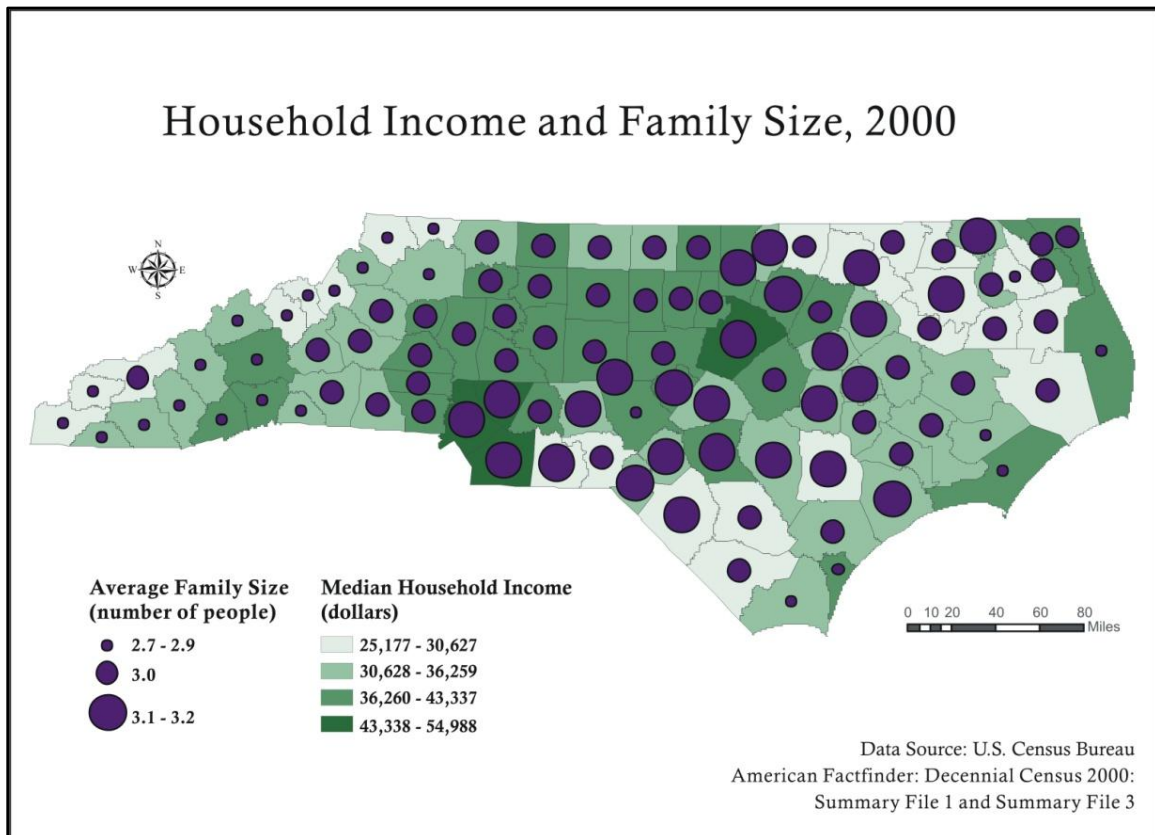


Figure 3: Layering of proportional symbols and choropleth map.

By using symbolization that is diverse in form and densely packed within the map space, the map message can be easily lost to the reader (Robinson et al. 1995). This confusion can be avoided through the use of highly contrasting color schemes for the proportional symbols and the choropleth enumeration unit fills (Dent Torguson, and Holder 2009). Creating adequate figure-ground contrast and using a simple geometric form, such as a circle, is the most effective way to use proportional symbols for bivariate mapping. This example of proportional symbols with choropleth symbolization (Figure 3) uses two sets of quantitative data, but there is much freedom in the superimposition approach for utilizing different types of data.

Multivariate choropleth color schemes

When attempting to identify relationships, choropleth maps can be used as part of the visualization process (Tyner 2010), but choropleth symbolization is susceptible to reader confusion when showing multiple variables. The choice of color scheme can have a dramatic effect on whether or not map users can accurately interpret specific details from a map, as well as appropriately understand the more general message of the map (Mersey 1990). Confusion by the map reader can be avoided by limiting the number of colors and patterns used on a map.

The number of classes should be limited to three or four in bivariate mapping or the legend can become overwhelming (Dent Torguson, and Holder 2009). The selection of color schemes for maps should be based on the polarization of the variable. For unipolar or unidirectional variables, sequential color schemes should be used, while diverging color schemes should be used for bipolar variables (Brewer 1994) (Figure 4). Multivariate approaches are more easily understood when used with two unidirectional ordered variables

(MacEachren 1995). Colors should progress in shade from light to dark, with high data values represented by dark tones. When viewing separate maps, correlation is most easily identified through the blackness or darkness of color schemes (Muller 1976). More sophisticated schemes can be made by varying saturation and value (Tyner 2010).

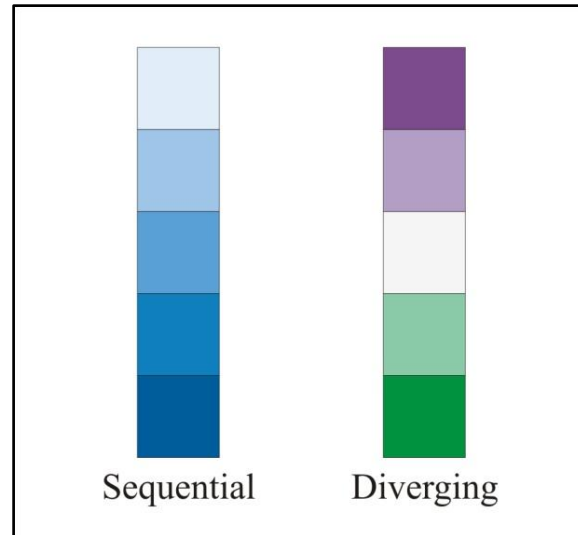


Figure 4: Color scheme examples.

When mapping political data, it is best to use colors that are associated with the political parties represented. The most important purpose of the political map is to show political affiliation in relation to territorial borders. Throughout the world, political parties are associated with a particular symbol or color. In Bolivia, these symbols are printed in color on the ballots to ensure the voting rights of the illiterate (World Unfurled 2005). Plan Progreso para Bolivia (PPB) is identified by red and yellow while Movimiento al Socialismo (MAS) is identified by cobalt blue (Figure 5). Using these colors to dictate symbolization in political maps, helps reader easily identify categories, leading to a better understanding of the map message.



Figure 5: Bolivian political party logos.

By pairing or combining color schemes, it is possible to visually identify patterns that might exist between datasets. Color schemes used for bivariate mapping are usually pairs of sequential schemes, pairs of diverging schemes, or paired sequential and diverging schemes. When using pairs of color schemes, each color scheme represents a single set of data. The differing hues and shades allow for multiple datasets to be viewed together. A pair of sequential color schemes can be applied to a map using a quantitative-qualitative data combination (Figure 6). Shade represents the ratio data while hue represents nominal data.

Choropleth maps can show two or three variables by using blends of colors which are created by combining color schemes. This approach is known as cross-variable mapping, which creates a hybrid variable by combining separate variables into a single variable (Slocum et al. 2005). This two-step process involves creating a basis for classifying data values that have been created by combining data sets. In the case of combining two variables

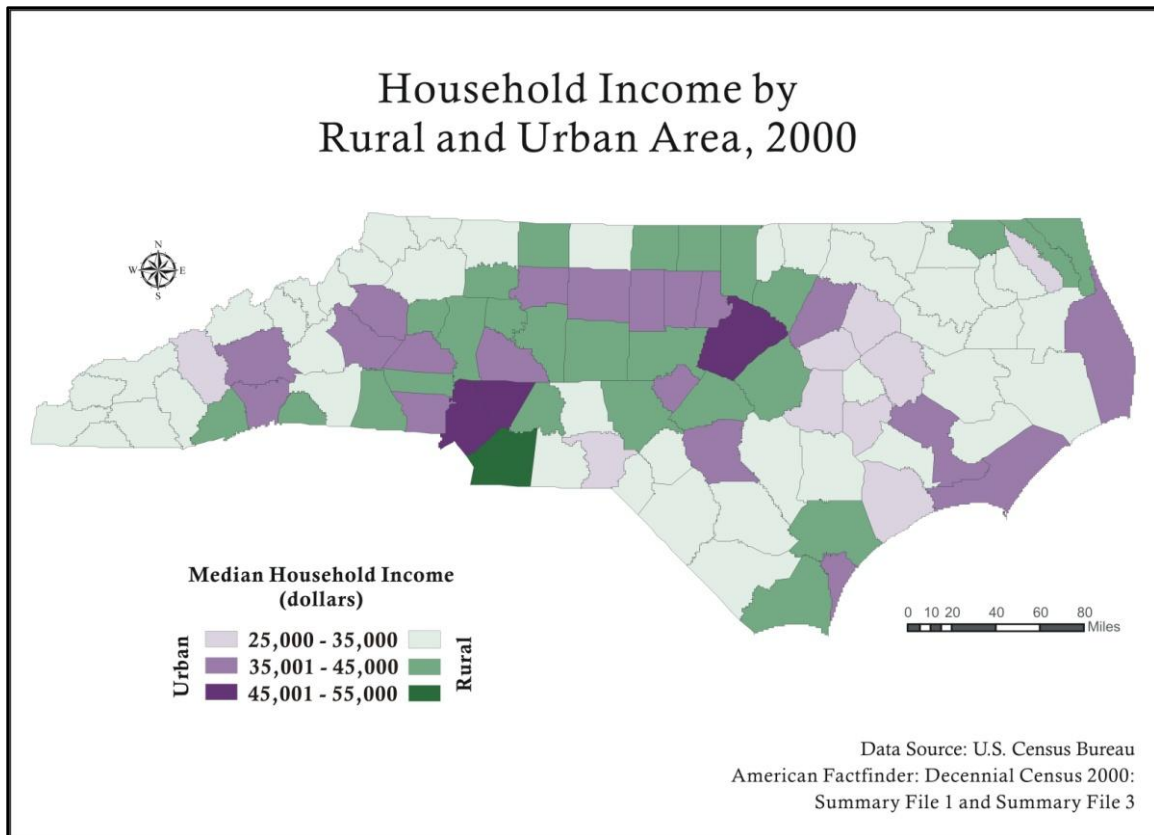


Figure 6: Pair of sequential color schemes map.

a rectangular grid legend is first created by plotting values from one variable against values from the second variable. Each box or color ends up representing a unique relationship between the two variables. The second step involves assigning each data case to a unique category contained within the grid (Robinson et al 1995).

The technique originated in the 1970s when the U.S. Bureau of the Census developed the “bivariate choropleth map”, which was a method for combining two-colored choropleth maps (Meyer, Broome, and Schweitzer 1975). This method is spectrally coded and utilizes the combination of cyan, magenta, and yellow. Although a technological achievement, this method received much criticism in its ability to communicate information about the individual distributions and the correlation between variables (Slocum et al. 2005).

Judy Olson (1981) conducted a study in response to these criticisms and found that this bivariate method was successful in transmitting information to readers about regions of homogenous value combinations. Therefore, this method can be effective in displaying a positive relationship between variables. Olson (1981) found that map readers do find these types of maps to be interesting and appealing. However, Eyton (1984) provided an alternative method based on complementary colors, which combine to produce a shade of grey. This approach to the cross-variable grid has the potential to appear more logically ordered, allowing patterns to be more easily identified.

In its simplest form, a paired color scheme consists of two hues varying in lightness. The two color schemes create a square grid on which positive and negative diagonals progress from low to high or high to low. Figure 7 below shows an example of the original combined color schemes approach, first developed by the U.S. Bureau of the Census. If used correctly, this form of bivariate choropleth mapping can be effective in showing relationships among variables. The colors used must be easily identified and the transitions smooth. Individual categories must be distinguishable and the two distributions must be easily differentiated (Eyton 1984).

The clarity of a map using multiple variables is often dependent on the effectiveness of the legend in providing a clear statement of the mapping process (Olson 1981; Robinson et al.1995). If the legend is designed correctly, it should be intuitive. However, many map readers prefer to view variables in separate maps over this single hybrid display. If this method is utilized, the legend should be a prominent part of the map design when using this type of map display.

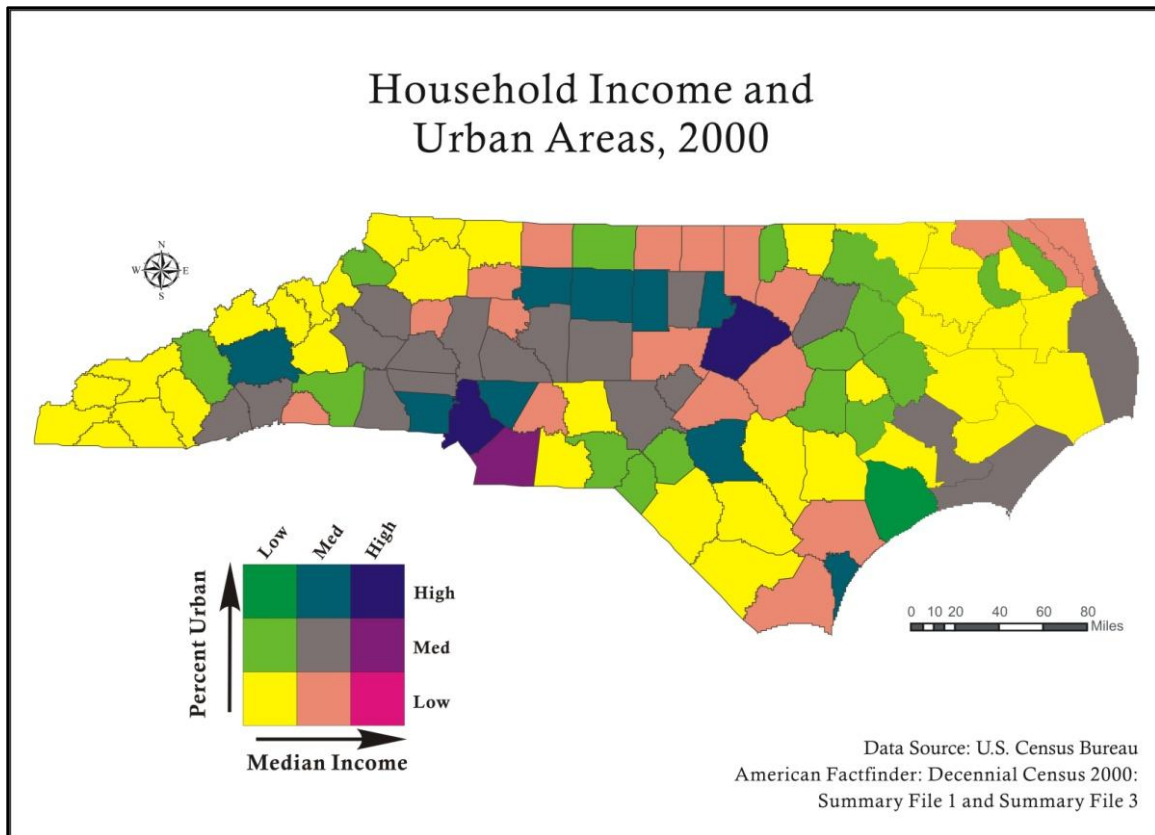


Figure 7: Combined sequential color schemes map.

Socio-political climate of Bolivia

Bolivia is located in central South America with a population of approximately ten million inhabitants. The total population has grown three-fold over the past fifty years, accompanied by an intense urbanization process. Bolivia remains South America's poorest country with the lowest Gross Domestic Product (GDP) per capita on this continent (UN Statistics Division 2011). The country has a history of difficult economic, political, and social issues, characterized by inequality and an economy that has been adversely affected by the region's recent economic slump. However, despite numerous setbacks, Bolivia has managed slow and steady progress as shown by an increase in trade and a reduction in infant mortality rates (WHO 2000).

Brief Political History of Bolivia

Modern Bolivia was once a part of the ancient Inca Empire before being conquered and colonized by Spain in the sixteenth century. The remoteness of the Andes in the western part of the country helped to protect Bolivia's indigenous population from European diseases (Newson 1985). The Spaniards sought mineral wealth and were later successful in the mining of silver, resulting in the exploitation of the indigenous population for use as labor in the extraction of silver deposits (Mahoney 2003). The indigenous population of the Andes decreased during the Spanish conquest, largely due to this extraction of labor and goods (Spalding 1973). This decrease led to the fragmentation of indigenous cultures throughout the Andes. The stratification of society that originated with the Spanish colonization of Bolivia still continues today and is seen in the inequalities that exist between the largely impoverished indigenous peoples and the European elite (Faguet 2004).

Bolivia's struggle for independence began in 1809 and ended sixteen years later. The country was named for liberator Simón Bolívar (Klein 2003). Through several subsequent wars, Bolivia lost large amounts of land to Chile, Brazil, and Paraguay. In 1952, the *Movimiento Nacionalista Revolucionario* (MNR) political party led a successful revolution that resulted in land reform promoting rural education and the nationalization of tin resources (Patch 1961). Unfortunately, twelve years of reform left the country divided and the president was overthrown by military leaders. From 1964 until 1982, Bolivia experienced a series of coups by primarily right-wing military dictatorships. In 1982, Democratic civilian rule was established after a long period of military control, but difficult problems with poverty and social unrest are still prominent in Bolivia (Domingo 2005).

People and Culture of Bolivia

The physical landscape is roughly divided into the high plains of the Andes and the lowlands of the Amazon (Figure 8) and closely mirrors the country's cultural landscape. Throughout Bolivia's history indigenous tribes have decreased in population, but these tribes, whose ancestry can be traced back to pre-colonial societies, remain the dominant groups in Bolivia at 59 percent of the population (Andolina, Radcliffe, and Laurie 2005). The remainder of the population consists mostly of mestizos, referring to people of mixed European and Amerindian descent (Rice and Van Cott 2006). German, Croatian, Serbian, Asian, Middle Eastern, and other minorities are also found in Bolivia. With over three dozen indigenous groups represented in Bolivia, four main groups account for the majority of indigenous peoples: *Quechua*, *Aymara*, *Chiquitano*, and *Guaraní* (INE 2001).

The bulk of indigenous peoples of Bolivia reside in the high plains, or altiplano, in the western Andean part of the country (Kronik and Verner 2010). The altiplano is one of the most extensive high plains on the Earth and is characterized by its harsh climate and dry winds (Garreaud, Vuille, and Clement 2003). Lake Titicaca, the world's highest navigable lake, is a dominant feature of the altiplano and an important natural resource for the indigenous peoples of Bolivia. Mestizos are mostly found in the eastern lowlands, which cover about half of the land in Bolivia (Galvan 2011). The climate ranges from wet and humid in the Amazonian areas to subtropical in the southern areas. Bolivia is divided into nine departments: Pando, La Paz, Oruro, and Potosí in the western portion of the country; Beni, Santa Cruz, and Tarija in the eastern portion; and Cochabamba and Chuquisaca in the central area.

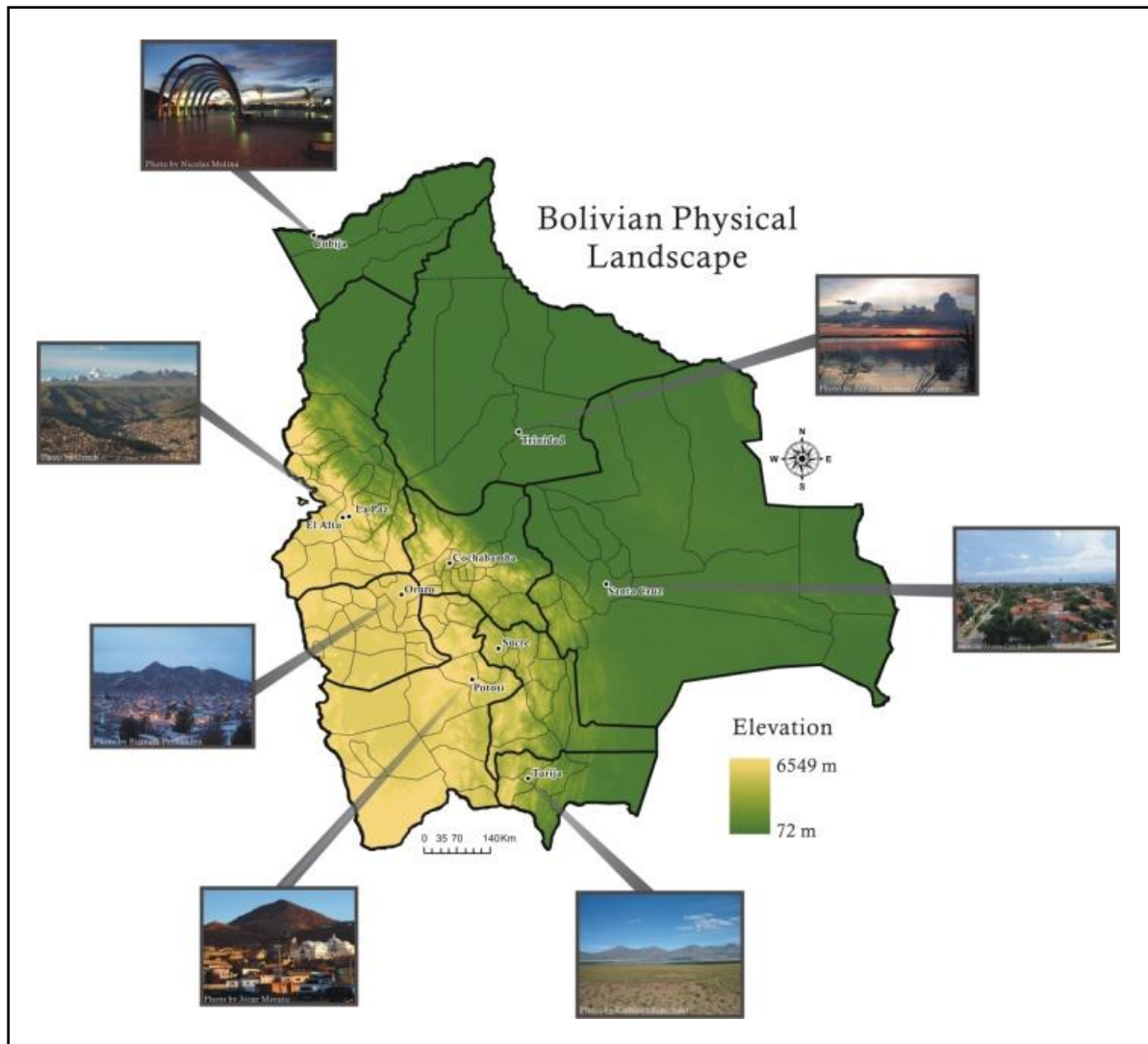


Figure 8: Physical landscape of Bolivia.

Mestizos tend to be the wealthier class of Bolivia, dominating the political and economic spheres (Schroeder 2007). Recently, cultural and economic divides between the altiplano and eastern lowlands of Bolivia have been reflected in political outcomes, as the rights and powers of the indigenous people increased. This contemporary movement can be traced to similar regional movements in the 1960s and 1970s which sought to reclaim indigenous voices and autonomy (Yashar 1998). The founders of this movement call themselves *Kataristas*, named after the Aymara leader of Indian rebellion Tupaq Katari, and

are dedicated to preserving and producing a meaningful indigenous alternative to the Western model of modernity (Canessa 2000). This rebirth of indigenous nationalism began in La Paz, a provincial and national capital, as part of efforts to preserve the traditional culture of the altiplano (Mallon 1992). La Paz remains a center for indigenous culture today by continuing this renewed interest in indigenous crafts and native languages.

With a population of 2.5 million, the Quechua make up approximately 25 percent of Bolivia's peoples (USDOS 2010). The people in this indigenous group are direct descendents of the highly organized Incan Empire. The Quechua language was spoken by the Incans and remains an official language of Bolivia (Galvan 2011). Family is the center of Quechua culture, with all members of extended families contributing to the farming of corn, potatoes, and quinoa (Tenenbaum 1996). Agriculture and animal husbandry provide the main source of sustenance for the Quechua (Galvan 2011). Quechua are mainly found in the altiplano and are native to the departments of Chuquisaca, Cochabamba, Potosí, Oruro, and La Paz (Kronik and Verner 2010).

The Aymara are the second largest indigenous group, constituting approximately 20 percent of Bolivia's population, and have existed in the region for over 2,000 years (USDOS 2010). Aymara culture is regarded as a precursor of the Inca culture which later became the basis for the strong socio-economic organization of the Inca Empire (Tenenbaum 1996). The Aymara lived closely together with their rulers, the Incas. The Aymara believe that two atmospheres compose one reality: the natural environment and the supernatural world (Eagen 2002). Aymara peoples are found in the altiplano of Bolivia and rely on agriculture, animal husbandry, mining, fishing, handcrafts, and trade as sources of income (Galvan 2011). Aymara have grown and chewed coca leaves for centuries, and use it in traditional medicine

as well as in ritual offerings to the sun god *Inti* and the earth goddess *Pachamama*. They are native to the departments of La Paz, Oruro, and Potosi (Kronik and Verner 2010).

The Chiquitano, an Amazonian culture, are Bolivia's third largest indigenous group making up one percent of the population (USDOS 2010). They reside in the eastern lowland areas near Santa Cruz in the vast Chiquitanos region (Godoy 2002). Chiquitano is spoken among this culture, but this language is not classified as a language family and is therefore not included as a category on census documents. Chiquitanos rely on agriculture for income, cultivating lowland crops such as bananas, cotton, rice, corn and manioc. Additionally, the Chiquitano are known as skilled musicians and creators of violins (Galvan 2011). According to the Chiquitano belief system, each element of nature has a master, including the mountains, the plains, and the forest. The Chiquitano, in spite of their long history of contact with Bolivian mestizo society, resist assimilation and have preserved a strong ethnic identity (Olson 1991).

The Guaraní, the fourth largest indigenous group, also make up approximately one percent of the population and are an eastern dry forest and desert culture (USDOS 2010). The main source of income for the Guaraní is lowland agriculture, including sugar cane, cotton, corn, rice, beans, and manioc (Galvan 2011). This culture is well known for their woven crafts as well. Baskets are woven from *pindo* palm fibers and cotton is woven into white cloth with black and brown stripes. Their religion is based on an impressive and elaborate mythology. The shaman is believed to possess supernatural powers that allow him to ward off evil as well as cure sickness (Keeny, Nickerson, and Natalizia 2000). They are native to the departments of Santa Cruz, Chiquisaca, and Tarija (Kronik and Verner 2010).

Bolivia and Natural Resources

The abundance of natural resources in Bolivia has led to various periods of economic independence and prosperity. Silver was an important economic resource until its mining declined in the late 1890s when tin took its place as the most mined mineral (Preston, Macklin, and Warburton 1997). Indigenous people remained the main source of labor for these industries and were forced to work under primitive conditions while being denied access to education and political participation (Milstead 1927). Rights of the indigenous peoples increased with various revolutions occurring in the early twentieth century. Tin accounted for more than 60 percent of exports during the period from 1930 to 1970 (Anderson and Meza 2001). However, the price of tin fell dramatically in the late 1980s resulting in a crash of the market and thus leaving Bolivia in need of a new major export. Bolivia has other possibilities for export with close to 40 percent of the world's lithium reserves (Tahil 2007) in addition to natural gas reserves.

Bolivia holds the second largest natural gas reserves in South America after Venezuela. These reserves are located in the eastern lowlands region of the country, particularly the southeastern department of Tarija (Anderson and Meza 2001). Over the past two decades, natural gas has become a source of profit, as well as controversy, for Bolivia, leading to social movements and political reform (Kaup 2008). Natural gas in lowland areas provides opportunities for participation in the global economy, although revenues might not benefit Bolivia as a whole. Globalization has done little to increase the well-being of the indigenous people and instead has worsened poverty in some rural areas (Schroeder 2007). In addition, the highland indigenous population resists participation in the global economy and support the nationalization of these natural resources.

These social divides contributed to what is known as the “Bolivian Gas Conflict”, which came to a head in October 2003. Hundreds of thousands of farmers, students, coca growers, union workers, and ordinary citizens went on strike (Shifter 2004). Protests and roadblocks initiated mostly by indigenous groups and the labor sector escalated into riots resulting in nearly eighty fatalities. These protests were rooted in disagreements over the exploitation and export of natural gas, as well as the demand for clarification of coca laws and the release of jailed political leaders. The governing coalition eventually demanded the resignation of President Gonzalo Sánchez de Lozada, after which Vice President Carlos Meza assumed his position and conceded to many of the protestors demands (Postero 2005).

On May 6, 2005, the Bolivian Congress approved the long awaited Hydrocarbons Law, even though President Mesa refused to sign or veto the new law. This new law returned legal ownership of all hydrocarbons and natural resources to the state (Dunkerley 2007). A higher tax burden was established for companies of the hydrocarbon sector and the government was granted control of the commercialization of the resources. The new law also required companies to consult with indigenous groups who live on land containing hydrocarbon deposits (Rochlin 2007).

The Rise of Evo Morales

The Movimiento al Socialismo (MAS) political party has governed Bolivia since the presidential election of 2006. Founded in 1997, MAS evolved out of a movement to protect the interests of coca growers, with one of the party’s aims being to grant more political power to indigenous and poor communities. These interests also included land reform and redistribution of gas wealth (Schroeder 2007). The party identifies itself with the colors of

cobalt blue, black, and white. Their emblem consists of a sun with the words ‘*Honestidad y Valentia*’ meaning ‘Honesty and Courage’ (CNE 2011). The followers of the MAS party are known as *masistas*. The acronym for this political party is a play on words, meaning ‘more’ in Spanish. MAS received almost unanimous support from poor, indigenous, and rural populations (Kohl and Bresnahan 2010). Many of the followers of MAS were former tin miners who became coca growers as a means of survival.

The current leader of MAS, Juan Evo Morales Ayma, is of Aymara descent and has a history of supporting the rights of laborers. Evo spent his childhood laboring in agricultural harvests and herding llamas. He eventually moved to Oruro in central western Bolivia to attend school. After completing the eleventh grade, Evo traveled to La Paz to fulfill his mandatory duty in the military. The next portion of his life was spent in the *Chapare*, where he moved with his family, to grow coca. Evo became very active in the regional coca-growers union and in 1985 was elected as the group’s general secretary. Three years later, he became the executive secretary of the Tropics Federation, a federation of several coca growing unions (Sivak 2010).

It was around this time that the government, encouraged by the United States, pushed Congress to pass a law that aimed to reduce the amount of coca that can be legally grown. Assistance from the United States in the eradication of coca continued into the mid 1990s. In 1996, Evo was appointed to the position of President of the Coordinating Committee of the Six Federations of the Tropics of Cochabamba (Sivak 2010). During this same period of time, Evo helped found the MAS political party. The following year, Evo took a major step in his career as a politician when he won a seat in the House of Deputies, where he denounced the militarization of the coca growing regions. Morales was eventually expelled from Congress,

but was not quieted. He became the representative of the people who were unjustly persecuted and his popularity flourished. Morales continues to show his support of the indigenous population through his dress. He is usually seen wearing traditional sweaters and carrying a wiphala, the Aymara flag, which has become a symbol of indigenous rights in Bolivia (Sivak 2010).

The 2002 Presidential election was the MAS party's first attempt to take power in Bolivia. During the campaign, Evo called for the expulsion of the U.S. Drug Enforcement Administration from Bolivia and the nationalization of hydrocarbons (Van Cott 2003). Gonzalo Sánchez de Lozada, known as "Goni", won the election by only a small margin over Morales. This was a surprising result for the traditional political parties who did not expect the MAS party be a contender in the election. After the election, Morales remained active in national affairs and played a large role in the resignation of Goni in 2003.

Later in the Presidential election of 2005, Evo Morales became the first fully indigenous head of state, with the first ever majority victory by a single party in a Presidential election. The MAS party hailed victorious with 54 percent of the vote, more than 20 points ahead of the second-place finisher (Kohl and Bresnahan 2010). Since this election, regional tensions have been highlighted as Morales has employed many controversial strategies to empower Bolivia's indigenous people (Dunkerley 2007). In his first term, Morales was able to partially nationalize Bolivia's hydrocarbons and telecommunications industries, increase government participation throughout the economy, and introduce new programs in health, education, and social security. His methods are somewhat unorthodox. For example, he cut his own salary by 57 percent and he is single, allowing his sister to act as first lady (Sivak 2010).

A constitutional referendum was held in January of 2009 to further the legal recognition of the rights of the indigenous population to maintain and promote their specific cultural, linguistic, and territorial integrity (Montenegro and Stephens 2006). Revisions to the constitution also shifted more power to Evo himself. The referendum included acknowledging Bolivia as a secular state, nationalizing all natural resources, acknowledging Sucre as the capital of Bolivia, and allowing a single re-election of a President resulting in consecutive terms (Kohl and Bresnahan 2010). Additionally, all previous terms are not considered for term limits, allowing Morales to be reelected twice more. The new constitution was enacted in February 2009.

Morales gained re-election in the presidential election of December 2009 with a landslide victory. With an even higher majority than the previous presidential election, Morales won with 62 percent of the votes and continued to his second term of presidency. He will now serve a five year term. His main opponent, Manfred Reyes Villa of the Plan Progreso para Bolivia political party, received only 23 percent of the votes (Zandvliet 2010). Currently, MAS holds a two-thirds majority in both the Chamber of Deputies and Senate, and remains committed to equality of wealth and nationalization of resources. During his second term, Morales vowed to further tighten state control on resources, including some of the world's largest lithium reserves. Additionally, Morales promised to launch state-run paper, cement, dairy, and drug companies, as well as to develop the iron and lithium industries. This is a move toward helping Bolivia to export more value-added products rather than the raw materials themselves (Kohl and Bresnahan 2010).

Currently, the main opposition party is the Plan Progreso para Bolivia (PPB) whose goals are mostly right-wing and pro-business. PPB has been the main opposing party since

the election of 2009. Identified by red, yellow and white, this political party was established in July 2007. They are symbolized by two connecting gears. They are currently led by Dr. José Luis Paredes Muñoz (CNE 2011).

Morales' strategies seem to have intensified regional divides in Bolivia, as well as strained relations with the United States. His roots with the coca growing regions conflict with American anti-drug policy. Plans to expand legal coca growing led the United States to revoke USAID from the Chapare, Bolivia's largest coca growing region. A chain of accusations and expulsions followed, culminating in the expulsion of the DEA from Bolivia (US DOS 2010). Morales described the United States as his leading adversary and has made the right to grow the coca leaf a symbol of anti-imperialism (Romero 2008).

Since Evo Morales' election as President of Bolivia in 2005, and as a result of his unusual policies, the racial and economic divides between the indigenous population of the west and the non-indigenous population of the eastern lowlands have been highlighted. This has led to a need to research these relatively abrupt changes occurring in Bolivia. These outcomes were partially driven by social differences reflected in regional divides. In order to study the election outcomes, social indicators of poverty can be visualized to better understand such regional divides. The changing socio-political climate of Bolivia can be visualized to provide insight into useful methods of display, which can lead to more informed national policy decisions, as well as international policy decisions for Bolivia and possibly other developing countries with similar complicated social, political, and economic landscapes.

Summary

Multivariate mapping techniques hold great potential for the communication of the relationships between the complicated and related social and political variables. Despite this potential, few studies have been conducted on the use of multivariate mapping (Robinson et al. 1995; Dent, Torguson, and Holder 2009), especially in socio-political applications. In the past, multivariate mapping has been overlooked due to the probability of information overload, which results in a loss of the map message. However, traditional approaches to multivariate mapping can be useful in the display of functional relationships. The strong positive relationship between indigenous speakers and MAS supporters in Bolivia is ideal for studying this cartographic strategy. This relationship is easily visualized through multivariate symbolization and color combinations.

CHAPTER 3: METHODS

Research Objectives

The purpose of this study was to evaluate the most effective multivariate mapping strategies for communicating complex phenomena; the socio-political climate of Bolivia was used as an example. Four multivariate maps were created using identical datasets to communicate the functional relationships between the Bolivian presidential election of 2009 results and indigenous language speakers. Sub-questions connected to the main research question included:

- a) Which method of multivariate mapping best communicated the map message?
- b) Which method of multivariate mapping was visually preferred?
- c) Which method of multivariate mapping is most easily read?
- d) Did gender or age play a role in the results?
- e) Did political activeness play a role in results?
- f) Did map experience affect map understanding?
- g) Did understanding of general questions contribute to results of specific questions?
- h) In what ways did results differ between the United States and Bolivia?

The four differing approaches to multivariate mapping that were used included: choropleth with proportional symbols, separable proportional symbols, pairs of sequential color schemes,

and combined sequential color schemes. These approaches were used to create information products in the design of a map-based paper survey.

Data Collection

Census data from the *Instituto Nacional de Estadística* (INE) de Bolivia were used to determine the primary language of the people. This served as the social indicator. The language was classified as either a native language or a non-native language. Native language categories included in the census data set were Aymara, Quechua, Guaraní, and otro-Nativo (other native); non-native language categories included Castellano (Spanish), and Extranjera (Foreign). Native language speakers were used as the social indicator to highlight the locations of the indigenous populations across Bolivia.

Election data was collected from the *Corte Nacional Electoral* (CNE) de Bolivia for the Presidential election of 2009 and was used as the political data set. The two majority political parties represented in this election were MAS and PPB. Election results were recorded as a percentage of total votes by province. The MAS party, which aligns with native language speakers, is currently in power; consequently, native language speaker data was displayed instead of non-native language speakers. This manipulation of the dataset displayed a positive relationship. Using vector GIS data of Bolivian provinces in ArcMap 9.3 and Corel Draw11, information products using the area ratio data collected were created to display the relationship between Bolivian political and social data.

Map Design

The data was analyzed and classified based on the most appropriate method for the comparison of datasets. Each dataset shows a different distribution. The political data shows

a skewed distribution, with MAS votes being negatively skewed and PPB votes being positively skewed (Figure 9). Unlike the political data, the language dataset shows a bimodal distribution (Figure 10). Classification methods that are most appropriate for map and dataset comparison are mean-standard deviation method, nested means, quantiles, and equal area intervals (Slocum et al. 2005). The equal area intervals classification method is appropriate for the comparison of datasets with differently shaped distributions because resulting classes are unaffected by the magnitudes of the data. The range for each data set was calculated and divided into equal area intervals. Three intervals were used to represent high, medium, and low native language speakers and high, medium, and low percentages of votes. Assigned categories varied based on each multivariate mapping approach. All maps were initially created in ArcMap 9.3 and then transferred to CorelDraw 11 for further design manipulation of symbolization and legends.

Following known guidelines for creating successful multivariate maps, the datasets were transformed into information products. Color combinations that cannot be distinguished by color-blind participants were considered and avoided during the creation of each map. Basic projection, scale, and classes were created in ArcMap 9.3. Maps were then transferred to CorelDraw 11 for further manipulation of color and symbolization, including legend creation. Each dataset was first mapped separately, in order to be used as a control, using choropleth symbolization. Each map was created in English (Figure 11; full version in Appendix A) and then in Spanish (Figure 12; full version in Appendix C) to accommodate survey administration, which took place in the United States and in Bolivia. These maps were placed side by side in the paper survey for ease of comparison.

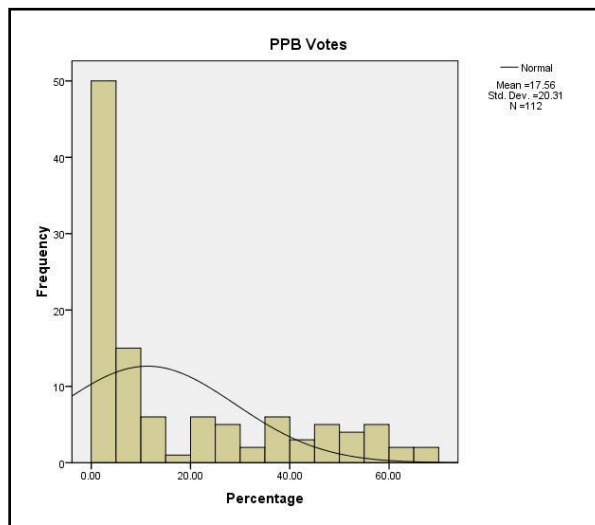
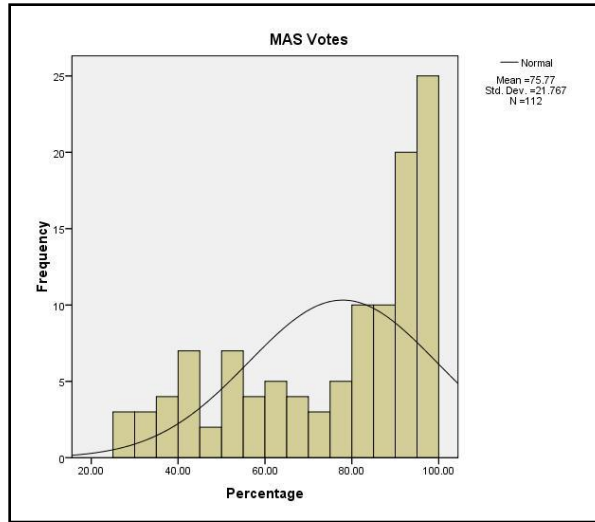


Figure 9: Distribution of political datasets.

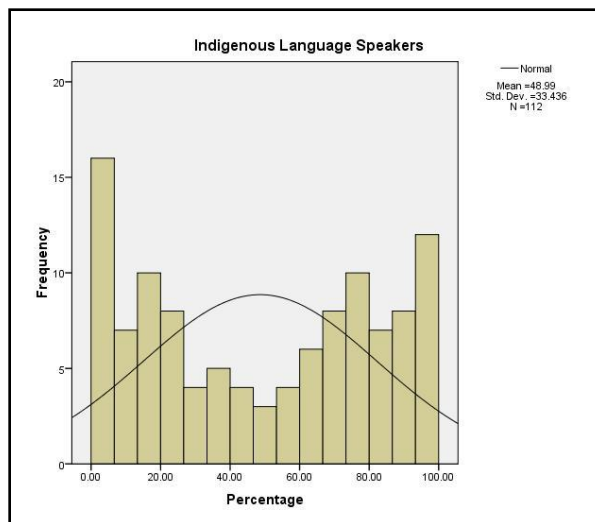


Figure 10: Distribution of language dataset.

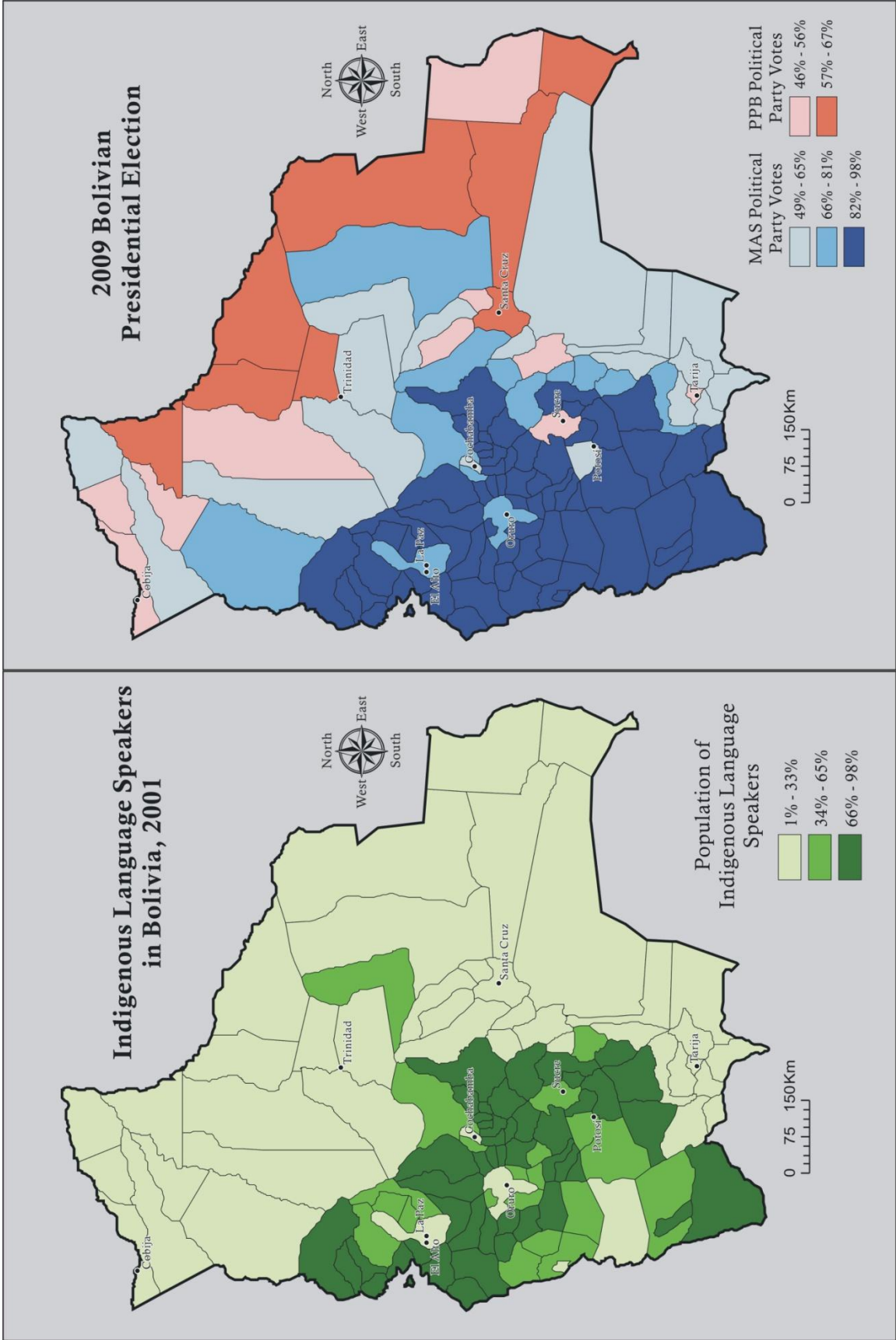


Figure 11: Separate maps for survey in English.

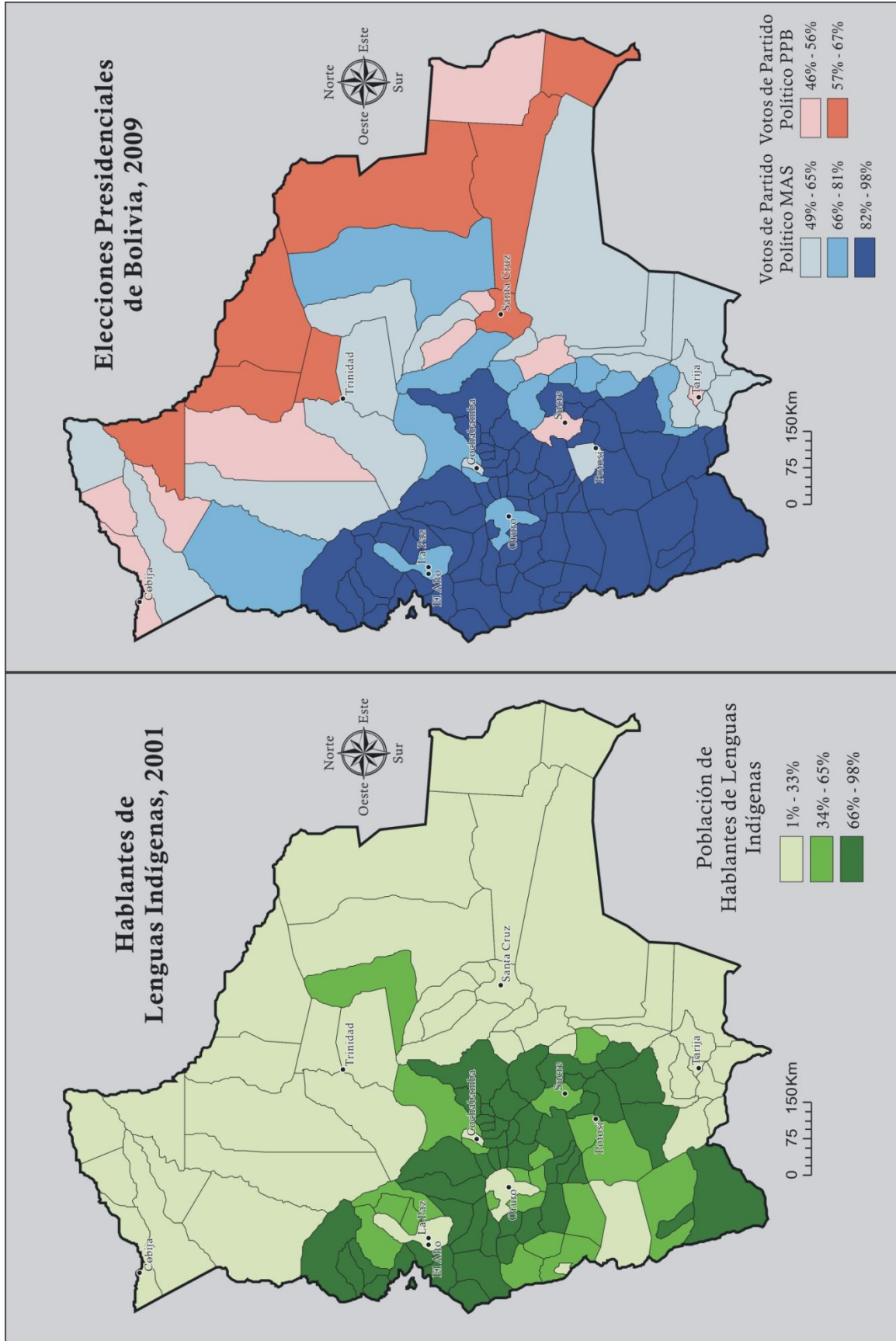


Figure 12: Separate maps for survey in Spanish.

The first multivariate map created was based on the combined color schemes method (Meyer, Broome, and Schweitzer 1975; Tyner 2010) which utilized the blends of cyan, magenta, and yellow to designate high, medium, and low categories (Figure 13; full version in Appendices A and C) This approach used two ratio variables: percentage of MAS votes and percentage of native language speakers. Interpretation of this approach relies heavily on the identification of color based on the legend.

The second approach to multivariate mapping, separable graduated circles, used a combination of ratio and nominal datasets (Figure 14; full version in Appendices A and C). The percentage of native language speakers was the ratio dataset and Majority PPB and Majority MAS were then used as the nominal categories to fill the graduated circles. The classes of the graduated circles represented the density of indigenous language speakers, while the hue of each circle showed the outcome of the election. The hues used to represent MAS votes and PPB votes were based on colors associated with these political parties in Bolivia (Figure 5).

The third multivariate approach, called the pair of sequential schemes, was created in the same manner using ratio and nominal datasets, but with choropleth (Figure 15; full version in Appendices A and C). The map had two color schemes, with colors representing political parties. The hues of the color schemes, blue and red, represented the election outcome, while the density of indigenous language speakers was shown through shade. The lighter shades represented less indigenous speakers and vice versa.

The fourth and final approach used two layers of symbolization: choropleth shading and graduated circles (Figure 16; full version in Appendices A and C). This method enables the use of ratio data in both datasets. When using two types of symbolization together, the

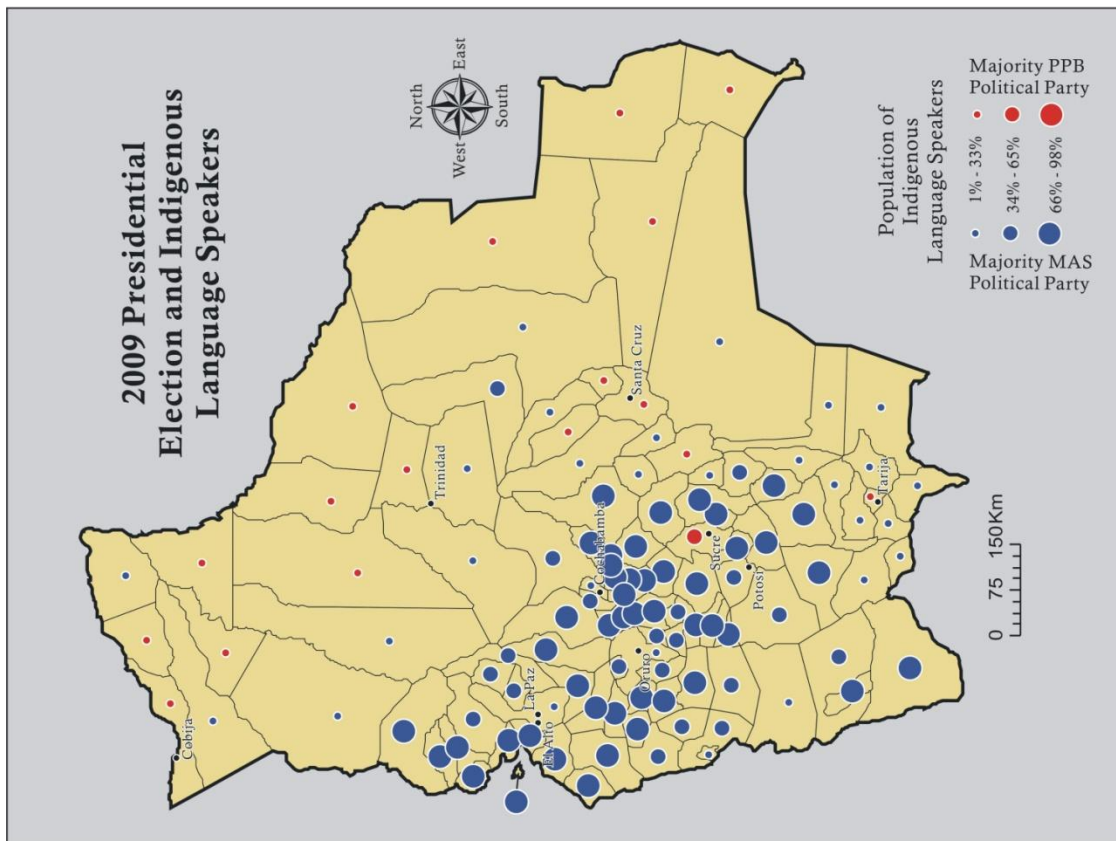
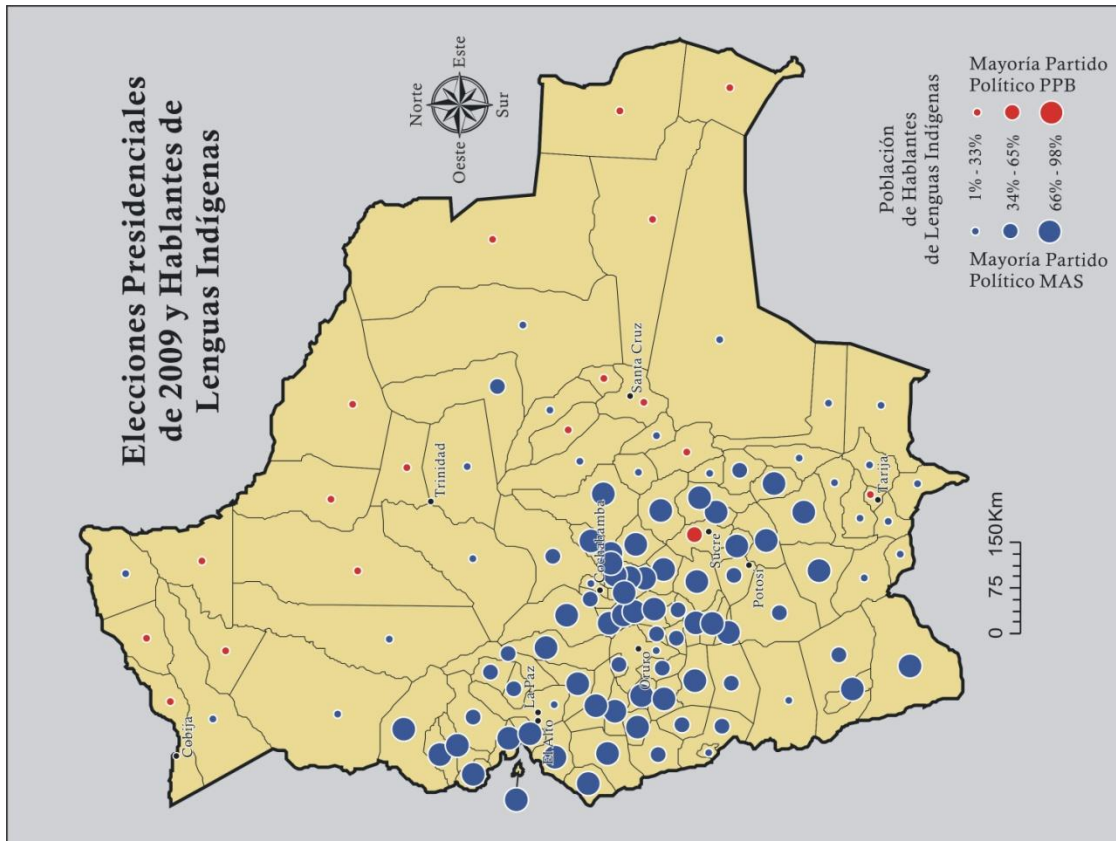


Figure 14: Separable graduated circles map for survey in English and Spanish.

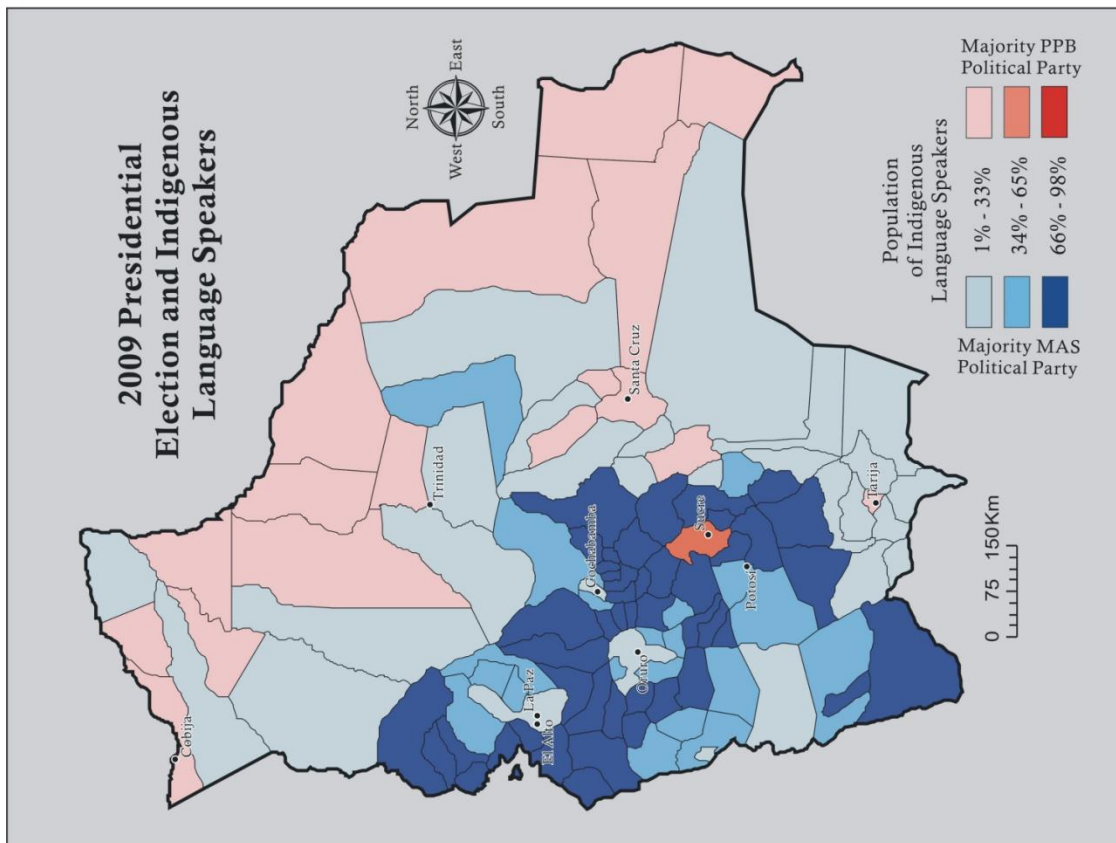
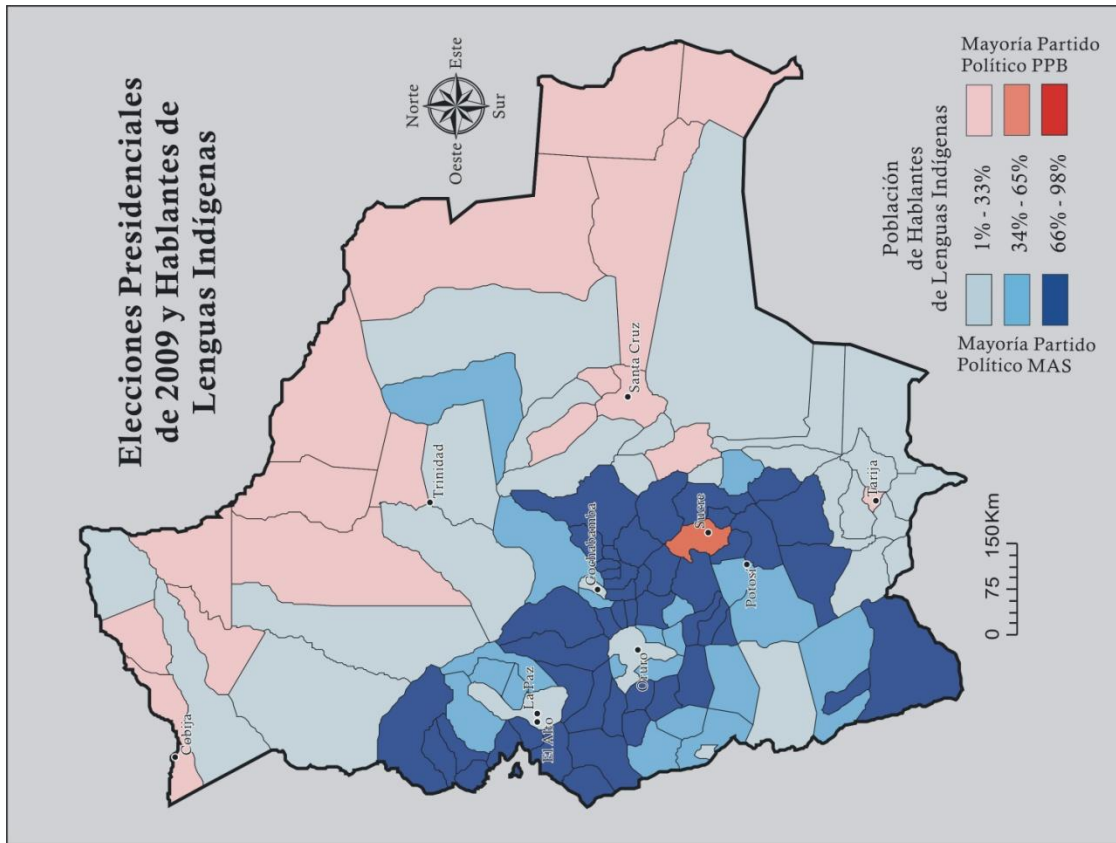


Figure 15: Pair of sequential color schemes map for survey in English and Spanish.

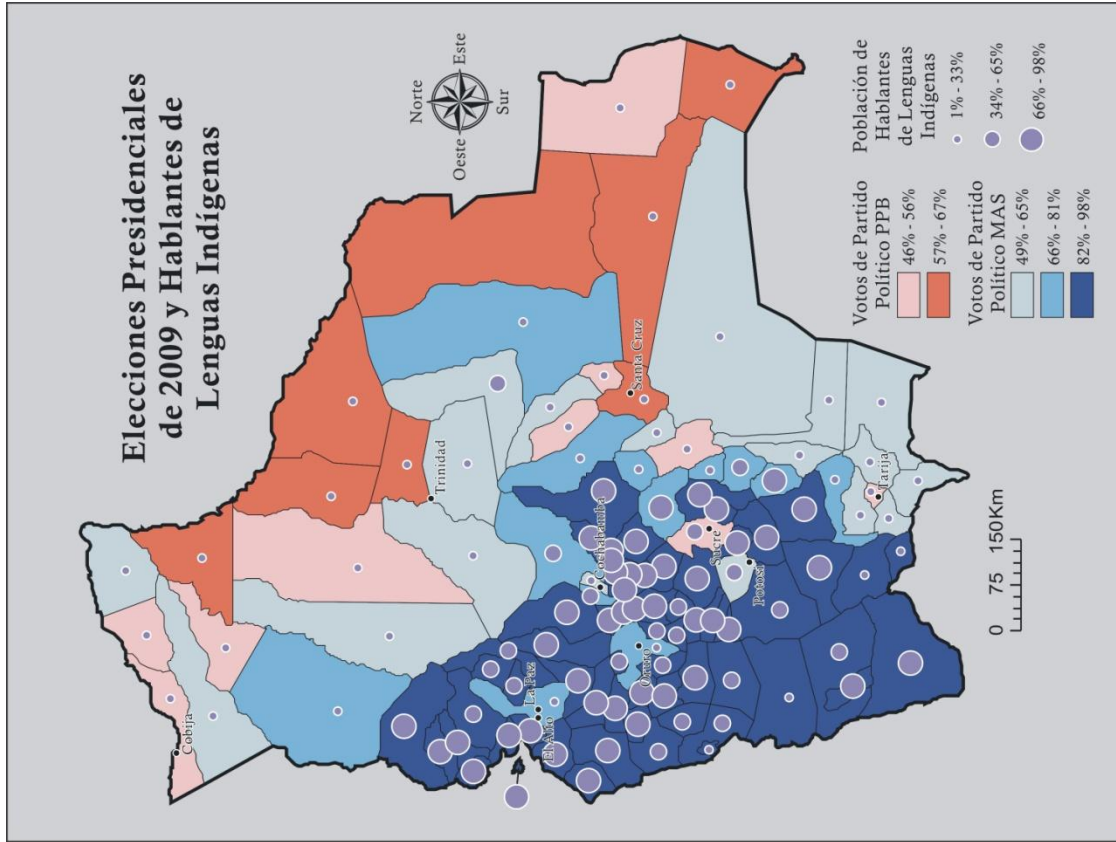
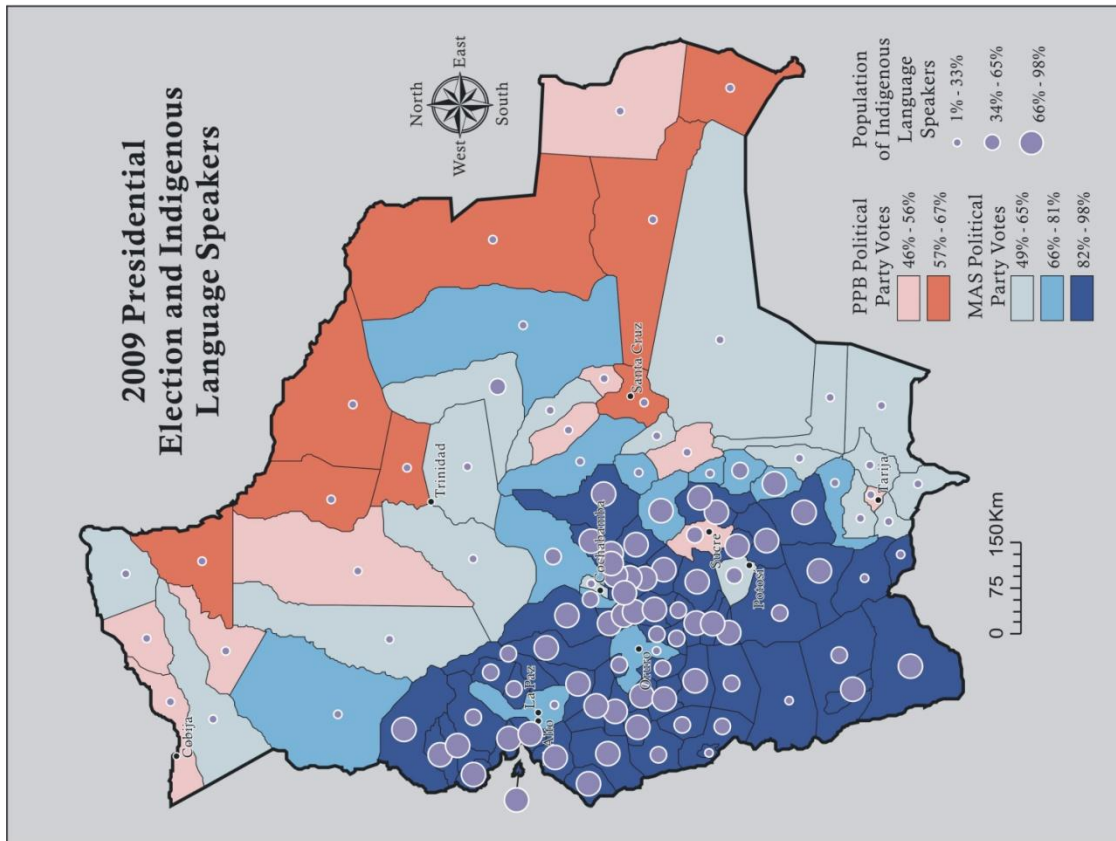


Figure 16: Choropleth with graduated circles map for survey in English and Spanish.

relationship between the variables is best shown with the political data as the base layer (the choropleth symbolization) and language overlaid (proportional circles). A contrasting hue to colors associated with the political parties was used for the proportional circles.

Survey Design

A paper map-based survey consisting of multiple choice questions and ranking scales was administered to evaluate the effectiveness of these four multivariate maps and the side-by-side map (used as the control) in the display of the relationship between the datasets. The design of the survey was based on research by Brewer, MacEachren, Pickle, and Herrmann (1997). The set of maps was shown to each subject two times. By allowing the participants to view the maps more than once, answers to the second set of questions can be selected with more confidence. This strategy helped the participants feel more comfortable while taking the survey and avoided feelings of frustration, which are common when one feels like he or she is being tested. This strategy reduced incomplete surveys or abrupt stopping by the participants.

Survey design was reviewed by the Institutional Review Board of Appalachian State University and determined to be exempt from further review, under the category of anonymous educational tests; surveys, interviews or observations. A directly translated Spanish version of the survey was created and later reviewed by Spanish speakers in Tarija, Bolivia, before administration. A pilot test was used to improve the survey design, consisting of two revision stages using verbal and written feedback from a total of seven expert and novice map readers. The first revision required adjustments in the structure of response collection. Minor changes were made to the wording of questions during the second revision.

A written consent form was signed by each participant as the first stage of survey completion, followed by a set of demographic questions (Section 1 of survey). Demographic interests included sex, age group, first spoken language, political activeness, and map experience. Sections 2-4 of the survey required the use of a map booklet, created using the maps designed for this study. Participants were not under any time constraints during completion and were able to ask questions pertaining to the survey completion process, but not pertaining to question answers.

The final map-based paper survey was then administered in the United States with 34 participants and in Bolivia with thirty participants. The purpose for collecting data from each of the two countries was to compare understanding of the mapping approaches as related to context and background of the participants. The United States sample was administered in various regions of the eastern United States, including North Carolina, Tennessee, and Florida. The Bolivian sample was administered in the city of Tarija which is located in the southern tip of the country. These regions were chosen for survey administration based on availability of contacts and avenues for reliable survey administration.

The population included participants from a range of ages and backgrounds. Participants ranged in age from nineteen to above fifty-one and had varying professions or areas of study. Both samples were heavily influenced by an education atmosphere with many contacts for participant request being through university contacts. All participants were associated with the educated and professional middle-class in both the United States and Bolivia and results from this study are specific to this group. The Tarija sample was specific to the well-educated European elite sector of the city and results from this study pertain

specifically to this group within Bolivia. Although participants for both groups were selected through social contacts, the two are parallel in demographic and educational background.

For each map, the survey used one general map message question, three specific map message questions, and two ranking scales which evaluated pleasantness and readability of the maps to the participant. The color paper maps were arranged into a booklet to be used with each set of questions for each map for each participant for a total of six questions per map. The map booklet consisted of two copies of each map series, ordered control map pair, combined color schemes map, separable graduated circles map, pair of sequential schemes map, and choropleth with graduated circles map, preventing the participant from needing to turn back through the booklet.

The first series of maps was viewed with one general map design question per map to acquaint the participant with map reading (Section 2 of survey). These questions were assessed through a multiple choice approach. Each of the five questions defined a major map element, including title, scale bar, compass, legend, and symbolization. The main function of this set of questions is to prepare the participant to answer the remainder of the survey. These results were not a main focus of data analysis, but instead were meant to orientate the participant to the survey and to the maps themselves.

The second map series consisted of questions which pertained to the map information of specific regions and patterns on each of the maps, which illustrated the relationship between datasets (Section 3). The second series of questions began with two multiple choice selections; first pertaining to the regional character of variables and second pertaining to the relationship between variables. Next, a question with two fill-in-the-blank responses assessed the participants' ability to interpret the map through the legend. These were followed by two

rating scales (1-5) for each individual map: visual pleasantness (pleasant to unpleasant) and readability (difficult to easy to read). This set of questions allowed the assessment of the effectiveness of each mapping method based on map message understanding, map legibility and visual preference.

In section 4, participants were given a page which included all maps seen in the survey and were asked to rank their overall reaction by assigning one of the numbers 1-5 (1 being the best and 5 the worst) in regards to which maps they preferred overall. The final page of the survey provided participants with a place to write general comments. The full set of survey questions can be seen in English in Appendix B with the Spanish translation in Appendix D.

Data Analysis

Results from the surveys were analyzed based on effectiveness of each mapping technique, which was determined through descriptive statistics, paired *t*-tests, and independent samples *t*-tests performed in SPSS 17.0. Survey results were divided by question type to be analyzed within the following groups: entire population, United States sample and Bolivia sample, by mapping approach and within demographic groups (gender, age, language, political activeness, and map experience). Question types include general questions, specific questions, individual map rating scales, and overall ranking of all maps. General questions were used to assess the participant's initial ability to read a map template. Specific questions with correct/incorrect answers assessed the participant's ability to understand the map message (the map message being that there is a functional relationship between the results of the presidential election of 2009 and indigenous language speakers). The rating scales

provided insight into the participant’s preference in visual presentation and ease of reading for each individual map. Finally, the overall ranking of all maps assessed the participant’s cumulative preference in viewing the datasets provided. See Table 1 for details with regard to research sub-questions.

Table 1: Summary of research questions.

Research Question	Evaluating Survey Section	Evaluating Statistic
a) Which method of multivariate mapping best communicated the map message?	3 and 4	Comparison of Means and Paired <i>t</i> test
b) Which method of multivariate mapping was visually preferred?	3 and 4	Comparison of Means and Paired <i>t</i> test
c) Which method of multivariate mapping is most easily read?	3 and 4	Comparison of Means and Paired <i>t</i> test
d) Did gender or age play a role in the results?	1 and 2	Comparison of Means and Pearson’s Correlation
e) Did political activeness play a role in results?	1 and 2	Comparison of Means and Pearson’s Correlation
f) Did map experience affect map understanding?	1 and 2	Comparison of Means and Pearson’s Correlation
g) Did understanding of general questions contribute to results of specific questions?	2 and 3	Comparison of Means and Pearson’s Correlation
h) In what ways did results differ between the United States and Bolivia?	All	Comparison of Means and Ind. samples <i>t</i> test

Each participant was assigned a score reflecting ability to interpret and understand the map message. Each was given a separate score based on the percentage correct by section of questions, general and specific, and for each mapping approach. Mean ratings based on various population separations were used to assess visual pleasantness and readability. Finally, a rank was assigned to each mapping approach based on the mean of data collected in the final section of the survey.

Survey results were summarized and analyzed using a series of descriptive statistics and statistical tests: comparison of means, Pearson's correlation, paired *t*-tests, and independent samples *t*-tests (Table 1). Scores reflecting percentage of correct responses were assigned to each case within the population and used in analysis. Rating and ranking scale response were summarized using means. The differences of means tests were evaluated between groups using *t*-tests at 95 percent confidence interval. The analysis of demographic influences, including age, gender, and language was based on the responses of the entire population. Observations were made based on commentary offered by participants during the administration of the survey.

Summary

In order to evaluate the most effective multivariate mapping strategies for communicating complex phenomena, the functional relationship between results of the Presidential election of 2009 and native language speakers in Bolivia was displayed using four multivariate mapping approaches (combined sequential color schemes, separable graduated circles, choropleth with proportional symbols, and pair of sequential color schemes). The two datasets were also displayed separately for map comparison, which acted

as a control. All maps were created based on multivariate mapping guidelines supported by previous research. Understanding of the map message and preference viewing in the five different mapping approaches were assessed through a map-based paper survey. Survey design included a series of multiple choice and fill-in questions with rating and ranking scales. The survey was administered to a total of sixty-four participants in both the eastern United States and Tarija, Bolivia. Using statistical procedures, responses gathered from these surveys were analyzed and interpreted to suggest which multivariate mapping approach was most easily interpreted and visually preferred.

CHAPTER 4: RESULTS AND DISCUSSION

The main objective of this analysis was to identify patterns that suggest which multivariate mapping approach is most appropriate for the display of socio-political datasets. The multivariate mapping approaches used in this study will be referred to with the following abbreviations: separate choropleth maps (separate maps), combined sequential color schemes (combined schemes), separable graduated circles (separable circles), pair of sequential color schemes (pair of schemes), and layered symbolization (choro/grad). The total sample size was 64, with 34 participants in the United States and 30 participants in Bolivia (Table 2).

Table 2: Summary of sample size

Sample	N
United States	34
Bolivia	30
Total	64

General Questions

In section two of the survey, the majority of the general map composition questions were answered correctly (Table 3). These scores reflect the participants' previous knowledge of map composition and map reading abilities. The entire sample answered 98.1 percent of the general questions correctly; the sample in the United States answered 99.4 percent correctly and the sample in Bolivia answered 96.6 percent correctly. Figure 17 shows the

range and difference of means between the two samples, which both reflect significantly high scores from the entire population.

Table 3: General questions (section 2) descriptive statistics.

Sample Statistics					
	Country	N	Mean (%)	Std. Deviation	Std. Error Mean
Score	United States	34	99.411	3.429	.588
	Bolivia	30	96.666	7.580	1.384

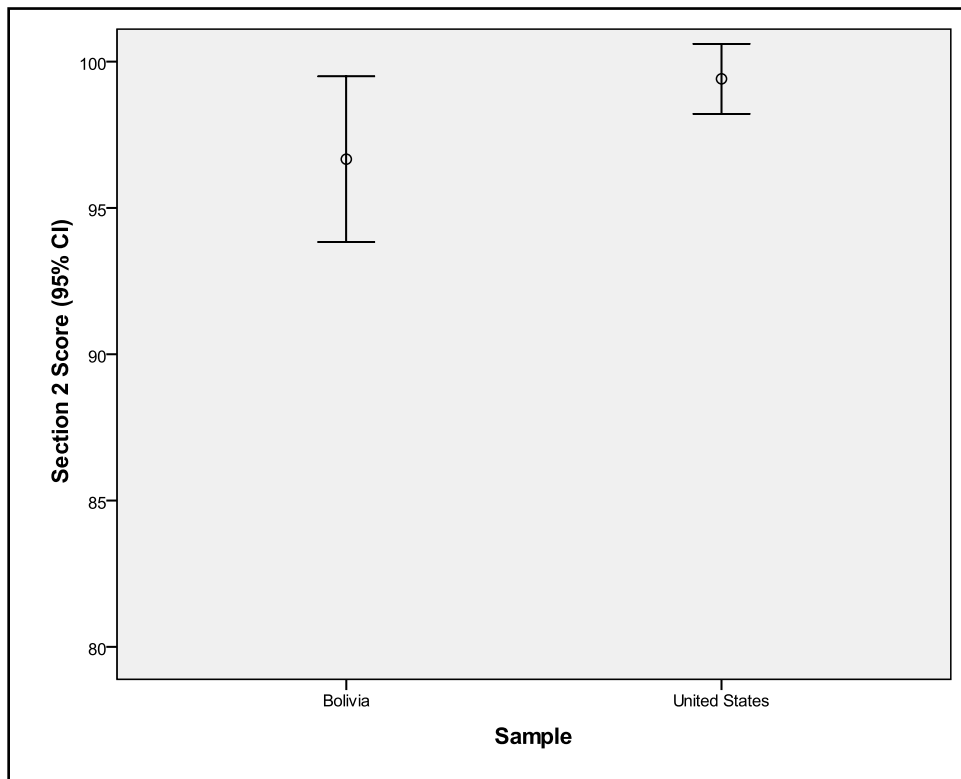


Figure 17: Summary of section 2 scores by sample.

An independent samples *t*-test failed to reveal a statistically reliable difference between the mean score in Bolivia and the mean score in the United States (Table 4). The question that was most incorrectly answered (question four) was related to understanding of legend interpretation. Others that were answered incorrectly pertained to compass purpose and title placement (Table 5). A comparison of the number of incorrect responses between the general questions and specific questions showed a weak positive relationship (Pearson's Correlation Coefficient of .233; Table 6). Both groups demonstrated acceptable basic map reading skills which implicated that participants should have the basic skills to work with the test maps comfortably.

Table 4: Results of general questions independent samples *t*-test.

Levene's Test for Equality of Variances	
F	Sig.
17.747	.000

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
1.825	39.296	.076	2.745	1.503	-.296	5.786

Table 5: Summary of general question (section 2) incorrect responses.

	Q1	Q2	Q3	Q4	Q5
United States	0	0	1	0	0
Bolivia	0	2	0	3	0

Table 6: Pearson's Correlation: General and specific questions.

		General	Specific
General	Pearson Corr.	1	.233
	Sig. (2-tailed)		.076
	N	64	64
Specific	Pearson Corr.	.233	1
	Sig. (2-tailed)	.076	
	N	64	64

Specific Questions

Participants were assigned a score reflecting the percentage correct of all questions in section 3 of the survey (multiple choice and fill-in questions). The total mean score for the entire sample was 74 percent. The United States sample had a score of 86 percent and the Bolivia sample had a score of 62 percent (Table 7). The score in the United States was 24 percent higher than in Bolivia. Figure 18 shows the difference of means between samples with error bars at a 95 percent confidence interval. An independent samples *t*-test revealed a statistically reliable difference between the mean scores of Bolivia and the United States (Table 8); the United States sample showed significantly higher scores.

Table 7: Summary of specific question (section 3) descriptive statistics.

	Country	N	Mean (%)	Std. Deviation	Std. Error Mean
Score	United States	34	85.882	10.764	1.846
	Bolivia	30	61.666	14.403	2.629

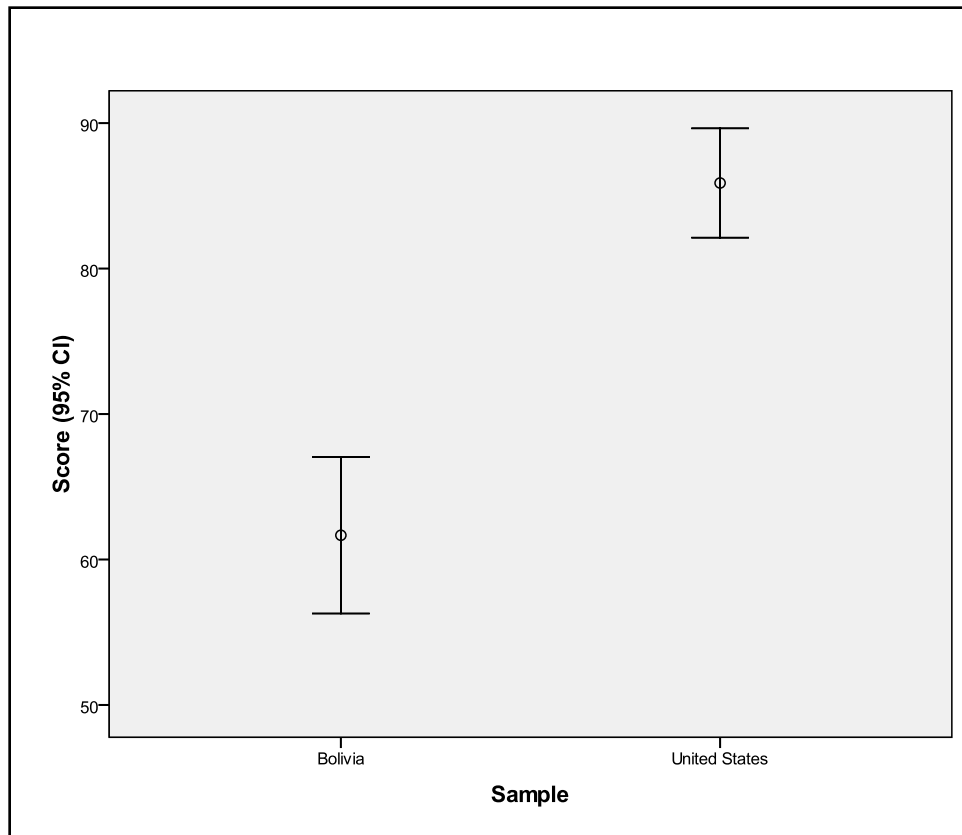


Figure 18: Summary of section 3 scores by sample.

Table 8: Results of specific questions independent samples *t*-test.

Levene's Test for Equality of Variances	
F	Sig.
3.676	.060

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
7.674	62	.000	24.215	3.155	17.907	30.523

The mean scores were further separated by mapping approach (Figure 19; Table 9). For the entire sample, the separate maps approach yielded the highest score. This was followed by the pair of schemes approach, separable circles, and combined schemes. The choro/grad approach yielded the lowest mean score. The United States group also received the highest scores from the separate maps; the second highest scores were with the pair of schemes, followed by choro/grad, separable circles, and combined schemes with the lowest scores. This pattern differed in the Bolivia group scores. For this group, the highest mean score was received with the pair of schemes approach. This was followed by the separable circles approach, then separate maps, combined schemes, and choro/grad with the lowest mean score.

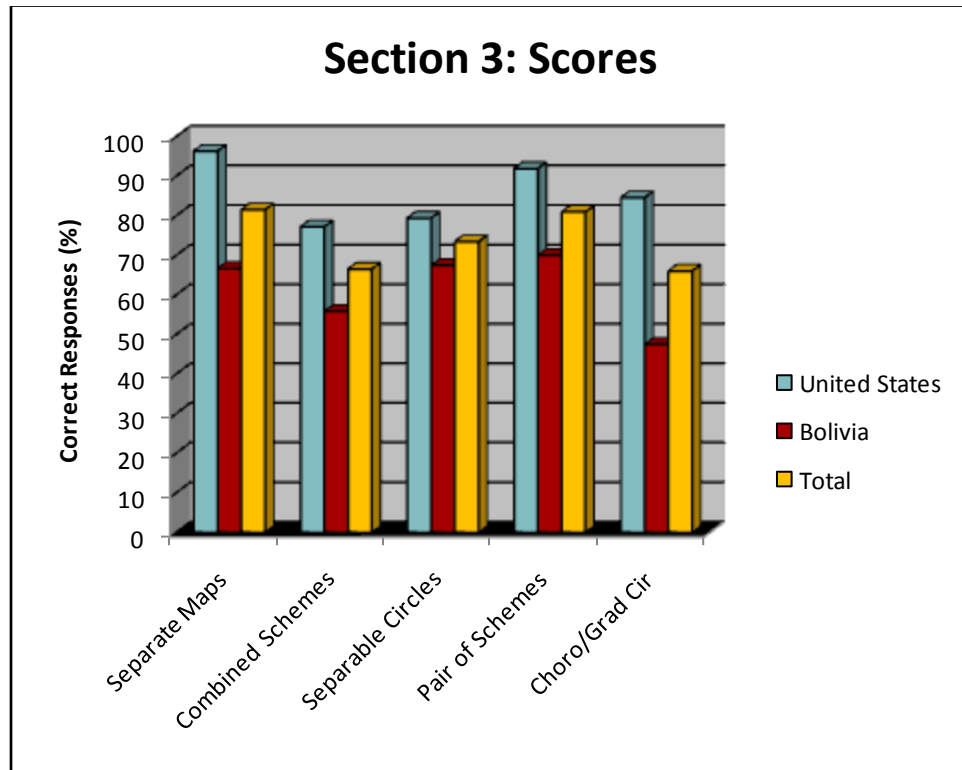


Figure 19: Total section 3 scores by mapping approach.

Table 9: Summary of specific question (section 3) scores in percent.

	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/Grad
United States	96.3	77.2	79.4	91.9	84.5
Bolivia	66.6	55.8	67.5	70.0	47.5
Total	81.4	66.5	73.4	80.9	66.0

Overall, the separate maps and pair of schemes approaches were easier to understand than the choro/grad and combined schemes approaches. Paired *t*-tests divided by mapping approach showed that almost all of the scores were significantly different (Table 10). Pairs that did not show a significant difference were: separate maps/pair of schemes, separable circles/combined schemes, and choro/grad circles/combined schemes. This shows that the Separate maps approach yielded significantly higher scores than the choro/grad and combined schemes approaches. Although the Bolivia sample scored 3.4% higher on the pair of schemes approach than the separate maps, there was not a statistically significant difference between the two (Table 11).

Table 10: Results of specific questions paired *t*-tests by mapping approach.

<i>t</i> (62) / <i>p</i>	Separate Maps	Combined Schemes	Separable Circles	Pair of schemes	Choro/Grad Circles
Separate Maps	-	4.8 / .000	3.0 / .004	.44 / .658	4.1 / .000
Combined Schemes	4.8 / .000	-	-1.8 / .065	-4.0 / .000	.29 / .770
Separable Circles	3.0 / .004	-1.8 / .065	-	-2.9 / .005	2.1 / .036
Pair of Schemes	.44 / .658	-4.0 / .000	-2.9 / .005	-	4.5 / .000
Choro/Grad Circles	4.1 / .000	.29 / .770	2.1 / .036	4.5 / .000	-

Table 11: Results of paired *t*-test for Bolivian sample only

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Dev.	Std. Error Mean	95% Conf. Int.				
				Lower	Upper			
Separate Maps – Pair of Schemes	-3.33	24.33	4.44	-12.41	5.75	-.75	29	.459

A comparison of the number of incorrect responses between the multiple choice and fill-in questions showed a moderately significant positive relationship, with a Pearson's Correlation Coefficient of .613 (Table 12). Many factors could have contributed to the correlation of these two variables, including cultural differences (discussed in Section 4.6: Observations from Bolivia). The multiple choice responses reflect the map reader's ability to understand the map message. The fill-in questions reflected the map reader's ability to quantify symbolization through legend interpretation. Most of the incorrect responses were related to the fill-in questions. The mean number of incorrect answers divided by question type and grouped by mapping approach can be seen in Figure 20. In general, there was a slight inverse relationship between the two question types. For example, the separate maps approach show the least incorrect answers for fill-in questions, yet the most incorrect answers for multiple choice questions. The largest number of incorrect multiple choice responses was seen with the separate maps approach and the least with the separable circles approach. The largest number of incorrect fill-in responses was seen with the choro/grad approach and the least with the separate maps approach.

Table 12: Pearson's Correlation: Multiple choice and fill-in questions.

		Multiple Choice	Fill In
Multiple Choice	Pearson Corr.	1	.613**
	Sig. (2-tailed)		.000
	N	64	64
Fill In	Pearson Corr.	.613**	1
	Sig. (2-tailed)	.000	
	N	64	64

****.** Correlation is significant at the 0.01 level (2-tailed).

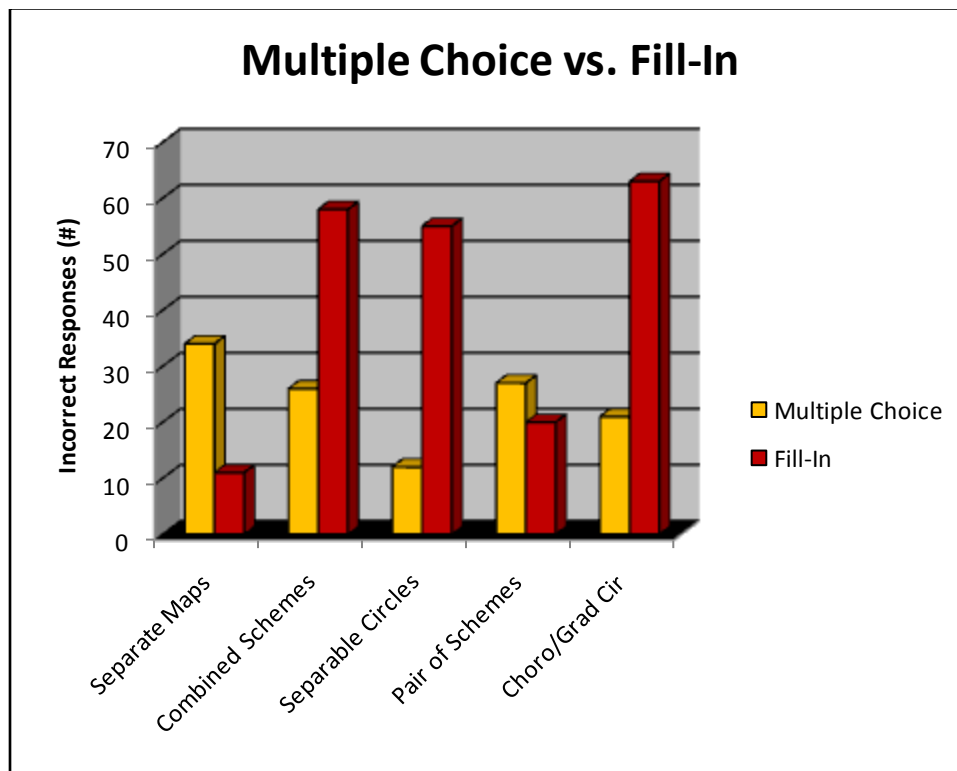


Figure 20: Summary of section 3 incorrect answers by question type.

A comparison of these two different types of questions between the two main groups, United States and Bolivia, by mapping approach can be seen in Figures 21 and 22 (Tables 13 and 14). In all cases, the Bolivian sample showed a larger number of incorrect answers. There was no strong pattern seen in incorrect responses between the two groups, but a few relationships were noted. The separate maps approach showed the least number of incorrect fill-in answers with both groups. The most number of incorrect fill-in responses were seen with the combined schemes approach in the United States and the choro/grad approach in Bolivia. There were no similarities between groups with incorrect responses to multiple choice questions. The United States group showed the least number of incorrect multiple choice responses with the choro/grad approach and the most with the pair of schemes approach. The Bolivian group showed the least number of incorrect multiple choice responses with the separable circles approach and the most with the separate maps approach.

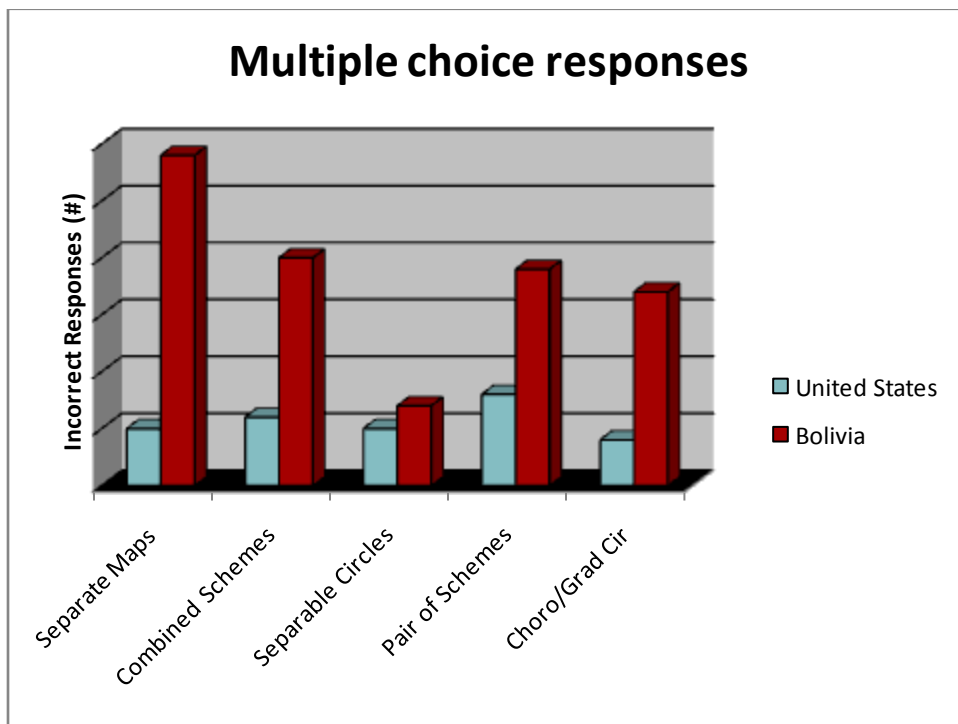


Figure 21: Summary of section 3 multiple choice responses by mapping approach.

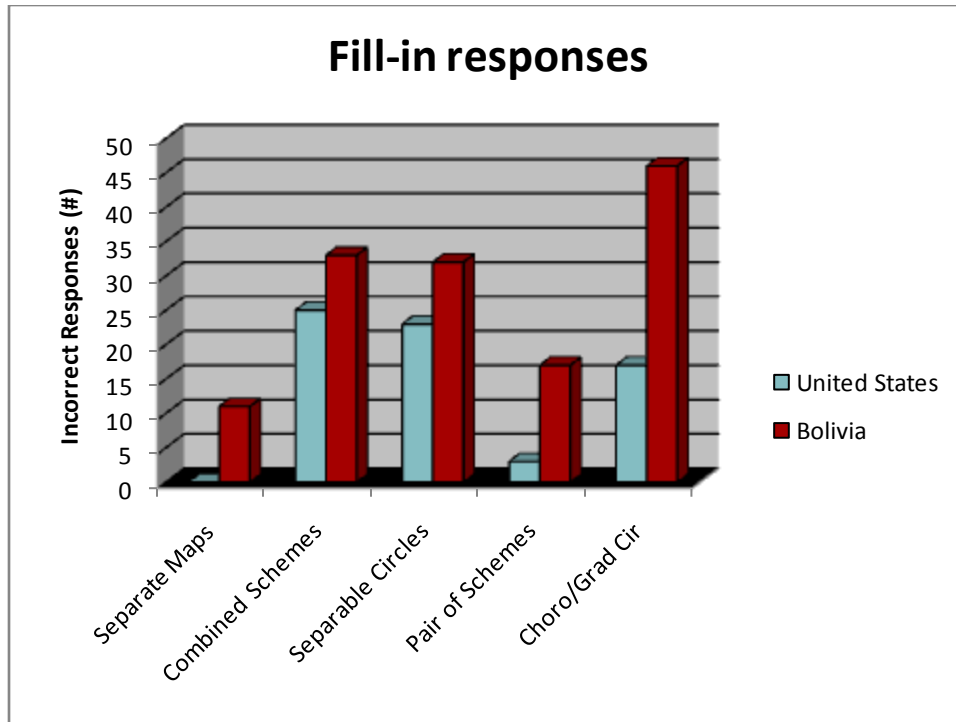


Figure 22: Summary of section 3 fill-in responses by mapping approach.

Table 13: Summary of section 3 multiple choice incorrect answers.

	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/ Grad
United States	5	6	5	8	4
Bolivia	29	20	7	19	17
Total	34	26	12	27	21

Table 14: Summary of section 3 fill-in incorrect answers.

	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/ Grad
United States	0	25	23	3	17
Bolivia	11	33	32	17	46
Total	11	58	55	20	63

The questions missed most frequently were fill-in questions associated with the mapping approaches that used separable graduated circles (Table 15). Question 13b, referring to separable circles approach, was incorrectly answered a total of thirty-nine times and question 23b, referring to choro/grad approach, was incorrectly answered a total of thirty-four times. Both of these questions ask for quantitative information about the city of La Paz, Bolivia, which is located in a relatively small areal unit. The multiple choice questions that were most frequently incorrectly answered (questions 1, 6 and 16) all included a reference to “north”. Bolivian responses accounted for 80 percent of the incorrect responses. There were twenty or less incorrect responses with the separate maps and pair of schemes approaches, and over fifty with the combined schemes, separable circles, and choro/grad approaches.

Table 4.15: Detail of specific question (section 3) incorrect responses.

	Separate Maps				Combined Schemes				Separable Circles			
	Q1	Q2	Q3a	Q3b	Q6	Q7	Q8a	Q8b	Q11	Q12	Q13a	Q13b
United States	4	1	0	0	5	1	11	14	3	2	1	22
Bolivia	21	8	6	5	13	7	19	14	2	5	5	27
Total	25	9	6	5	18	8	30	28	5	7	6	49

	Pair of Schemes				Choro/Grad			
	Q16	Q17	Q18a	Q18b	Q21	Q22	Q23a	Q23b
United States	4	4	0	3	2	2	7	10
Bolivia	18	1	10	7	6	11	22	24
Total	22	5	10	10	8	13	29	34

Rating Scales

Participants rated each multivariate mapping approach based on two separate criteria: visual pleasantness and readability. Each map received these two ratings in Section 3 of the survey. A rating between 1 and 5 was assigned, with 5 being the most visually pleasant or easiest to read. The mean rating was calculated by map within each group and for the entire sample. All ratings fell within the range of 2.97 to 4.26.

The visual pleasantness ratings are summarized in Table 16 and Figure 23 below. The separate maps approach received the highest mean rating of 4.19 for visual pleasantness by the entire sample. Both the United States and Bolivia groups also assigned the highest rating to the separate maps approach. The lowest rating of pleasantness was also consistent between groups, assigning a total mean rating of 3.6 to the separable circles approach. This approach is lacking in color when compared to the other approaches. The total mean scores showed that the pair of schemes approach received the second highest rating, followed by combined schemes and choro/grad approaches. A paired *t*-test (Table 17) revealed that the separate maps approach ratings were significantly higher than the ratings for all multivariate approaches. The differences among the multivariate approaches were not statistically significant with the exception of the pair of schemes approach being higher than the separable circles approach.

Table 16: Summary of visual pleasantness ratings.

	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/ Grad
United States	4.18	3.76	3.47	3.97	3.68
Bolivia	4.2	3.9	3.73	3.77	3.93
Total	4.19	3.83	3.6	3.87	3.80

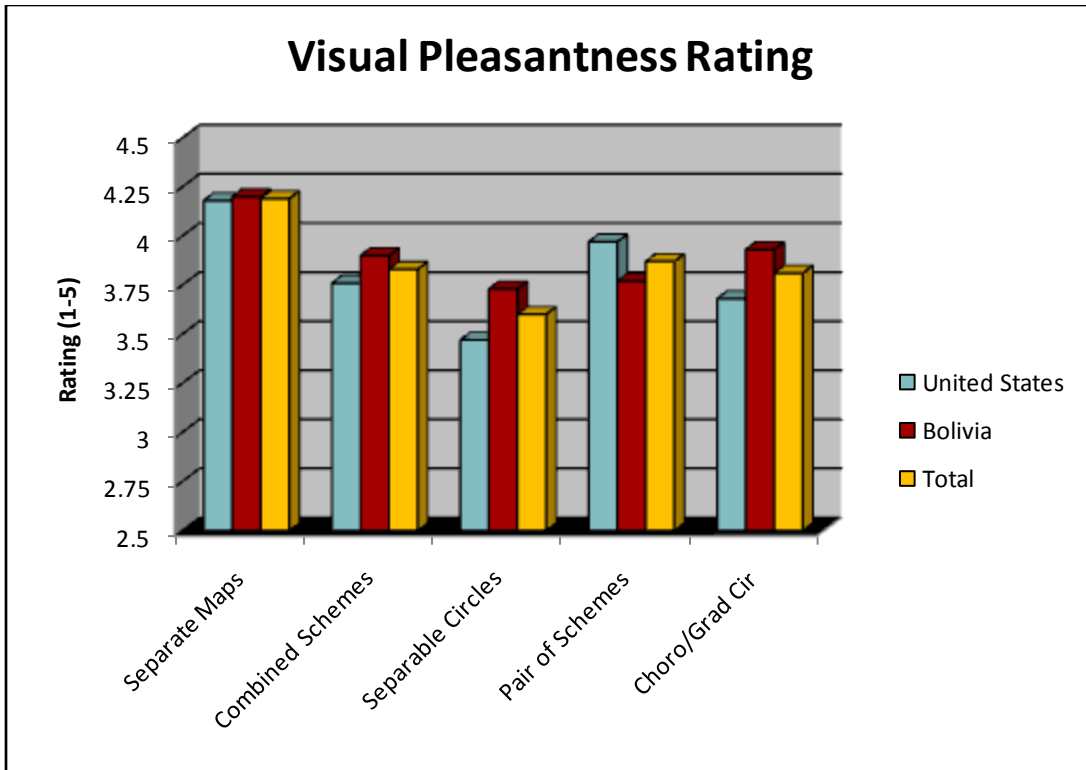


Figure 23: Summary of visual pleasantness ratings.

Table 17: Results of visual pleasantness ratings paired *t*-tests by mapping approach.

<i>t</i> (62) / <i>p</i>	Separate Maps	Combined Schemes	Separable Circles	Pair of schemes	Choro/Grad Circles
Separate Maps	-	3.49 / .001	4.66 / .000	3.63 / .001	3.6 / .001
Combined Schemes	3.49 / .001	-	1.49 / .152	-0.36 / .717	0.26 / .795
Separable Circles	4.66 / .000	1.49 / .152	-	-2.60 / .011	-1.53 / .129
Pair of Schemes	3.63 / .001	-0.36 / .717	-2.60 / .011	-	0.72 / .470
Choro/Grad Circles	3.6 / .001	0.26 / .795	-1.53 / .129	0.72 / .470	-

The readability ratings are summarized in Figure 24 and Table 18. The trend in order of these ratings was consistent with both sample groups. Once again the separate maps approach received the highest rating of 4.05. The separable circles approach once again

received the lowest rating of 3.23. The second highest rating was assigned to the pair of schemes approach followed by the choro/grad and combined schemes approaches. In the Bolivia group the rating for pair of schemes was a very close second to the separate maps approach. A paired *t*-test revealed a significant difference between most scores (Table 19). Once again, the separate maps approach ratings were significantly higher than the ratings for all multivariate approaches. Differences among the multivariate approaches were not statistically significant included: combined schemes/separable circles, combined schemes/choro/grad, and pair of schemes/choro/grad.

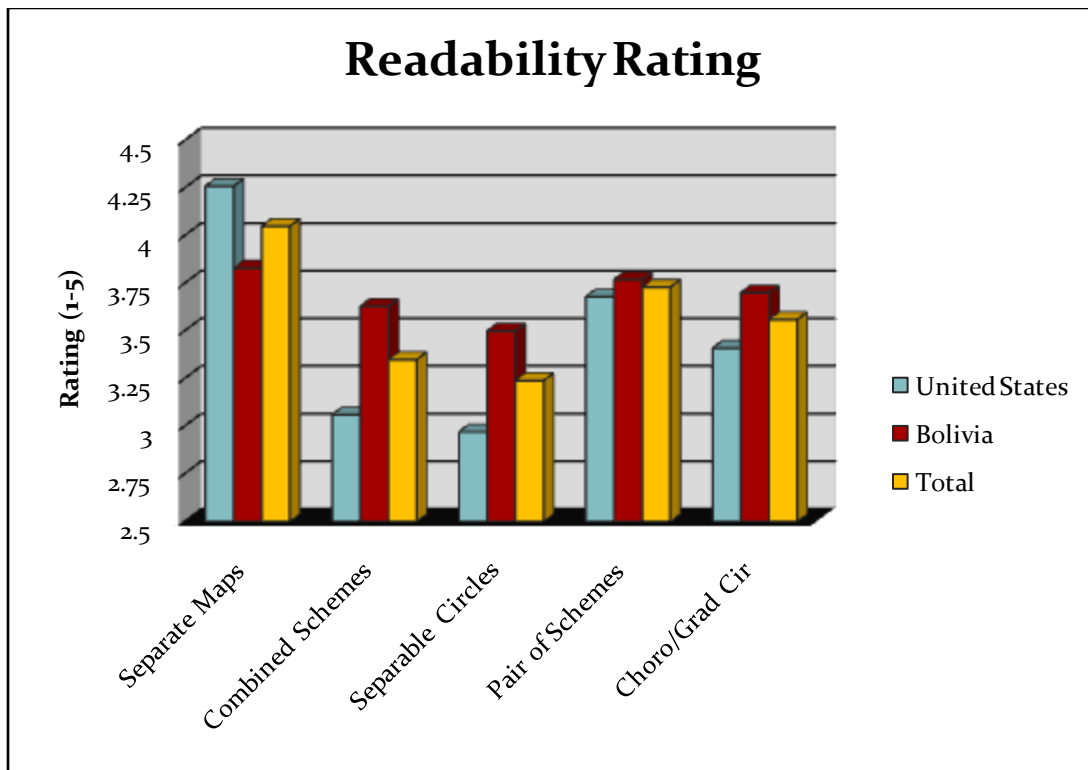


Figure 24: Summary of readability ratings.

Table 18: Summary of readability ratings.

	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/ Grad
United States	4.26	3.06	2.97	3.68	3.41
Bolivia	3.83	3.63	3.5	3.77	3.7
Total	4.05	3.35	3.23	3.72	3.55

Table 19: Results of readability ratings paired *t*-tests by mapping approach.

<i>t</i> (62) / <i>p</i>	Separate Maps	Combined Schemes	Separable Circles	Pair of schemes	Choro/Grad Circles
Separate Maps	-	4.95 / .000	5.14 / .000	2.46 / .016	3.66 / .001
Combined Schemes	4.95 / .000	-	0.80 / .423	-2.93 / .005	-1.62 / .109
Separable Circles	5.14 / .000	0.80 / .423	-	-4.03 / .000	-2.68 / .009
Pair of Schemes	2.46 / .016	-2.93 / .005	-4.03 / .000	-	1.37 / .174
Choro/Grad Circles	3.66 / .001	-1.62 / .109	-2.68 / .009	1.37 / .174	-

Overall Ranking

In section four of the survey, participants assigned overall rankings to all multivariate mapping approaches. This section gave the participants an opportunity to reassess their preference in mapping approach after being exposed to all methods. The means of these rankings (1-5; 1 being the best) calculated by mapping approach are shown in Figure 25 with details in Table 20. For both groups within the sample, the separate maps approach was given the highest ranking (2.05) and the combined schemes the lowest ranking (3.67). The second highest rank for the entire sample was assigned to the choro/grad approach, followed by separable circles and pair of schemes approaches.

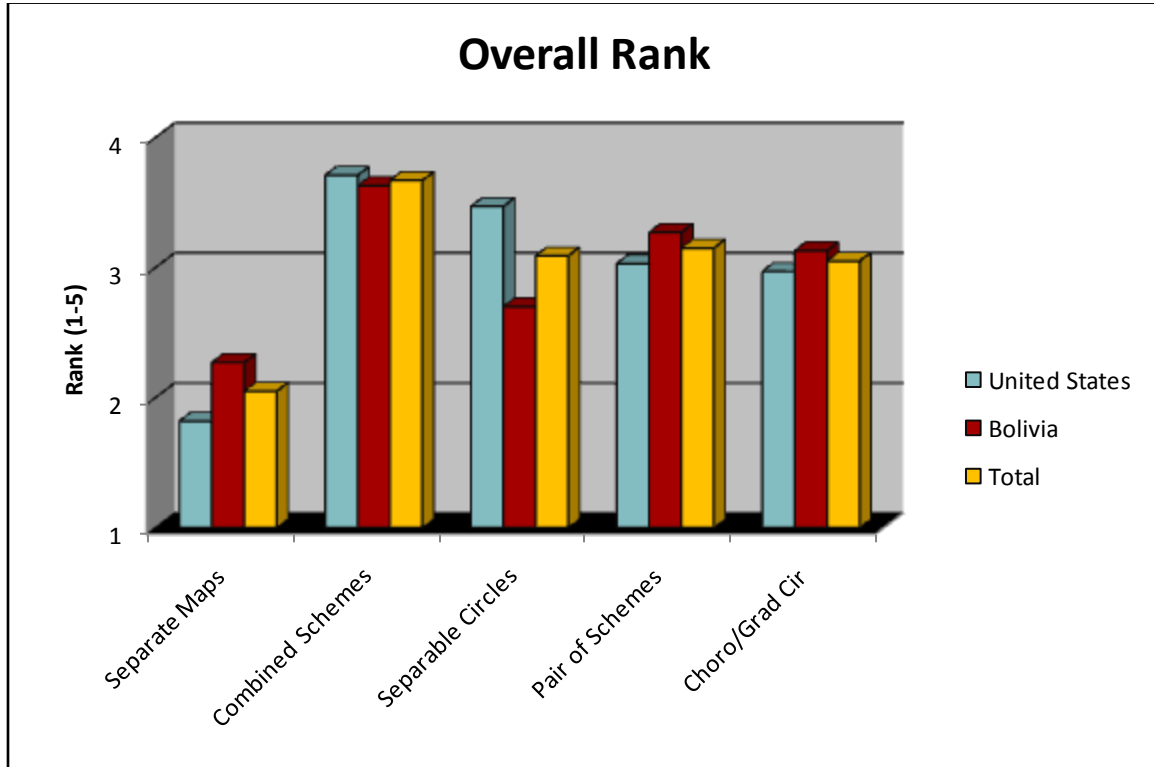


Figure 25: Summary of overall ranking.

Table 20: Summary of overall ranks by mapping approach.

	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/ Grad
United States	1.82	3.71	3.47	3.03	2.97
Bolivia	2.27	3.63	2.70	3.27	3.13
Total	2.05	3.67	3.08	3.15	3.05

Demographic Groups

Specific question scores were compared among demographic categories designated in demographic survey questions. With demographic categories sex, age group, and first spoken language, the specific question scores and map approach ratings were compared across the

entire population. The demographic categories of political activeness and map experience yielded ratings that were correlated to specific map questions scores. A summary of demographic groups for the population is shown in Table 21.

Table 21: Summary of population demographics.

Demographic category	Demographic Group	Percentage of Population
Sex	Male	39.1
	Female	60.9
Age Group	19 and under	6.2
	20 to 30	54.7
	31 to 40	18.8
	41 to 50	17.2
	51 and over	3.1
First Spoken Language	English	48.5
	Spanish	46.8
	Other	4.7

The population was 39.5 percent male and 60.5 percent female. Descriptive statistics in Table 22 showed that the female group had a higher mean score (76.8 percent) than the male group (71.0 percent). However, a *t* test failed to reveal a statistically reliable difference between the mean score in females and the mean score in males (Table 23). Both males and females assigned the highest rating for visual pleasantness and readability to the separate maps approach and the lowest rating to the separable circles approach (Tables 24 and 25). This is consistent with population ratings from Section 4.2 Specific Questions. The range of ratings assigned for both visual pleasantness and readability differed between groups (Figure 26). The female group tended to assign higher ratings than the male group. However, there were no significant differences in general trends.

Table 22: Summary of descriptive statistics by sex.

Sample Statistics					
	Sex	N	Mean (%)	Std. Deviation	Std. Error Mean
Score	Male	25	71.000	16.708	3.341
	Female	39	76.794	17.751	2.842

Table 23: Results of independent samples *t*-test by sex.

Levene's Test for Equality of Variances	
F	Sig.
.001	.971

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
-1.303	62	.197	-5.794	4.446	-14.683	3.093

Table 24: Summary of visual pleasantness ratings by sex.

Sex	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/ Grad
Male	3.88	3.72	3.4	3.72	3.68
Female	4.38	3.8	3.7	3.9	3.87

Table 25: Summary of readability ratings by sex.

Sex	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/ Grad
Male	3.84	3.44	3.24	3.68	3.56
Female	4.20	3.25	3.20	3.74	3.53

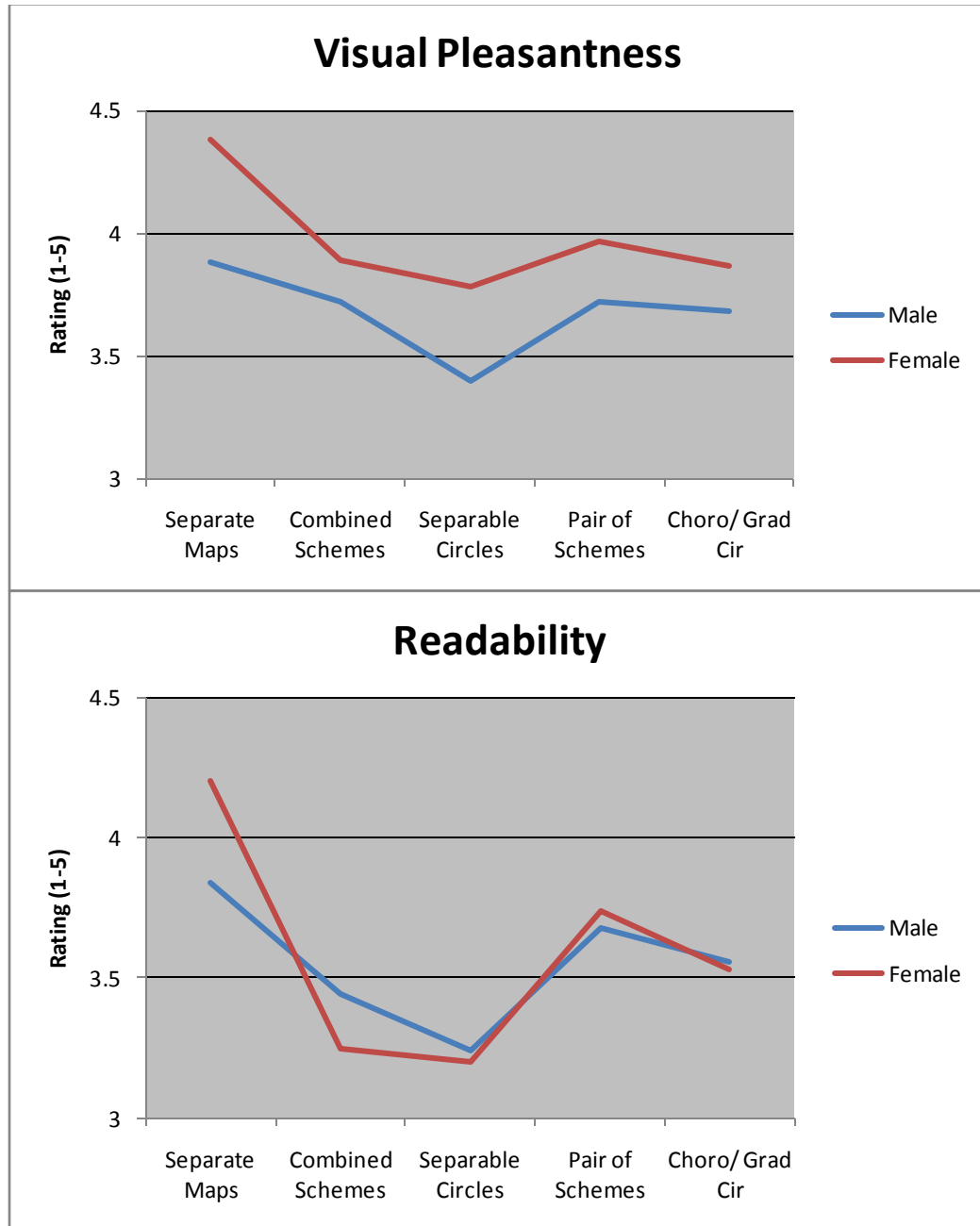


Figure 26: Summary of map approach ratings by sex.

The population was classified into the following age groups; nineteen and under (6.65 percent of the sample), twenty to thirty (54 percent of the sample), thirty-one to forty (19.4 percent of the sample), forty-one to fifty (16.8 percent of the sample), and fifty-one and over (3.1 percent of the sample). Table 26 explains the descriptive statistics for this population division. The highest mean score was achieved by the age group forty to fifty; the lowest mean score by the age group nineteen and under. The ratings for visual pleasantness and readability follow the same general trend among map approaches with a few exceptions (Figure 27; Tables 27 and 28). The visual pleasantness ratings for the separable graduated circles and choro/grad approaches varied the most among age groups. The fifty-one and over age group was an overall outlier with constant ratings in visual pleasantness and readability that were mostly higher than all other age groups; however this sample group had very few observations. The readability ratings varied notably with the approaches using separable graduated circles and the pair of schemes. Although there were variances in ratings among the different age groups, the overall ordering of ratings among the mapping approaches remained constant.

Table 26: Summary of descriptive statistics by age group.

Age Group	Mean (%)	N	Std. Deviation
19 and under	65.0	4	15.811
20 – 30	75.428	35	19.680
30 – 40	70.416	12	16.577
40 – 50	80.000	11	11.401
51 and over	72.500	2	3.535
Total	74.531	64	17.451

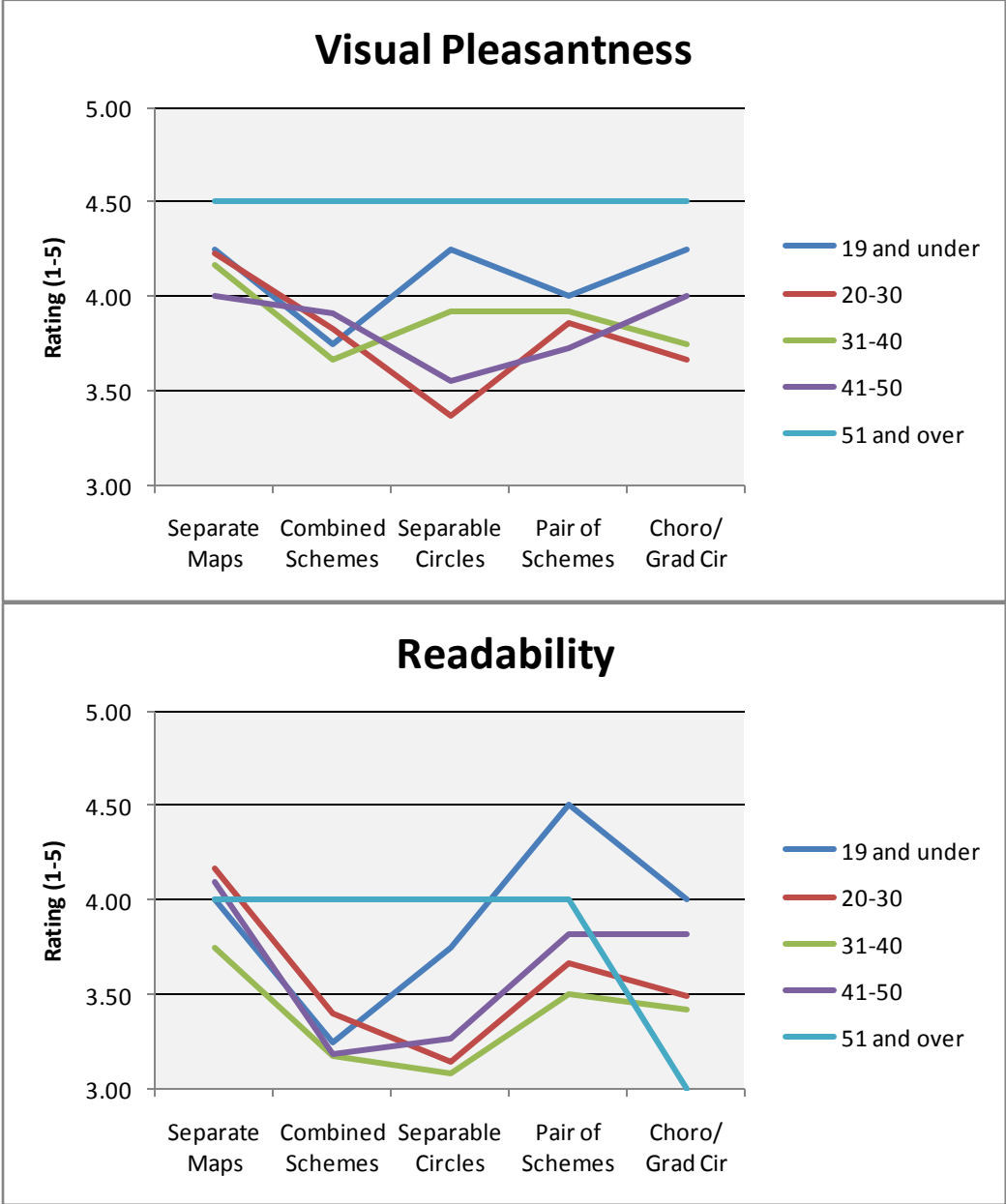


Figure 27: Summary of map approach ratings by age group.

Table 27: Summary of visual pleasantness ratings by age group.

Age Group	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/ Grad
19 and under	4.25	3.75	4.25	4.00	4.25
20 - 30	4.23	3.83	3.37	3.86	3.66
31 – 40	4.17	3.67	3.92	3.92	3.75
41 – 50	4.00	3.91	3.55	3.73	4.00
51 and over	4.50	4.50	4.50	4.50	4.50

Table 28: Summary of readability ratings by age group.

Age Group	Separate Maps	Combined Schemes	Separable Circles	Pair of Schemes	Choro/ Grad
19 and under	4.00	3.25	3.75	4.50	4.00
20 - 30	4.17	3.40	3.14	3.66	3.49
31 – 40	3.75	3.17	3.08	3.50	3.42
41 – 50	4.09	3.18	3.27	3.82	3.82
51 and over	4.00	4.00	4.00	4.00	3.00

Demographic data was collected pertaining to the first language spoken of each participant. The Bolivia sample was 100 percent Spanish speaking and the United States sample was almost entirely English speaking (Table 29). Therefore, descriptive statistics divided by language spoken (Table 30) will be almost identical to statistics analyzed between sample groups (refer to Section 4.2: Specific Questions for further detail in analysis of participants grouped by language).

Table 29: Summary of first spoken language percentage by sample.

Sample	English	Spanish/ Castellano	Other
United States	94.1	0	5.9
Bolivia	0	100	0

Table 30: Summary of first language spoken groups.

Language	Mean	N	Std. Deviation
English	86.250	32	10.924
Spanish/Castellano	61.666	30	14.403
Other	80.000	2	7.071
Total	74.531	64	17.451

Participants were asked to rate their personal political activeness. These ratings were compared to section three scores and did not show a relationship between political activeness and map understanding (Figure 28). A Pearson’s correlation coefficient of 0.004 (Table 31) showed a very weak positive relationship between these variables. The average political activeness rating was 2.53 in the United States sample and 2.76 in the Bolivia sample, both close to mid-range.

A plot of political activeness and correct response to map questions showed no strong pattern emerging (Figure 29). A Pearson’s correlation coefficient of 1.82 (Table 32) reflected this weak positive relationship. The correlation between map experience and percentage of correct responses for each of the sixty-four observations showed no significant relationship. However, a comparison of means for these variables within each sample did show a pattern. The United States showed a mean score of 86 percent and a mean map experience rating of

3.3, which are both higher than those of the Bolivia sample. The Bolivia sample showed a mean score of 62 percent and a mean map experience rating of 2.7. Between samples, a general positive relationship was seen between specific question score and map experience.

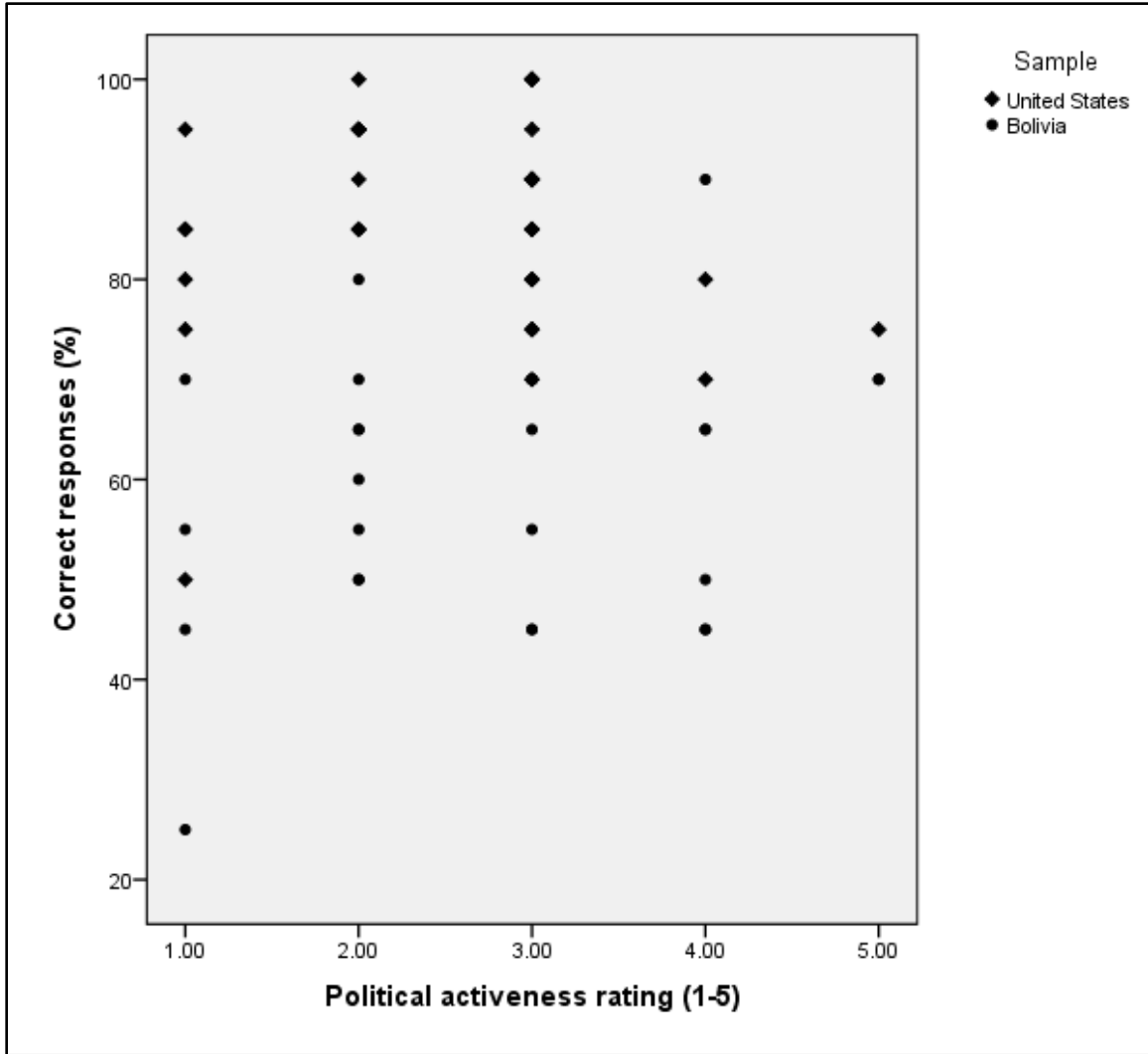


Figure 28: Relationship between map understanding and political activeness.

Table 31: Pearson's Correlation: Political activeness and map understanding.

		Score	Political Activeness
Score	Pearson Corr.	1	.004
	Sig. (2-tailed)		.977
	N	64	64
Political Activeness	Pearson Corr.	.004	1
	Sig. (2-tailed)	.977	
	N	64	64

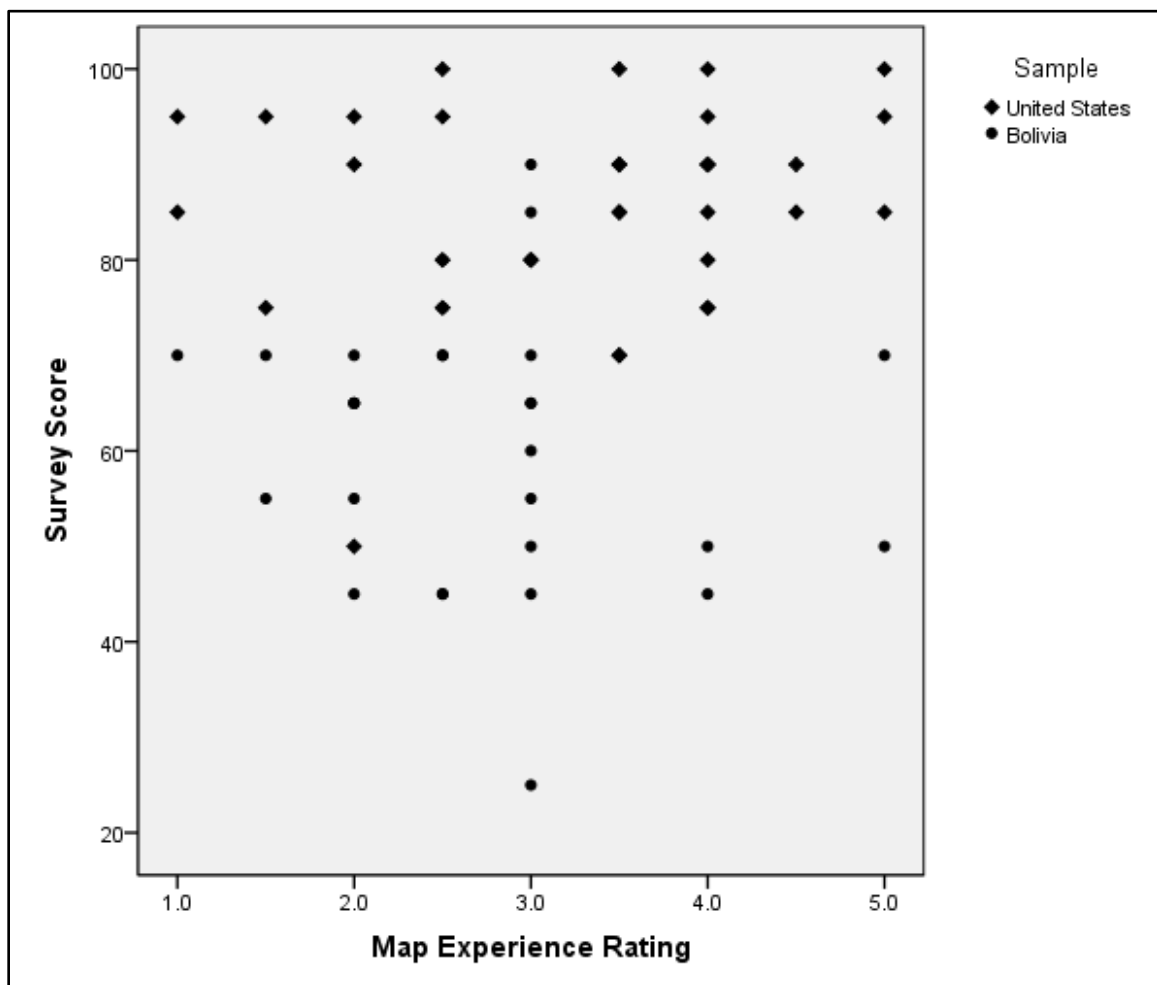


Figure 29: Relationship between map understanding and map experience.

Table 32: Pearson’s Correlation: Map experience and map understanding.

		Score	Map Experience
Score	Pearson Corr.	1	.182
	Sig. (2-tailed)		.150
	N	64	64
Map Experience	Pearson Corr.	.182	1
	Sig. (2-tailed)	.150	
	N	64	64

Observations from Bolivia

Some obstacles were observed within the Bolivia sample which reflected cultural differences. In the sample area of Tarija, Bolivia, participants expressed a lack of familiarity with map reading, as well as confusion over the definition of “north. Tarija is a city situated between the altiplano and lowlands of southern Bolivia (Figure 30). The majority of the people in this city have long standing roots in the area. Many of the participants expressed little necessity for map use due to familiarity with their surroundings. This was evident when participants in Bolivia frequently requested clarification about general map questions, especially the one specific to reading the map scale bar. Their questions were answered without revealing the correct response on the survey.

To the Bolivia sample, “north” was defined by the area of the country known as the altiplano, thus being north in elevation not latitude (Figure 30). The responses to questions containing the word “north” were compared among samples in (Figure 31) and showed that there were more incorrect answers from the Bolivian sample than from the United States

sample (Table 33). The Bolivian sample answered a total of 57.7 percent of these questions incorrectly while the United States sample only answered 12.7 percent incorrectly. Although each map used in the survey contained a direction compass (Figure 32) which clearly indicated the expectation of the location of north, inherited conceptions of “north” could have influenced the Bolivia sample results.

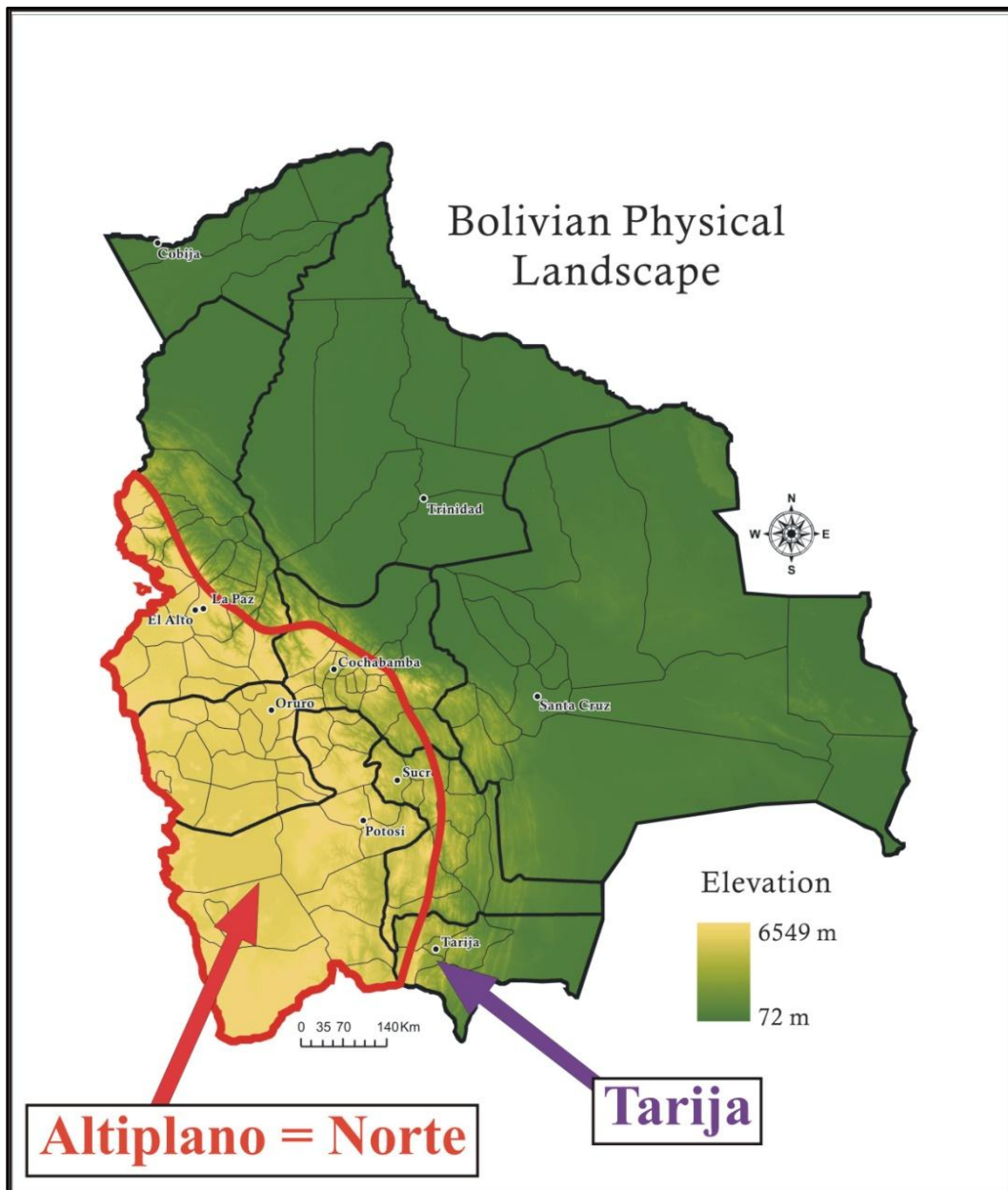


Figure 30: Depiction of Bolivian sample understanding of “north”.

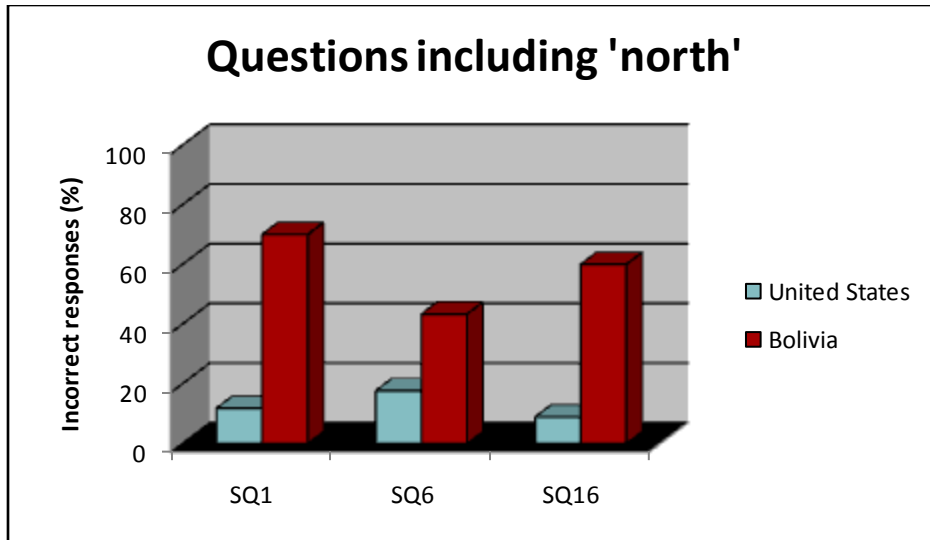


Figure 31: Summary of incorrect responses from “north” questions

Table 33: Summary of incorrect answers from questions including “north”.

Sample	Q1	Q6	Q16
United States	4	6	3
Bolivia	21	13	18

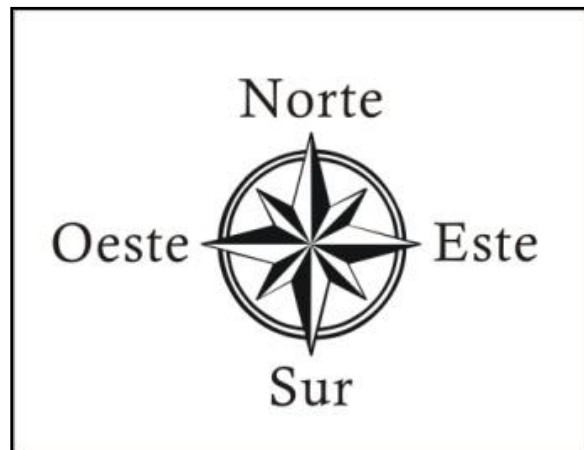


Figure 32: Direction compass from survey maps.

Due to differing translations of the word “north”, the survey results were analyzed excluding questions that used the directional term. To maintain consistency, the first question for each mapping approach in section three, specific questions, was removed for analysis; questions 1, 6, 11, 16, and 21. With the exclusion of these questions, the mean score was calculated by sample. There was no significant change in the mean scores when excluding these questions. In fact, there was no change from the total population (74 percent) and the Bolivia sample (62 percent). The United States sample had a score of only one percent higher with this exclusion. The exclusion scores were analyzed by map approach, seen in Figure 33. There was no significant change from the order of results seen with all questions included.

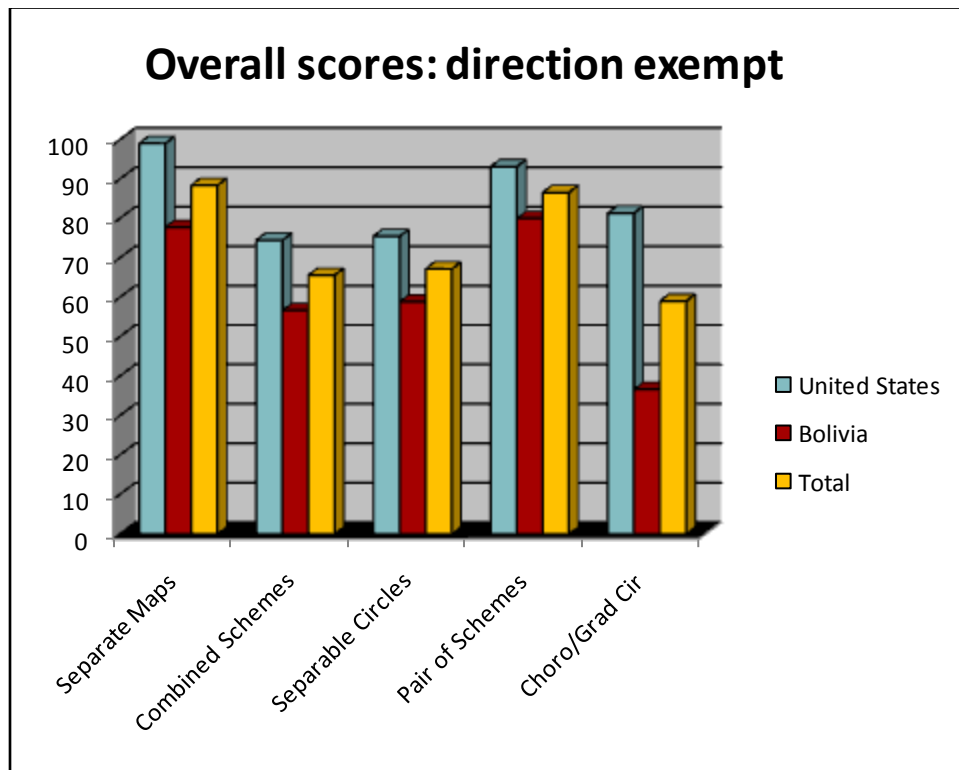


Figure 33: Section 3 scores excluding direction questions by mapping approach.

Confounds

Question design for this survey was intended to ask similar groups of questions to interpret the datasets which remained consistent through the five different visualizations. It was possible that some questions could have elicited an incorrect response that was interpreted correctly through the legend, but misguided by a limited understanding of symbolization. This would suggest the map design influenced the participant's response. Many participants commented that they found approaches which utilized graduated circles difficult to connect with a specific province.

Survey administration was attempted to be automated through self guided completion. Often participants were unsupervised during survey completion, giving them opportunities to consult on question responses. Although the entire population consisted of participants with varying ages and backgrounds, the two sample groups had uneven demographic groups, some with very few cases. Ratings used between the two sample groups could have been assigned according to different understandings based on cultural tendencies. For example, the definition of political activeness could vary due to different laws. In Bolivia, citizens are required to vote, whereas in the United States it is a choice.

There were some notable variances among the United States and Bolivia sample groups. The sample size varied by four participants with the United States being larger, but each sample had a minimum of thirty participants. The understanding of the information translated by this survey could be biased to the Bolivian sample based on familiarity with data. The participants in this sample could possibly answer many of the survey questions correctly without viewing the maps. However, participants in the United States sample would not be able to do this unless they were familiar with the political atmosphere of Bolivia.

Summary

Although the United States sample scored 2.8 percent higher on the general question section of the survey than the Bolivia sample, there was no statistically significant difference between the two. Results did show a significant difference in the scores of the specific question section, with the United States sample scoring 24 percent higher than the Bolivian sample. There was a weak positive relationship between the scores of the general and specific questions. When these specific question scores were broken down by mapping approach, the separate maps and pair of schemes approaches received the highest scores, while the choro/grad and combined schemes approaches received the lowest scores. There was a moderately significant correlation between the understanding of multiple choice questions and understanding of fill-in questions. The fill-in questions received more incorrect responses than the multiple choice questions. The fill-in questions that were most frequently answered incorrectly used graduated circles in a relatively small province.

The results of the rating scales were consistent with both samples in the survey group. The separate maps approach received the highest rating in both visual pleasantness and readability and the separable circles approach received the lowest. In both rating areas, the pair of schemes approach was preferred second to the separate maps approach and therefore was the most highly preferred multivariate mapping approach. In the final section of the survey, the sample groups consistently ranked the separate maps approach the most preferred in the display of this information and the combined schemes approach the least preferred.

There was no significant difference in survey results between males and females. The scores also remained consistent with population results, although females tended to assign higher ratings. The age group forty to fifty received the highest scores while the nineteen and

under age group received the lowest. Rating and ranking trends followed the same general trend as the entire population results, with few notable differences. Demographic data collected pertaining to language spoken corresponded to the sample division, United States and Bolivia, and therefore yielded the same results. Results revealed a weak positive relationship between both political activeness and map experience when compared to survey scores. However, a comparison of means shows that overall the Bolivian sample had less map experience, as well as a lower score when compared to the United States sample.

Cultural differences were observed during the administration of the survey, including lack of familiarity with map reading and confusion over the definition of 'north' from Bolivian participants. These differences can help to explain variances between sample results, but also contribute to confounds associated with this study. Familiarity with data, survey and question design, and subjectivity of interpretation could also have contributed to biasing survey results.

CHAPTER 5: CONCLUSION

The results of this study support previous research which suggests that the viewing of separate datasets is more easily understood than their combination through multivariate mapping approaches (MacEachren 1995; Dent, Torguson, and Holder 2009; Tyner 2010). However, some interesting trends were identified during the analysis of the survey results. These trends included: 1) certain types of symbolization can be more confusing for map readers when used in multivariate mapping approaches, 2) cultural conditions can greatly influence the perception of elements associated with map interpretation, and 3) preferences and effectiveness of multivariate mapping approaches can differ in various regions of the world.

The second section of the survey (general questions), yielded high scores from the entire group implying that an overall understanding of basic map elements exists from all participants. Although the difference in overall score of Section 2 between the sample groups was slight, this suggested that Bolivian participants were not as accustomed to map reading as United States participants. It is possible that primary education in basic map reading is not as prevalent in Bolivia as it is in the United States. There was hesitation from participants in Bolivia in responding to this set of questions, which could be a result of lack of experience in map reading and understanding. During survey administration many Bolivian participants

asked the meaning of “scale bar” and “compass” while expressing the absence of necessity for maps in their daily lives.

Results were generalized for section 3 of the survey (specific questions) based on the entire population (Table 34). These results were for the most part consistent within each sample group. The United States sample showed a better understanding of the map content and overall message with scores that were significantly higher than the Bolivian sample yielded from section three. This section evaluated the participants’ ability to understand the ultimate map message, as well as the map symbolization. The fill-in questions yielded the majority of incorrect answers, indicating that the overall map message was more easily understood than specific information contained within the symbolization.

Table 34: Summary of results by mapping approach.

Approach	Map Understanding	Visual Pleasantness	Ease of Reading
Separate Maps	High	High	High
Pair of Schemes	High	Moderate	High
Separable Circles	Moderate	Low	Low
Choro/Grad Circles	Low	Moderate	Moderate
Combined Schemes	Low	Moderate	Low

*Categories are based on an equal area interval classification of results

Overall the separate maps approach proved to be the most beneficial approach for the entire group in map understanding, visual preference, and ease of reading, with significantly higher scores than the multivariate mapping approaches. There was one exception in the map

interpretation, with the pair of sequential schemes approach showing scores that were not significantly different than the separate maps approach. However, the Bolivia sample received its highest scores on the pair of sequential schemes approach in the evaluation of map understanding. This could suggest that readers without map experience can benefit from the use of multivariate mapping in the display of a functional relationship between complex datasets. Based on the specific question scores and readability ratings from the survey, the pair of sequential schemes approach was the most effective multivariate method in transmitting the map message.

The approaches that generally yielded the lowest scores throughout the survey process were the choropleth/graduated circles, combined sequential color schemes, and separable graduated circles approaches. Participants found approaches using graduated circles difficult to understand, especially when asked to identify information from smaller area units. The choropleth/graduated circles layering approach illustrates the maximum amount of information available from the data sets, which is also displayed in the separate maps approach. Some participants expressed that viewing this amount of information in one static view was more overwhelming than viewing the information in separate maps. The combined color scheme approach received many positive comments in regard to visual pleasantness, but was negatively perceived in regard to map content understanding. Both the choropleth/graduated circles and combined color schemes approaches use a ratio/ratio dataset combination. Observations from this study support previous research that suggests the ratio/ratio dataset combination can cause confusion in multivariate mapping.

When using multivariate mapping approaches, it is best to avoid the combination of two ratio datasets. Participants found the choropleth/graduated circles approach, which

utilized the layering of the two ratio datasets, overwhelming and confusing. Combining a ratio dataset with a nominal dataset can be more effective in transmitting the desired map message. The pair of sequential color schemes approach utilized this data combination and resulted in the highest survey scores when considering multivariate mapping approaches only. The separable graduated circles approach also displayed a ratio/nominal data combination. However, this approach was not received well by the participants due to its use of graduated circles.

When designing a multivariate map it was found that color choice plays a key role in viewing preference of map readers. Initially, map readers are attracted to color, which was illustrated when the multivariate mapping approach with the least amount of color received the lowest visually preferred ratings. As the map message is interpreted, this preference changed based on the reader's ability to interpret the information contained within the symbolization. An abundance of hues, as seen in the combined sequential color schemes approach led to confusion in the map interpretation. The pair of sequential schemes approach proved to be the most preferred multivariate mapping method and utilizes only two hues with varying shades. This approach also used only one form of symbolization, choropleth shading, which yielded higher scores than approaches which utilized graduated circles.

This study emphasized that when designing a visual evaluation tool, cultural influences must be considered. Although the ultimate map message and interpretation can be successfully translated by participants, when specific information is requested, there can be confusion related to conception of words and phrases. In this study, the perception of the idea of "north" became an obstacle for the Bolivian respondents. Although survey results did not significantly differ when removing questionable responses, the participant can be at a

disadvantage when presented with confusing guidelines, which will in turn affect study results. Bolivians within the professional and educated middle class from the city of Tarija tend to define “north” according to elevation, not according to direction, resulting in the misconception of direction guidelines.

Further analysis of the benefit of certain multivariate mapping approaches, including the pair of sequential color schemes approach, to audiences who lack map reading experience is needed to solidify results of this study. When designing any information product, the preferences and abilities of the audience must be considered. Cultural variations exist between countries and even within regions of these countries. In continuing studies of the perception of multivariate mapping approaches, assessing the understanding of basic map reading and familiarity should be an initial concern.

Familiarity with the data used in multivariate approaches can also be a concern when evaluating map understanding. The Bolivian sample was initially more acquainted with the data used in this study compared to the United States sample, due to the origin of the information. The bias associated with this design can possibly be avoided in future studies by creating two sets of maps that use different datasets, one for each sample area. For example, instead of using Bolivian political and social data for the survey administered in Tarija, political and social data from the United States could be used. However, when using this strategy for survey design, the functional relationships displayed in the two different regions should be of similar strength.

Through administration to a larger sample size, further observations could support the findings of this study and possibly reveal new trends and patterns not seen with this minimal sample. Results of this study revealed trends specific to the population involved, which is

characterized by a professional and educated middle class. Participants of this study were recruited through social contacts and methods of convenience. A larger and more random sample would be more inclusive of varying demographic characteristics, including age and first language spoken. The results of a larger study could be analyzed based on a data model with multiple hypotheses formulated from observations of this study.

In a world with increasing technological advancements, multivariate mapping has the potential to be useful in a digital environment that allows for the viewing of maps in an interactive manner. Computer technologies could be useful in the transmission of relationships that exist between multiple datasets by introducing the information into one static view through a process of the addition of layers. The end result of the layer addition would be the final multivariate map containing all of the data. This approach to the viewing of multivariate maps exists between static and dynamic viewing approaches.

The international context of this study emphasized that regional variance that can possibly influence the interpretation of information and message contained within a map. Very few studies have assessed the international perception of multivariate mapping approaches. Further investigation is needed in order to realize the full potential of multivariate mapping techniques in the transmission of complex data relationships as it pertains to different groups with varying regional and demographic characteristics. Accurate and clear communication of social and political phenomena using complex visual data displays such as those found in multivariate maps hold the potential to help us better understand ourselves and our relationships to each other.

REFERENCES

- Andersen, L. and R. Meza. 2001. *The Natural Gas Sector in Bolivia: An Overview*. Documento de Trabajo (Document of work) 1/2001, Instituto de Investigaciones Socio Económicas (Institute of Socio Economic Investigations), Universidad Católica Boliviana (Boliviana Catholic University). La Paz.
- Andolina, R., S. Radcliffe, and N. Laurie. 2005. Development and culture: Transnational identity making in Bolivia. *Political Geography* 24: 678-702.
- Brewer, C. 1994. Color use guidelines for mapping and visualization. In *Visualization in modern cartography*, ed. A. MacEachren and D. Taylor. Oxford, England: Pergamon.
- Brewer, C., A. MacEachren, L. Pickle, and D. Herrmann. 1997. Mapping morality: Evaluating color schemes for choropleth maps. *Annals of the Association of American Geographers* 87 (3): 411-438.
- Canessa, A. 2000. Contesting hybridity: Evangelistas and Kataristas in highland Bolivia. *Journal of Latin American Studies* 32(1): 115-144.
- Corte Nacional Electoral (CNE) de Bolivia (National Elections Court of Bolivia). 2011. Political Representation. http://www.cne.org.bo/org_politica/partidos (last accessed 10 April 2011).
- Dent, B., J. Torguson, and T. Hodler. 2009. *Cartography: Thematic map design, Sixth edition*. New York: McGraw-Hill.
- Domingo, P. 2005. Democracy and New Social Forces in Bolivia. *Social Forces* 83(4): 1727-1743.
- Dunkerley, J. 2007. Evo Morales, the 'Two Bolivias' and the Third Bolivian Revolution. *Journal of Latin American Studies* 39: 133-166.
- Eagen, J. 2002. *The Aymara of South America*. Minneapolis, MN: Learner Publications Company.
- Eyton, R. 1984. Complementary-color, two-variable maps. *Annals of the Association of American Geographers* 74 (3): 477-490.

- Faguet, J. 2004. Does decentralization increase responsiveness to local needs? Evidence from Bolivia. *Journal of Public Economics* 88(3-4): 867-893.
- Galvan, J. 2011. *Culture and Customs of Bolivia*. Santa Barbara, California: ABC-CLIO, LLC.
- Garreaud, R., M. Vuille and A. Clement. 2003. The climate of the Altiplano: Observed current conditions and mechanisms of past change. *Palaeogeography, Palaeoclimatology, and Palaeoecology* 194(1): 5-22.
- Godoy, R. 2002. *Indians, markets and rainforests: theory, methods, analysis*. New York: Columbia University Press.
- Instituto Nacional de Estadística (INE) de Bolivia (National Statistics Institute of Bolivia). 2001. Census of Population and Housing. <http://www.ine.gov.bo/cgi-bin/Redatam/RG4WebEngine.exe/> (last accessed 25 March 2010).
- Kaup, B. 2008. Negotiating through nature: The resistant materiality and materiality of resistance in Bolivia's natural gas sector. *Geoforum* 39(1): 1734-1742.
- Keeny, B., K. Nickerson and R. Natalizia. 2000. *Guarani: Shamans of the forest*. Philadelphia: Ringing Rocks Press.
- Klein, H. 2003. *A concise history of Bolivia*. Cambridge: Cambridge University Press.
- Kohl, B. and R. Bresnahan. 2010. Bolivia under Morales: Consolidating power, initiating decolonization. *Latin American Perspectives* 37(5): 5-17.
- Kronik, J. and D. Verner. 2010. *Indigenous peoples and climate change in Latin America and the Caribbean*. Washington, D.C.: The World Bank.
- MacEachren, A. 1995. *How maps work: Representation, visualization, and design*. New York: Guilford Press.
- Mahoney, J. 2003. Long-run development and the legacy of colonialism in Spanish America. *American Journal of Sociology* 109(1): 50-106.
- Mallon, F. 1992. Indigenous communities, political cultures, and the state in Latin America, 1780–1990. *Journal of Latin American Studies* 24: 35-53.
- Mersey, J. 1990. Colour and thematic map design: The role of colour scheme and map complexity in choropleth map communication. *Cartographica* 27 (3), Monograph 41.
- Meyer, M., F. Broome, and R. Schweitzer. 1975. Color statistical mapping by the U.S. Bureau of Census. *The American Cartographer* 2(5): 100-117.

- Milstead, H. 1927. Bolivia as a source of tin. *Economic Geography* 3(3): 354-360.
- Montenegro R, and C. Stephens. 2006. Indigenous health in Latin America and the Caribbean. *Lancet* 367: 1859–69.
- Muller, J. 1976. Visual associations in choroplethic mapping. *Proceedings of the Association of American Geographers* 8: 160-165.
- Nelson, E. 2000. Designing Effective Bivariate Symbols: The Influence of Perceptual Grouping Processes. *Cartography and Geographic Information Science* 27(4): 261-278.
- Newson, L. 1985. Indian Population Patterns in Colonial Spanish America. *Latin American Research Review* 20:41–74.
- Olson, J. 1981. Spectrally encoded two-variable maps. *Annals of the Association of American Geographers* 71(2): 259-276.
- Olson, J. 1991. *The Indians of Central and South America: An ethnohistorical dictionary*. Westport, CT: Library of Congress-in-Publication Data.
- Patch, R. 1961. Bolivia: The restrained revolution. *The Annals of the American Academy of Political and Social Science* 334(1): 123-132.
- Postero, N. 2005. Indigenous responses to Neoliberalism: A look at the Bolivian uprising of 2003. *PoLAR: Political and Legal Anthropology Review* 28(1): 73–92.
- Preston, D., M. Macklin and J. Warburton. 1997. Fewer people, less erosion: The twentieth century in southern Bolivia. *The Geographical Journal* 163(2): 198-205.
- Rice, R. and D. Van Cott. 2006. The emergence and performance of indigenous peoples' parties in South America: A subnational statistical analysis. *Comparative Political Studies* 39: 709.
- Robinson, A., J. Morrison, P. Muehrcke, J. Kimerling, and S. Guptill. 1995. *Elements of cartography: Sixth edition*. New Jersey: John Wiley and Sons, Inc.
- Rochlin, J. 2007. Latin America's left turn and the new strategic landscape: the case of Bolivia. *Third World Quarterly* 28(7): 1327–1342.
- Romero, S. 2008. Bolivian is uneasy ally as US presses drug war. *New York Times*. <http://www.nytimes.com/2008/08/29/world/americas/29bolivia.html>. (last accessed 1 May 2010).

- Schroeder, K. 2007. Economic globalization and Bolivia's regional divide. *Journal of Latin American Geography* 6(2): 99-120.
- Shifter, M. 2004. Breakdown in the Andes. *Foreign Affairs* September/October: 126-139.
- Sivak, M. 2010. *Evo Morales: The extraordinary rise of the first indigenous president of Bolivia*. New York: Palgrave Macmillan.
- Slocum, T., R. McMaster, F. Kessler and H. Howard. 2005. *Thematic cartography and geographic visualization: Second edition*. New Jersey: Pearson Prentice Hall.
- Spalding, K. 1973. Kurakas and commerce: A chapter in the evolution of Andean society. *The Hispanic American Historical Review* 53(4): 581-599.
- Tahil, W. 2007. The trouble with lithium. *Meridian International Research*.
<http://www.inference.phy.cam.ac.uk/sustainable/refs/nuclear/TroubleLithium.pdf>
 (last accessed 6 December 2010).
- Tenenbaum, B. (Ed.). 1996. *Latin American history and culture*. (Vols 1-4). New York: Simon & Schuster MacMillan.
- Tyner, J. 2010. *Principles of map design*. New York: Guilford Press.
- United States Department of State (USDOS). 2010. Bolivia: Plurinational state of Bolivia.
<http://www.state.gov/r/pa/ei/bgn/35751.htm> (last accessed 1 May 2010).
- Van Cott, D. 2003. From exclusion to inclusion: Bolivia's 2002 elections. *Journal of Latin American Studies* 35(4): 751-776.
- World Health Organization (WHO). 2000. Millennium development goals.
http://www.paho.org/english/mdg/cpo_bolivia.asp (last accessed 5 October 2010).
- World Unfurled. 2005. Election Day in Bolivia. December 18, 2005.
<http://worldunfurled.com/2005/12/18/election-day-in-bolivia/> (last accessed 10 April 2011).
- Yashar, D. 1998. Contesting citizenship: Indigenous movements and democracy in Latin America. *Comparative Politics* 31(1): 23-42.
- Zandvliet, Hans. 2010. Evolución Electoral del MAS en Bolivia en las Elecciones y Referéndums desde 2005 al 2009 (Election Evolution of MAS in Bolivia in the Elections and Referendums from 2005 to 2009). The Democracy Center Blog from Bolivia. <http://democracyctr.org/blog/Elecciones%20Bolivia%202005-2009.pdf> (last accessed April 29, 2010).

APPENDIX A: ENGLISH SURVEY MAP BOOK

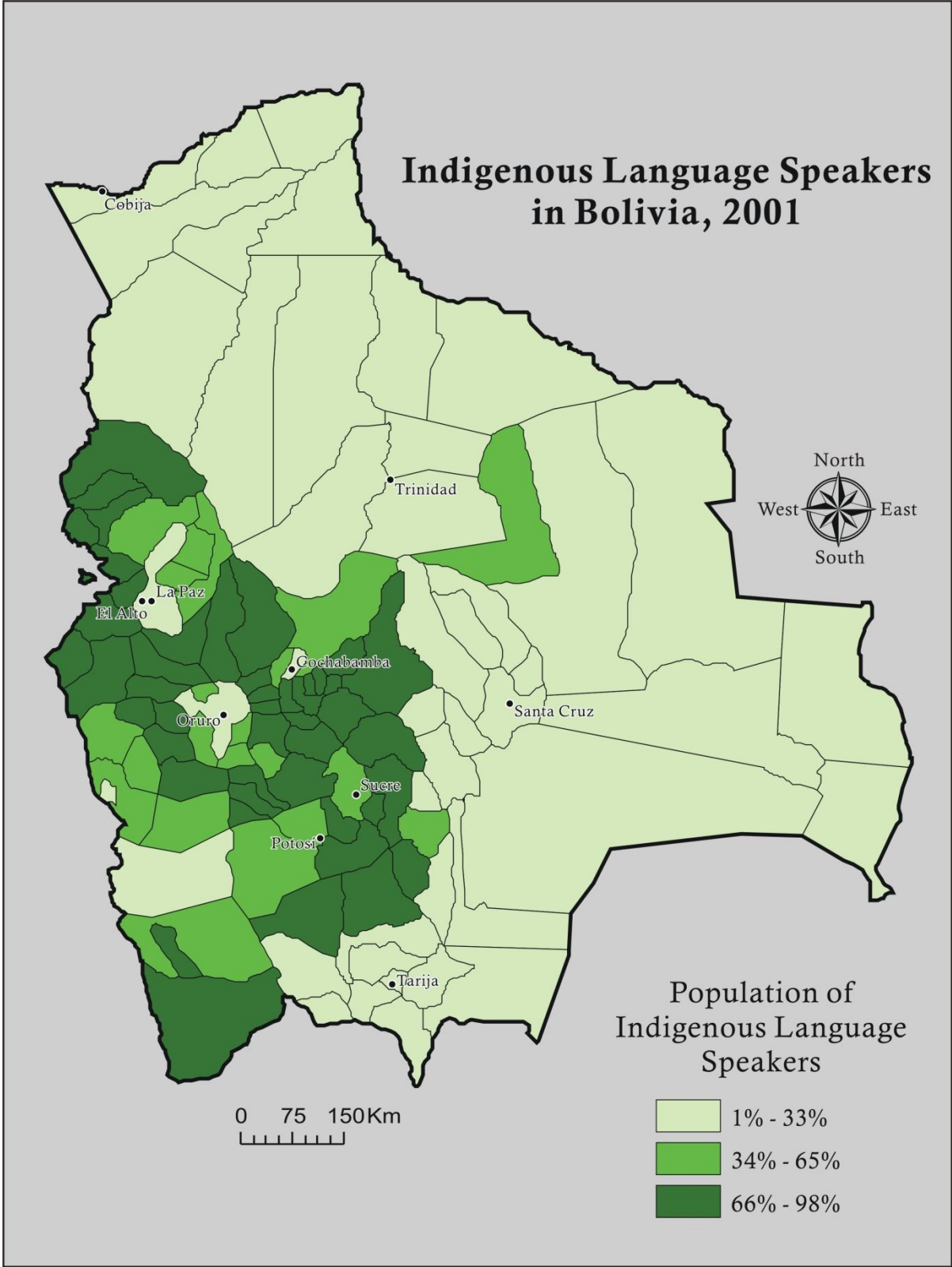
This series of maps shows voting and language data
for Bolivian Provinces

Data Sources:

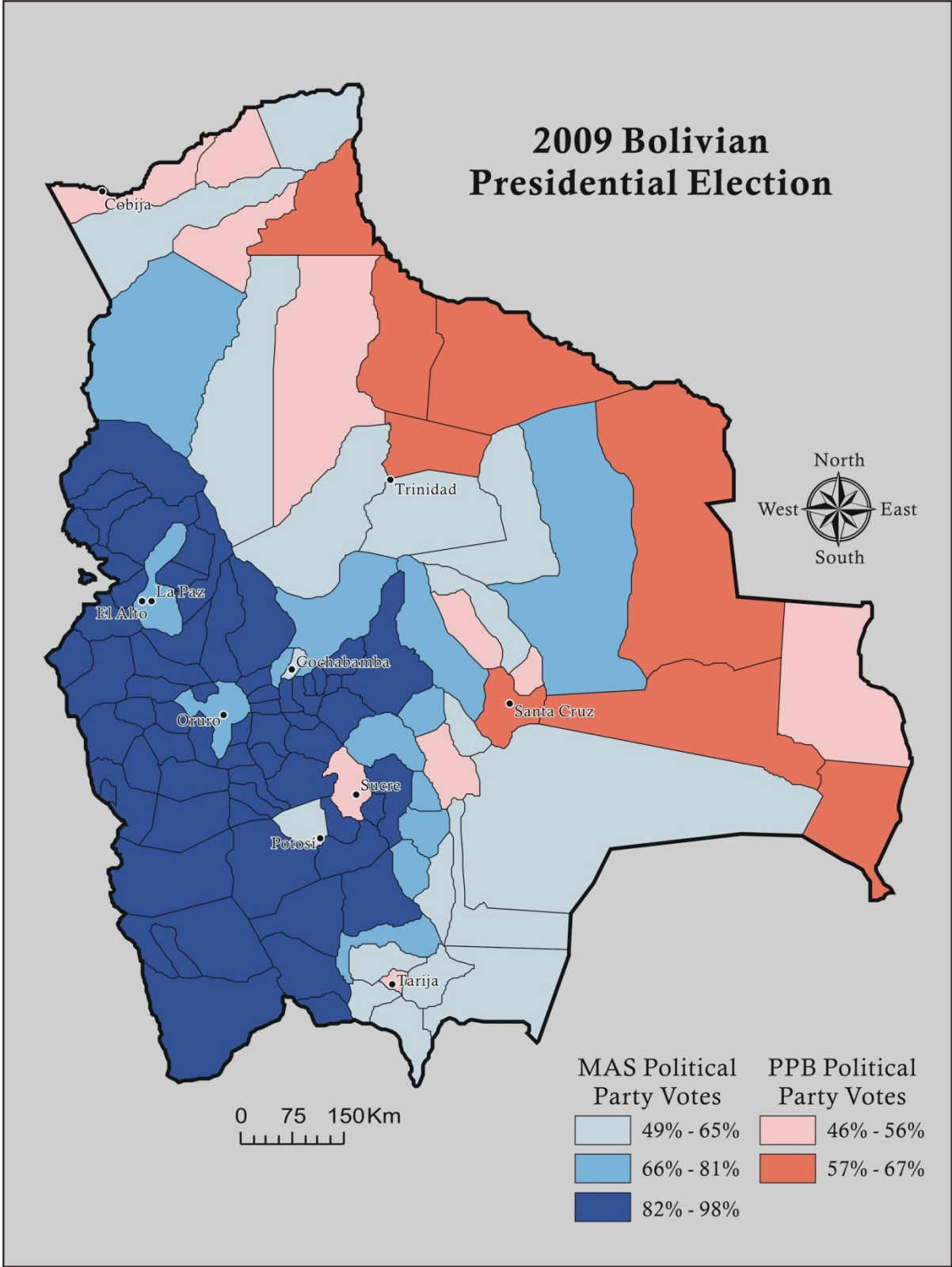
Instituto Nacional de Estadística (INE) de Bolivia
Census of Population and Housing, 2001
[http://www.ine.gov.bo/cgi-
bin/Redatam/RG4WebEngine.exe/](http://www.ine.gov.bo/cgi-bin/Redatam/RG4WebEngine.exe/)
Accessed March 25, 2010.

Zandvliet, Hans. 2010. "Evolución Electoral del MAS en
Bolivia en las Elecciones y Referéndums desde 2005 al
2009."
The Democracy Center Blog from Bolivia.
[http://democracyctr.org/blog/Elecciones%20Bolivia%
202005-2009.pdf](http://democracyctr.org/blog/Elecciones%20Bolivia%202005-2009.pdf)
Accessed April 29, 2010.

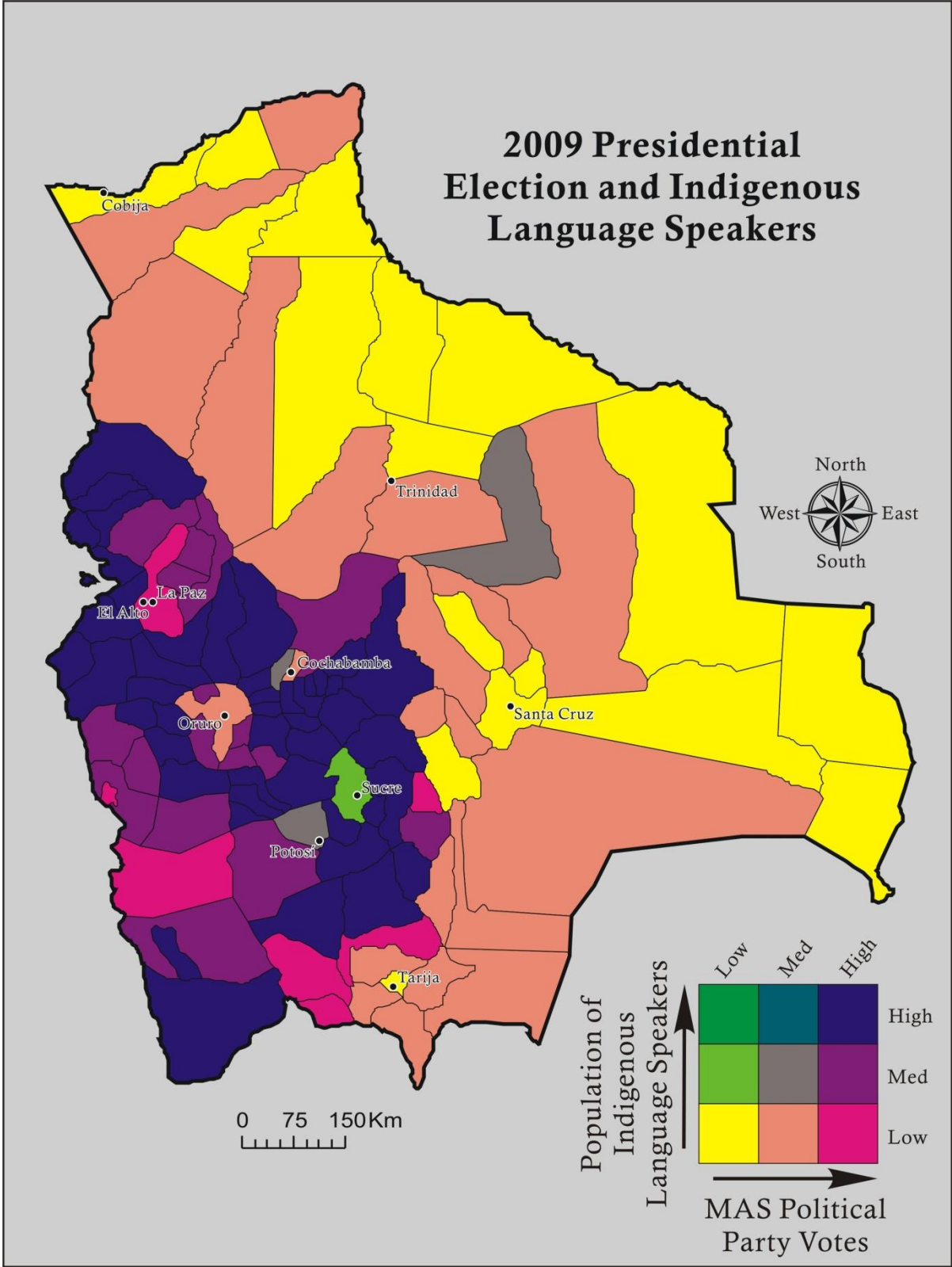
Created by: Cheryl Hagevik
Appalachian State University
Spring 2011



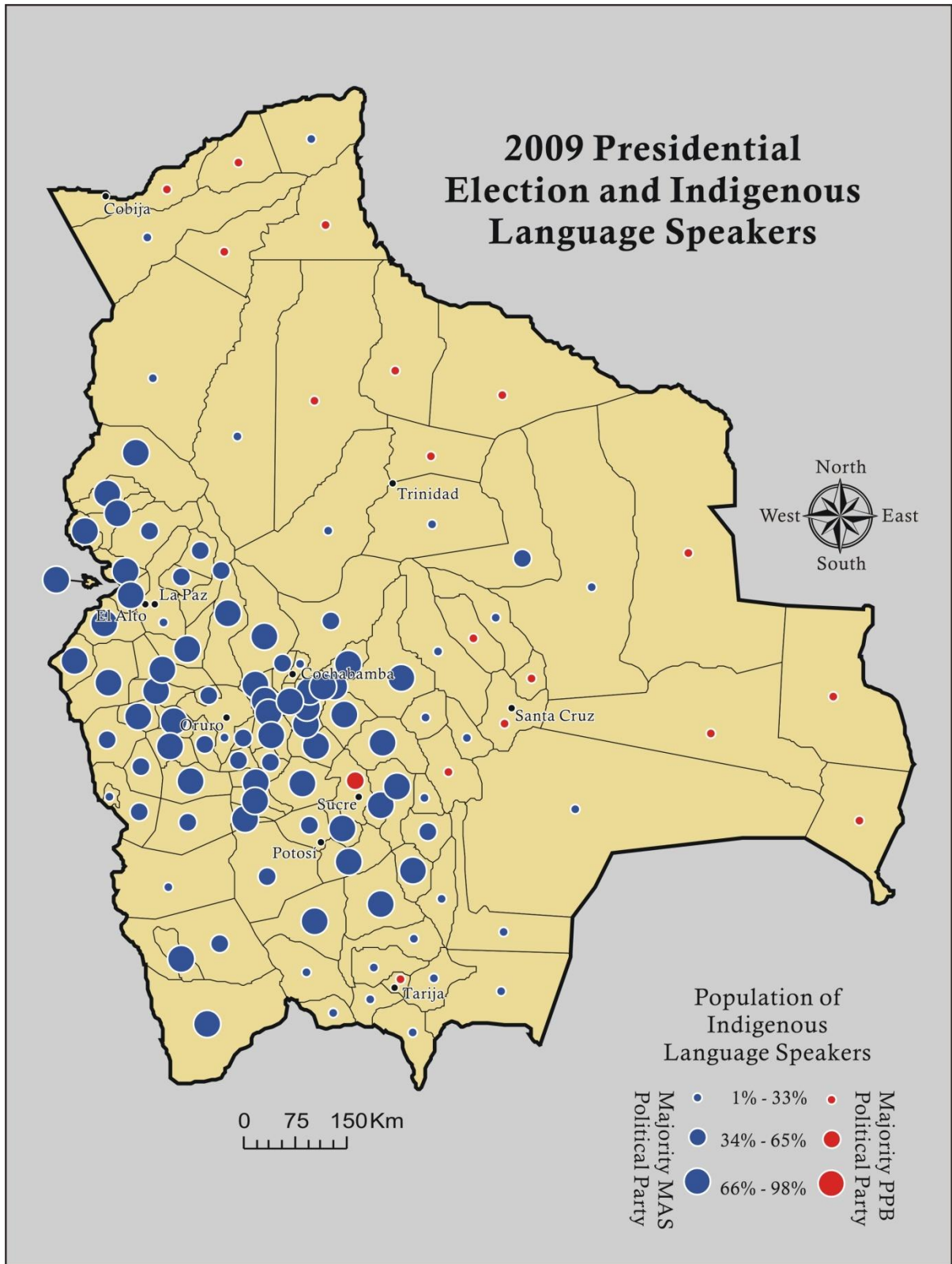
1a



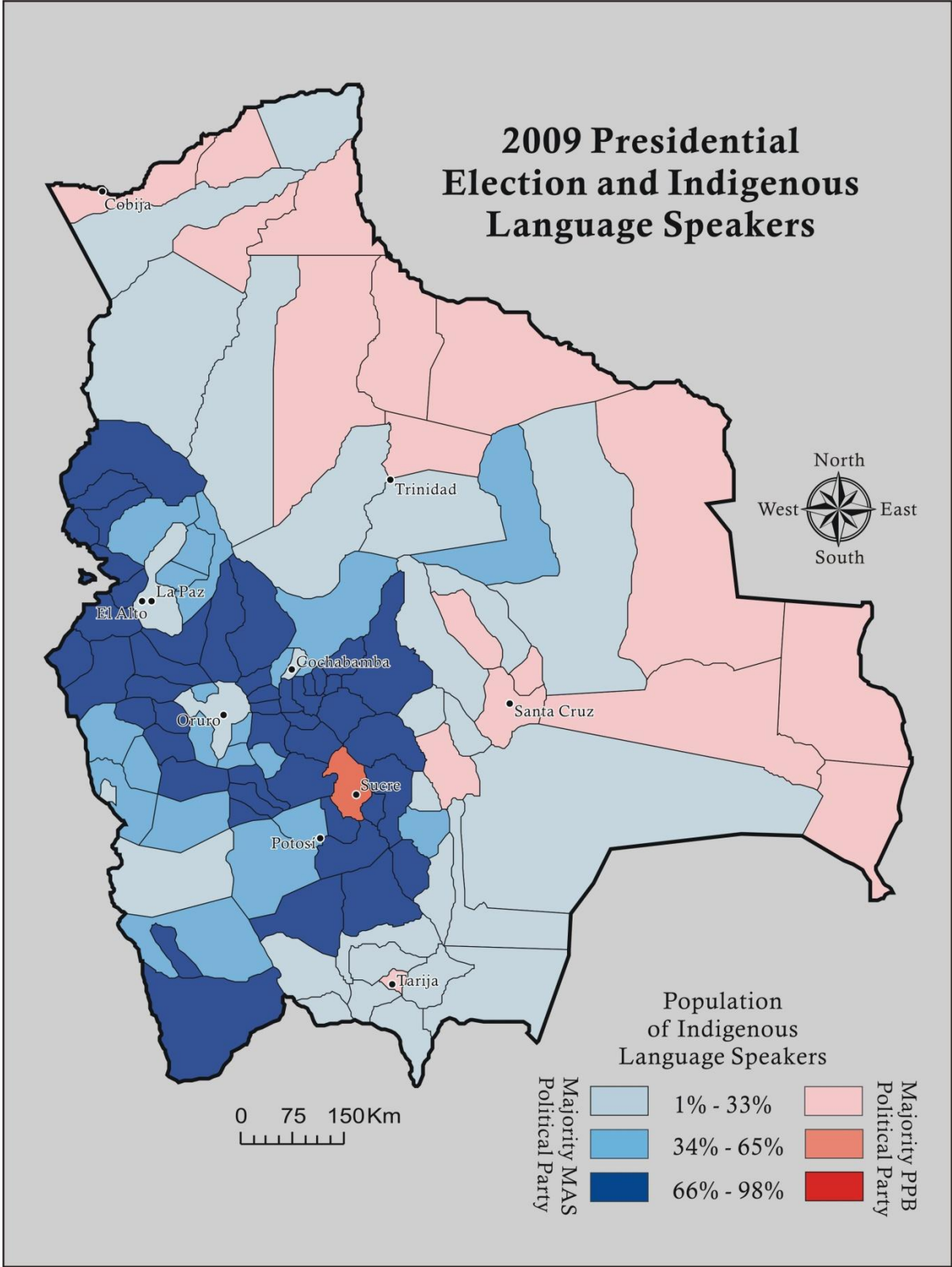
1b

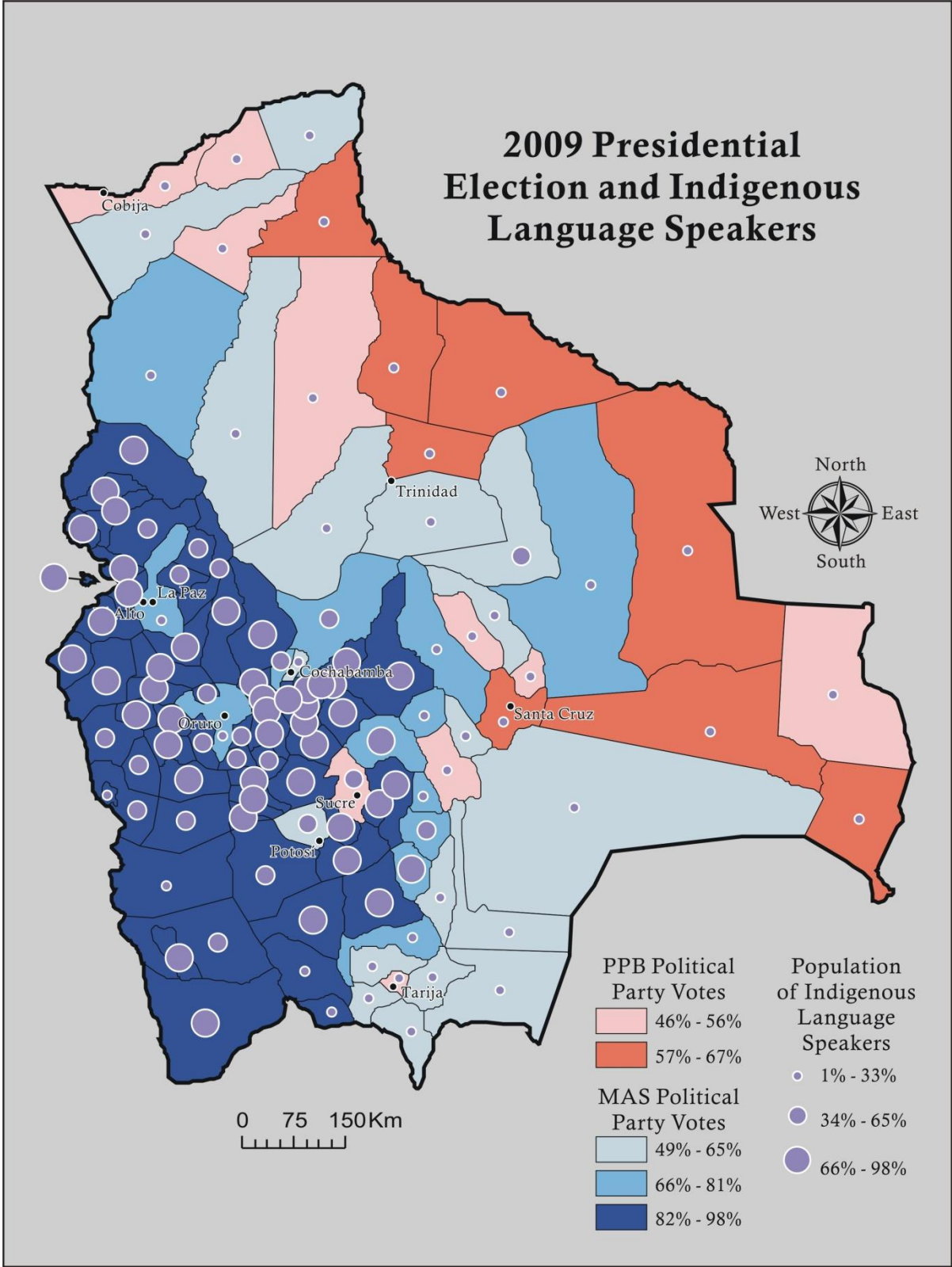


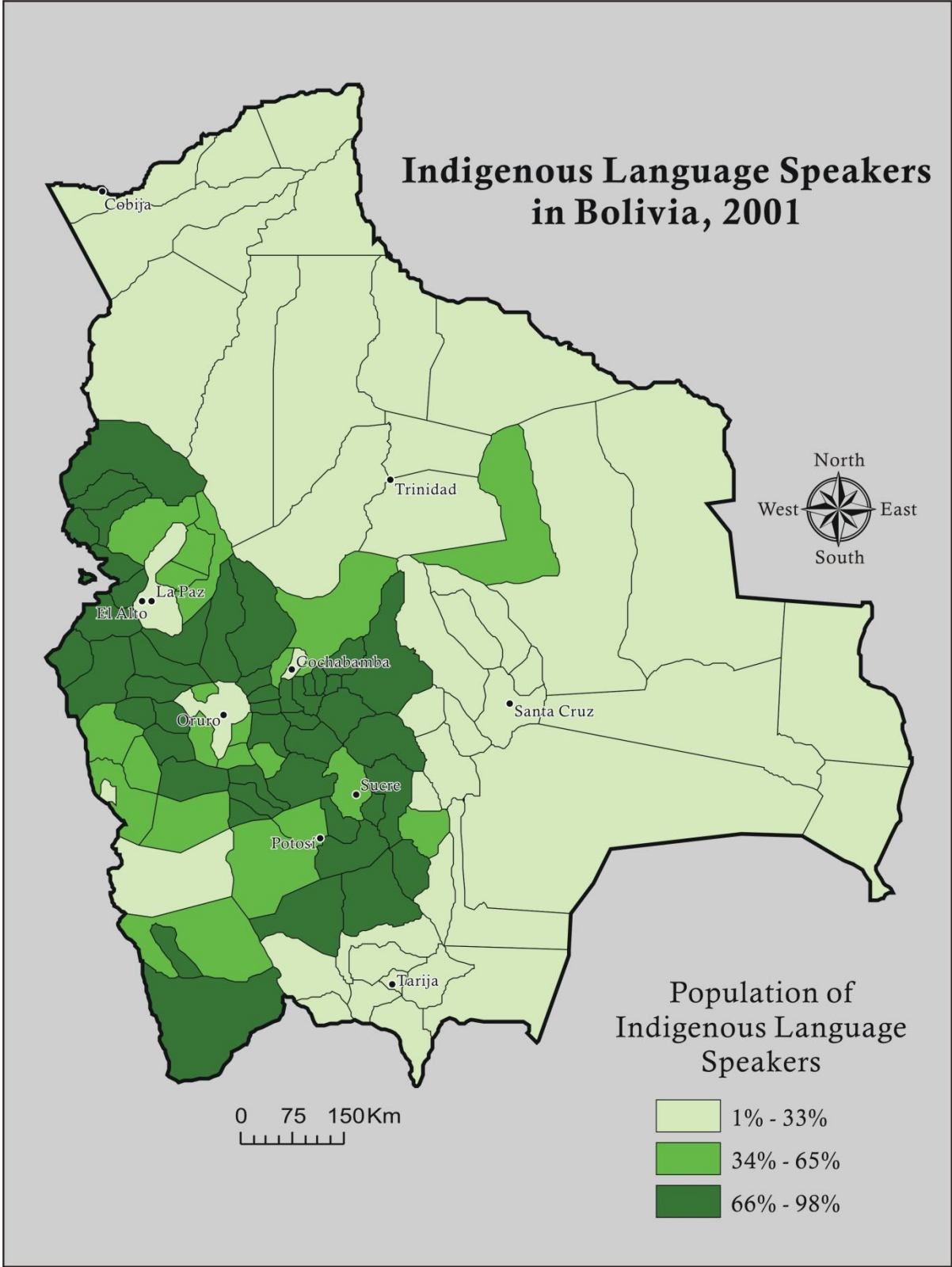
2009 Presidential Election and Indigenous Language Speakers



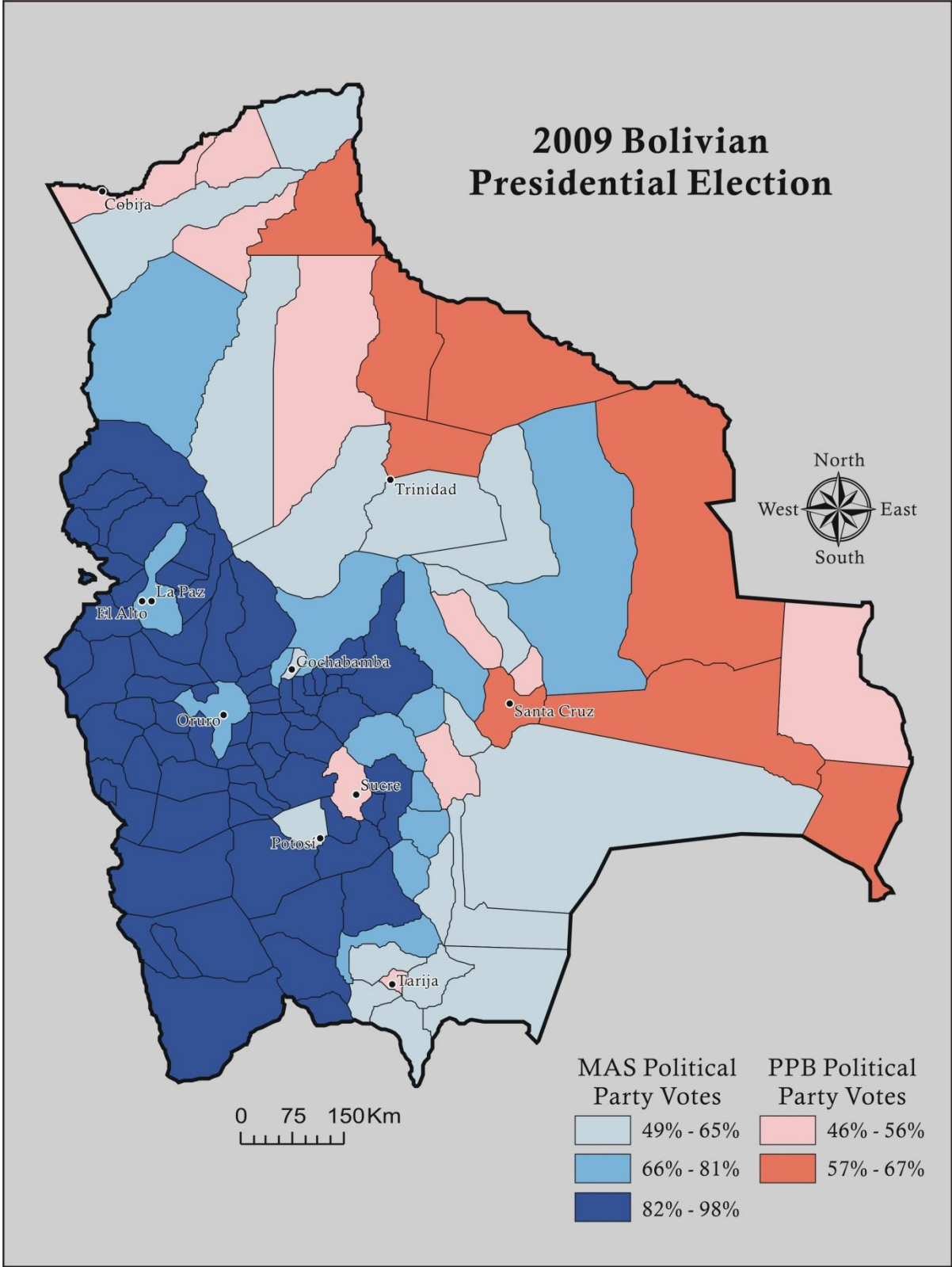
2009 Presidential Election and Indigenous Language Speakers



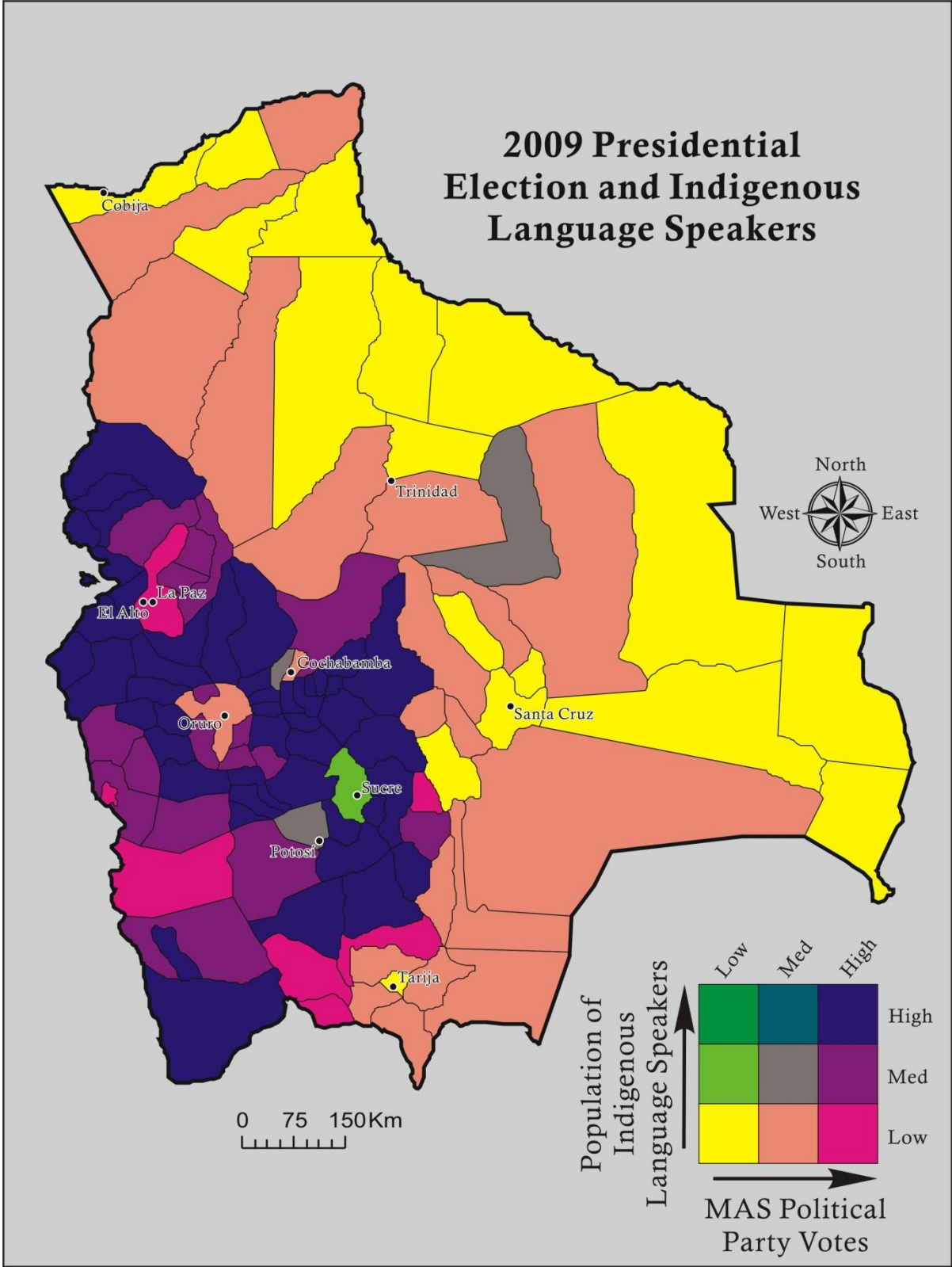




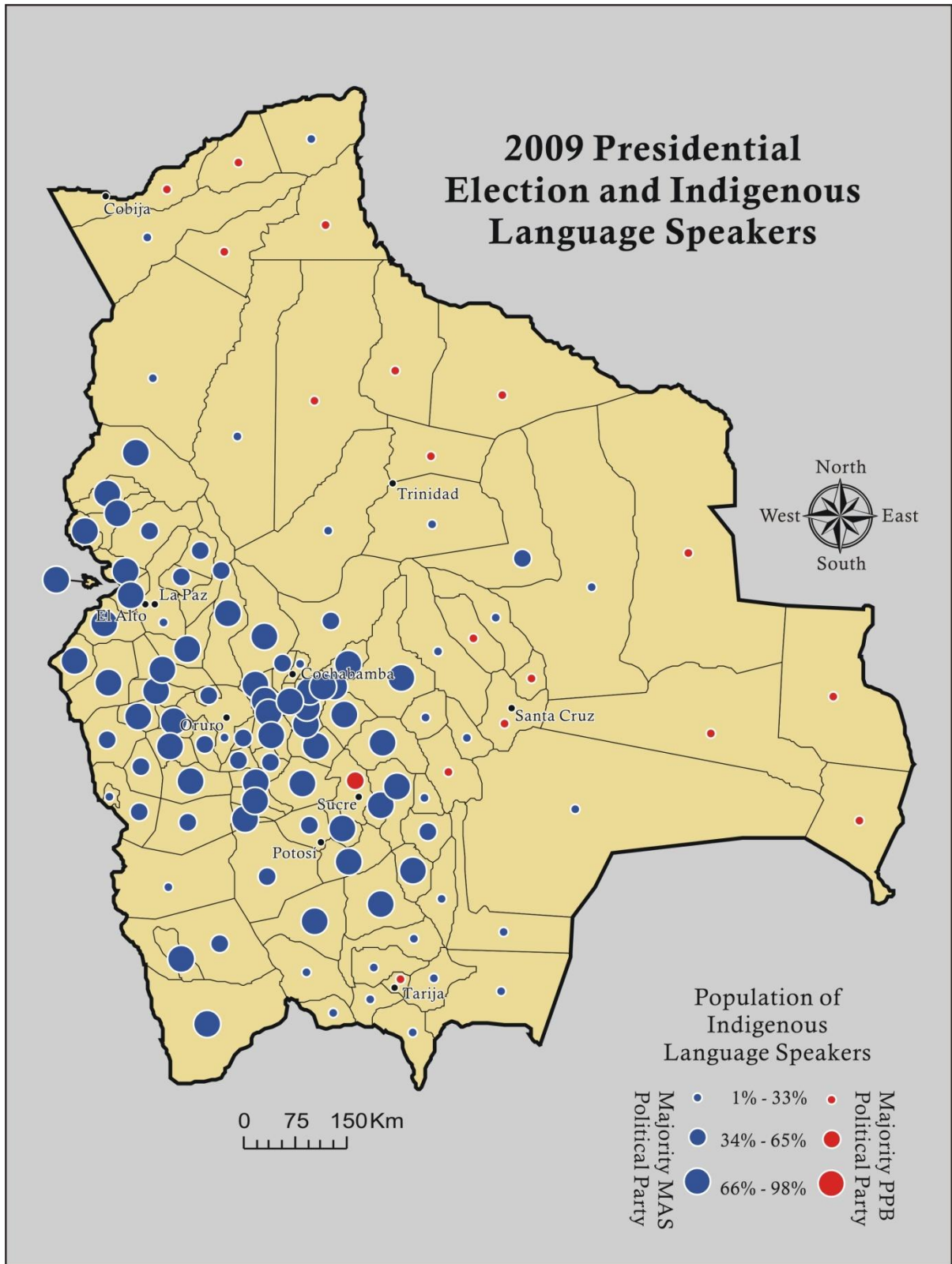
6a



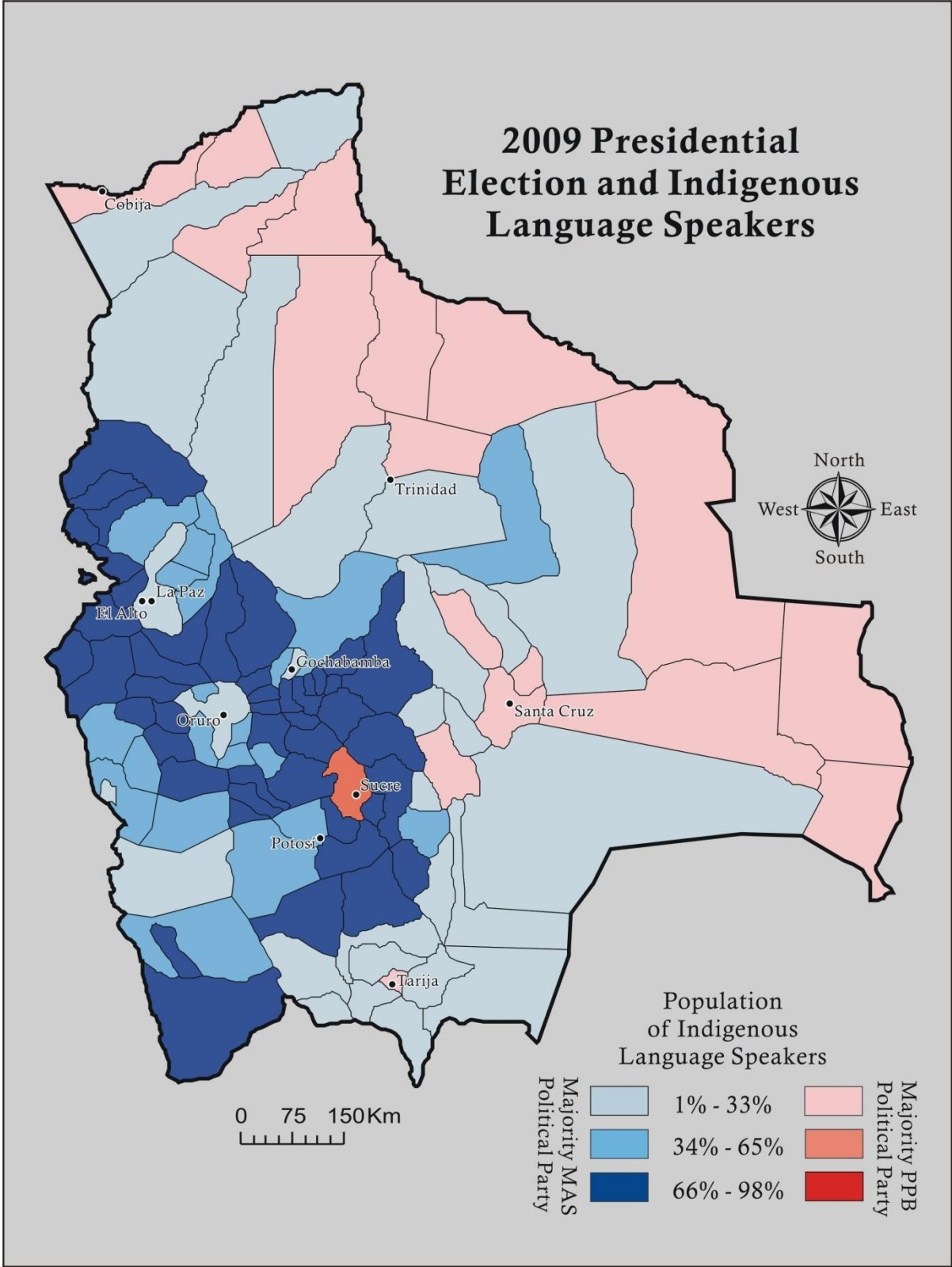
6b

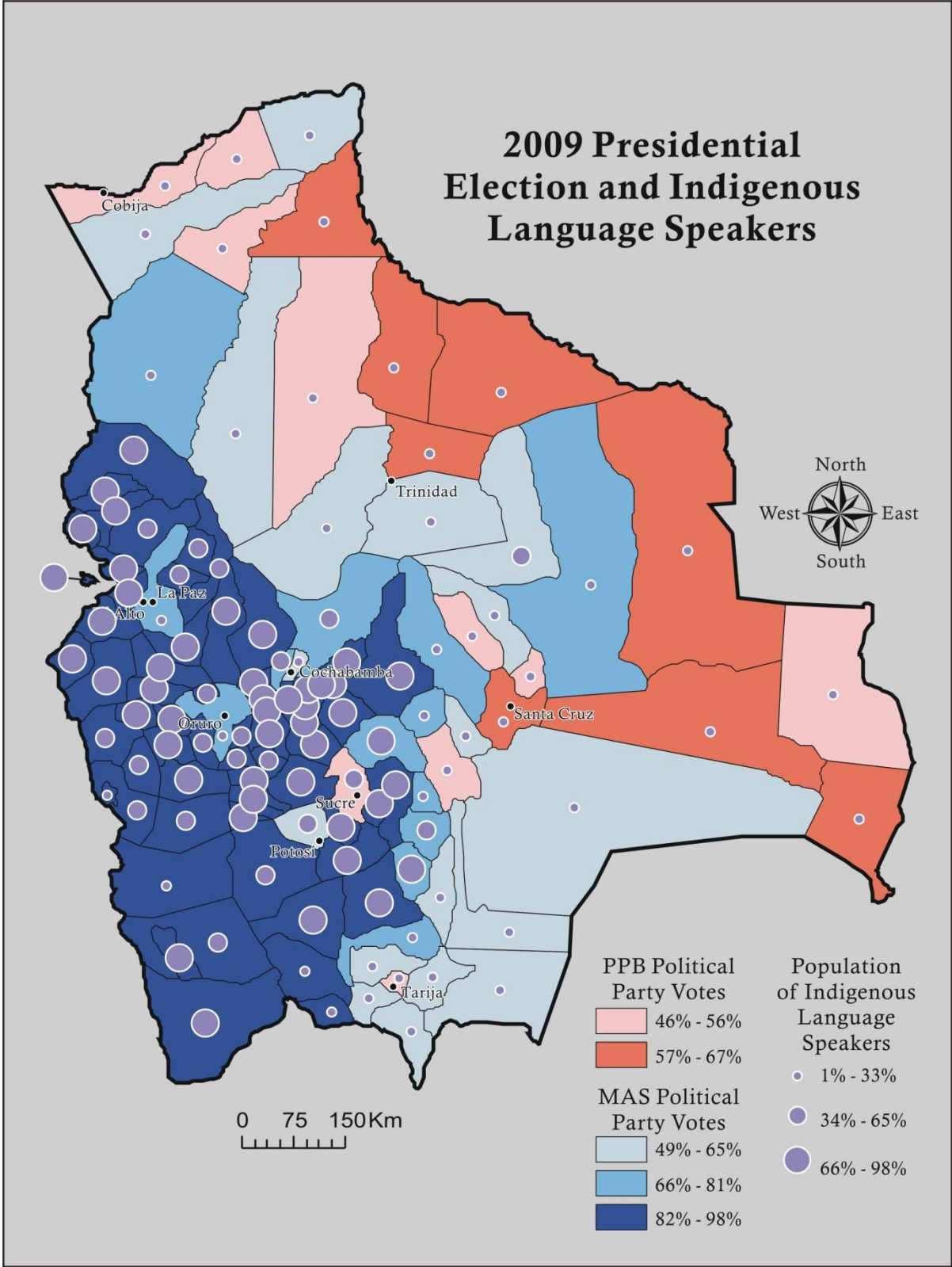


2009 Presidential Election and Indigenous Language Speakers



2009 Presidential Election and Indigenous Language Speakers





APPENDIX B: ENGLISH SURVEY QUESTIONS

SURVEY PARTICIPANT CONSENT FORM

I agree to share my opinions as a participant in this research project, *Mapping Bolivia's socio-political climate: Evaluation of multivariate strategies*, which concerns the evaluation of five different mapping approaches using political and social data from Bolivia. I understand that my survey responses will be recorded and used for data in a master's thesis study, by Cheryl Hagevik of the Department of Geography and Planning at Appalachian State University (Faculty Advisor Dr. Christopher Badurek). I also understand that my responses will be confidential and my name will not be used in connection with responses or publications resulting from this survey.

I understand that there are no foreseeable risks associated with my participation. I also know that this study may benefit participants or society by assessment of multivariate mapping approaches in the dissemination of information to the public concerning political and social relationships. I give Cheryl Hagevik ownership of my survey responses and understand that these responses will be kept in the researcher's possession. I understand that responses and information from this survey will be published. I understand I will receive no compensation for my participation.

I understand that the survey is voluntary and I can end it at any time without consequence. I also understand that if I have questions about this research project, I can call Cheryl Hagevik at (828) 773-9527 and hagevikca@appstate.edu, Dr. Christopher Badurek at (828) 262-7054 and badurekca@appstate.edu, or Appalachian State University's Office of Research Protections at (828) 262-7981 or irb@appstate.edu.

Cheryl A Hagevik
Name of Interviewer

Christopher A Badurek
Name of Faculty Advisor

Name of Participant (printed)

Signature of Interviewer

Signature of Faculty Advisor

Signature of Participant

Date of Survey Completion

Section 1: Demographics. Please circle the best response.

1. Sex:
 - a) Male
 - b) Female

2. Age Group:
 - a) 19 and under
 - b) 20 to 30
 - c) 31 to 40
 - d) 41 to 50
 - e) 51 and over

3. First Spoken Language:
 - a) English
 - b) Spanish
 - c) Aymara
 - d) Quechua
 - e) Guarani
 - f) Other: Please identify _____

4. Which of the following political activities do you participate in (circle all that apply):
 - a) Following news reports (television, newspaper, etc.)
 - b) Voting
 - c) Campaigning
 - d) Active Politician

5. How often are you active in politics? (For example: campaigning, political volunteering, voting)

5	4	3	2	1
Frequently Often	Some	Rarely	Never	

6. How often do you use maps to find locations or guide routes?

5	4	3	2	1
Frequently	Often	Some	Rarely	Never

7. How often do you use maps as a source of information (environmental, social, economic, political, etc.)?

5	4	3	2	1
Frequently	Often	Some	Rarely	Never

Section 2: Use the book of maps to answer the following questions. This series of maps shows voting and language data for Bolivian provinces.
Please circle the best response.

1. Open to pages 1a and 1b.
What is the largest number found on the map scale bar?
 - a) 75
 - b) 100
 - c) 150
 - d) 175

2. Turn to page 2.
Where is the map title placed within the map space?
 - a) Top Left
 - b) Top Right
 - c) Bottom Left
 - d) Bottom Right

3. Turn to page 3.
What does the compass tell you?
 - a) Color
 - b) Direction
 - c) Scale
 - d) Date

4. Turn to page 4.
What is the highest category found in the legend?
 - a) 1% - 33%
 - b) 34% - 65%
 - c) 66% - 98%
 - d) 78% - 98%

5. Turn to page 5.
The purple circles are found in how many sizes?
 - a) 1
 - b) 2
 - c) 3
 - d) 4

Section 3: Continue to use the book of maps to answer the following questions. This series of maps shows voting and language data for Bolivian provinces.

Use pages 6a and 6b to answer questions 1-5.

Circle the best response:

1. The provinces in northwestern Bolivia show a population with:
 - a) High percentage of MAS Votes
 - b) Low percentage of indigenous speakers
 - c) High percentage of indigenous speakers

2. The percentage of indigenous language speakers is highest in provinces with:
 - a) Low MAS votes
 - b) High PPB votes
 - c) High MAS votes

Write a response:

3. What is the range for PPB votes in the following cities:
Santa Cruz _____ %
Tarija _____ %

Circle the best rating based on your opinion of these two maps together:

4. Visual Pleasantness:
Unpleasant 1 2 3 4 5 Pleasant

5. Readability:
Difficult to Read 1 2 3 4 5 Easy to Read

Please do not turn back

This series of maps shows voting and language data for Bolivian provinces.

Use page 7 to answer questions 6-10.

Circle the best response:

6. The provinces in northwestern Bolivia show a population with:
 - a) Low to med percentage of MAS votes
 - b) Med to high percentage of MAS votes
 - c) Med to high percentage of indigenous language speakers

7. Dark blue shades represent areas of the country with:
 - a) Low MAS votes and low percentage of indigenous language speakers
 - b) High MAS votes and low percentage of indigenous language speakers
 - c) High MAS votes and high percentage of indigenous language speakers

Write a response:

8. In the city of Sucre, what is the range for the following categories:
MAS Votes _____ (High, Med or Low)
Indigenous Language Speakers _____ (High, Med, Low)

Circle the best rating based on your opinion:

9. Visual Pleasantness:
Unpleasant 1 2 3 4 5 Pleasant

10. Readability:
Difficult to Read 1 2 3 4 5 Easy to Read

Please do not turn back

This series of maps shows voting and language data for Bolivian provinces.

Use page 8 to answer questions 11-15.

Circle the best response:

- 11. In the 2009 Bolivian Presidential Election, the majority of provinces were won by:
 - a) MAS Political Party
 - b) PPB Political Party
 - c) Neither MAS or PPB Political Party

- 12. High percentages of indigenous language speakers are found in areas with:
 - a) Majority PPB Political Party
 - b) Majority MAS Political Party
 - c) Both Majority MAS and PPB Political Party

Write a response:

- 13. What is the range for Indigenous Language Speakers in the following cities:
 - Santa Cruz _____%
 - La Paz _____%

Circle the best rating based on your opinion:

- 14. Visual Pleasantness:
Unpleasant 1 2 3 4 5 Pleasant

- 15. Readability:
Difficult to Read 1 2 3 4 5 Easy to Read

Please do not turn back

This series of maps shows voting and language data for Bolivian provinces.

Use page 9 to answer questions 16-20.

Circle the best response:

16. The provinces in northwestern Bolivia show a population with:
- a) High percentages of indigenous language speakers
 - b) Medium percentages of indigenous language speakers
 - c) Low percentages of indigenous language speakers
17. Larger amounts of indigenous language speakers are found in areas of the country with:
- a) Majority MAS votes
 - b) Majority PPB votes
 - c) Both Majority MAS votes and Majority PPB votes

Write a response:

18. What is the range for Indigenous Language Speakers in the following cities:
- Oruro _____%
- Potosí _____%

Circle the best rating based on your opinion:

19. Visual Pleasantness:

Unpleasant 1 2 3 4 5 Pleasant

20. Readability:

Difficult to Read 1 2 3 4 5 Easy to Read

Please do not turn back

This series of maps shows voting and language data for Bolivian provinces.

Use page 10 to answer questions 21-25.

Circle the best response:

21. The provinces in southwestern Bolivia show a population with mostly:
- a) High percentage of MAS votes and high percentage of indigenous language speakers
 - b) Low percentage of MAS votes and low percentage of indigenous language speakers
 - c) High percentage of PPB votes and high percentage of indigenous language speakers
22. In general, areas with majority PPB political party show:
- a) High percentage of indigenous language speakers
 - b) Medium percentage of indigenous language speakers
 - c) Low percentage of indigenous language speakers

Write a response:

23. What is the range for Indigenous Language Speakers in the following cities:
- Cochabamba _____%
- La Paz _____%

Circle the best rating based on your opinion:

24. Visual Pleasantness:

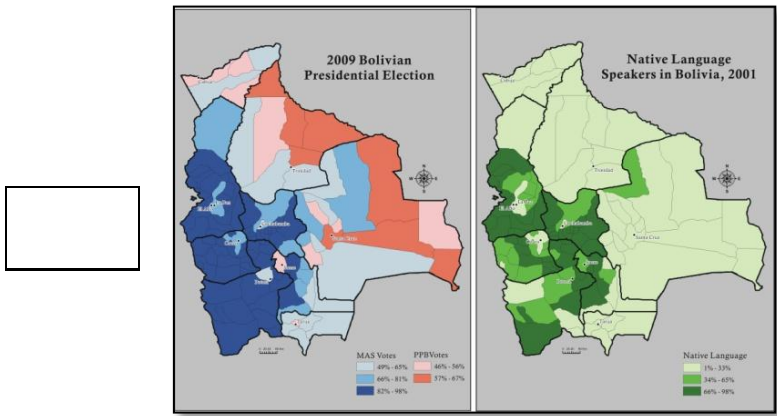
Unpleasant 1 2 3 4 5 Pleasant

25. Readability:

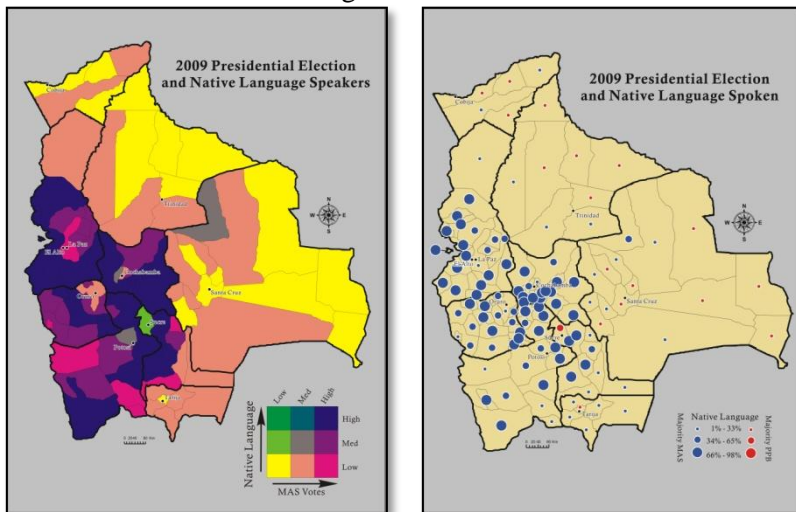
Difficult to Read 1 2 3 4 5 Easy to Read

Please do not turn back

Section 4: Please rank these maps from 1 to 5 (1 being the best, 2 being your second choice, etc.) to indicate your overall preference in viewing this data. Write appropriate number in the blank provided. You may now turn back through the book of maps.

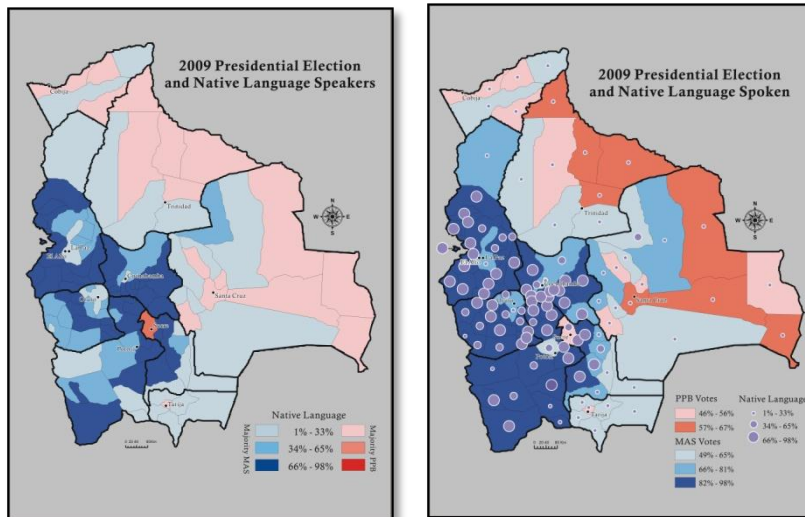


Pages 6a and 6b



Page 7

Page 8



Page 9

Page 10

Please provide any additional comments regarding why or why not you prefer a certain mapping approach pictured within this survey:

Thank You for your participation!

APPENDIX C: SPANISH SURVEY MAP BOOK

Esta serie de mapas muestra datos de votación y
lenguas de las Provincias de Bolivia

Fuentes de Datos:

Instituto Nacional de Estadística (INE) de Bolivia
Censo de Población y Vivienda-2001

[http://www.ine.gov.bo/cgi-
bin/Redatam/RG4WebEngine.exe/](http://www.ine.gov.bo/cgi-bin/Redatam/RG4WebEngine.exe/)
Obtengo 25 Marzo 2010.

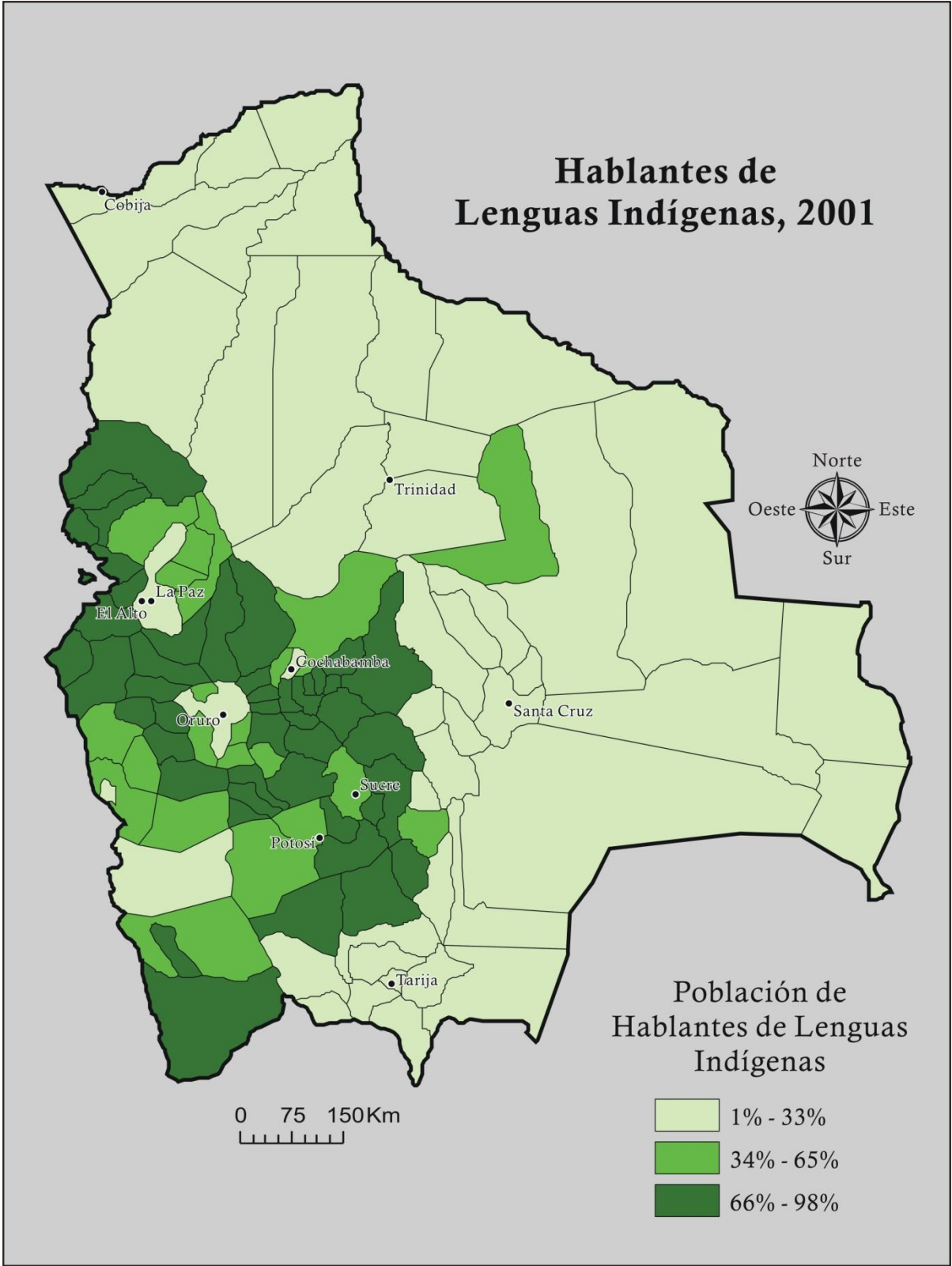
Zandvliet, Hans. 2010. "Evolución Electoral del MAS en
Bolivia en las Elecciones y Referéndums desde 2005 al
2009."

Blog del Centro de Democracia de Bolivia.

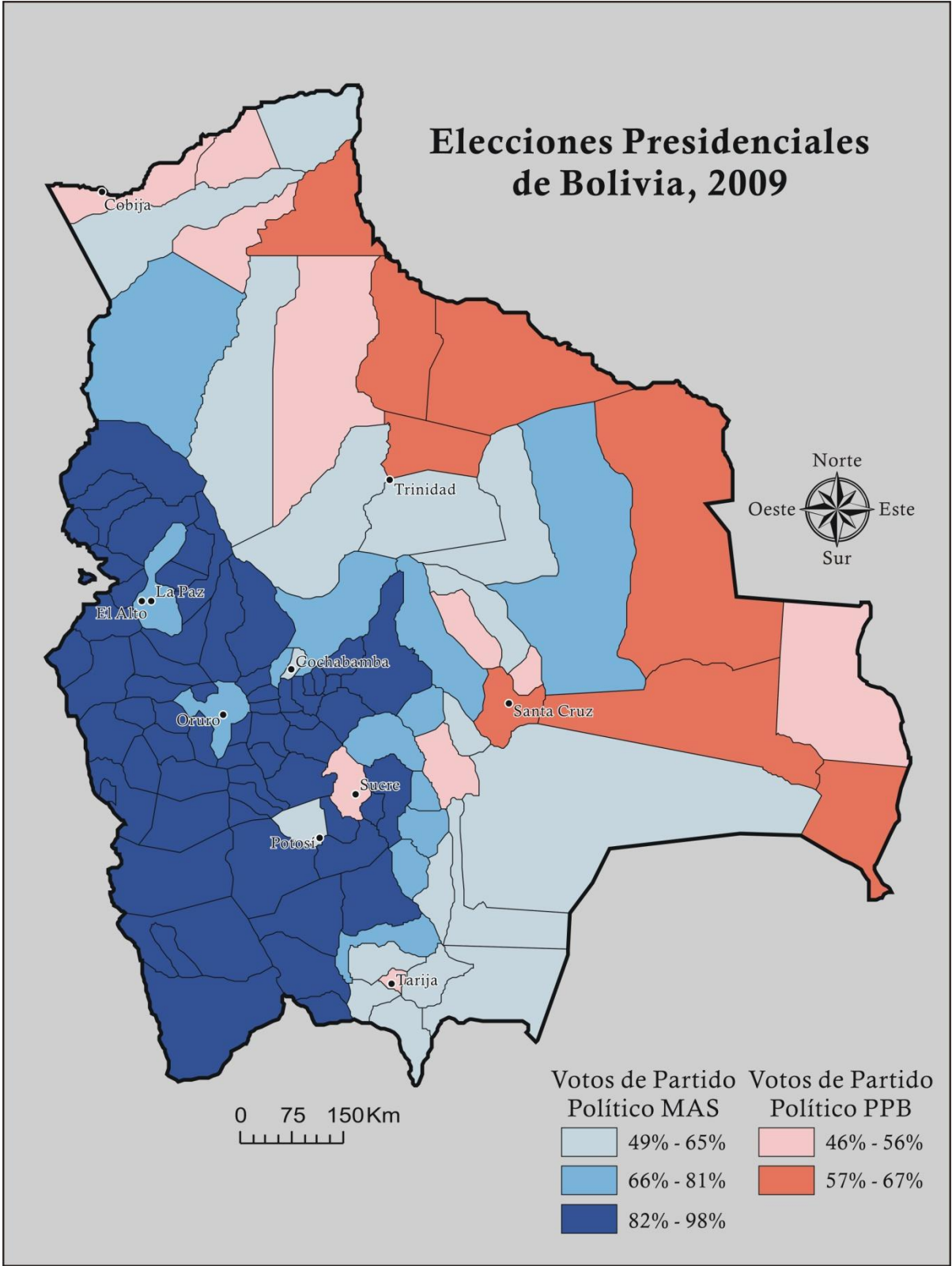
[http://democracyctr.org/blog/Elecciones%20Bolivia%
202005-2009.pdf](http://democracyctr.org/blog/Elecciones%20Bolivia%202005-2009.pdf)

Obtuvo 29 Abril 2010.

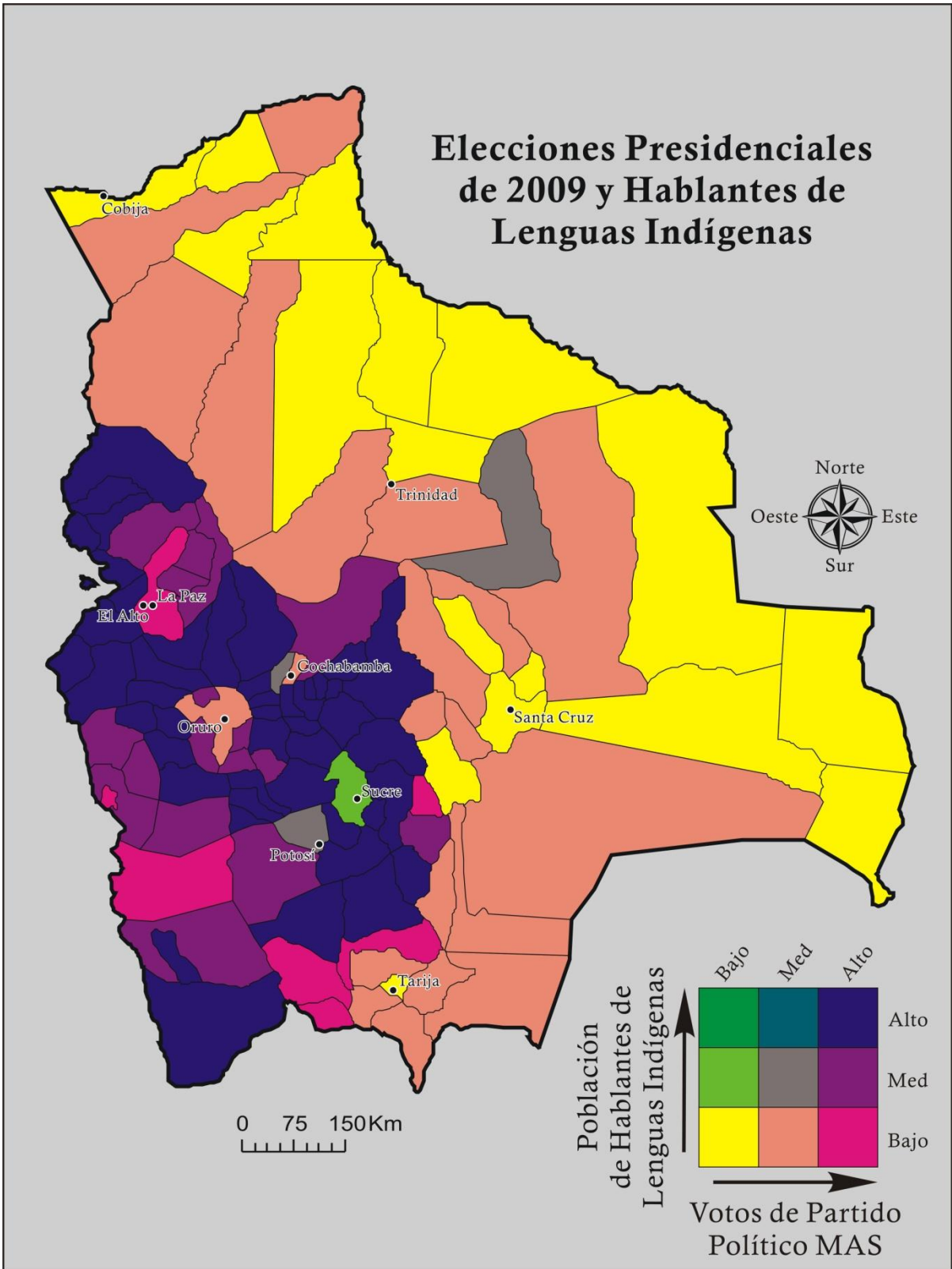
Creado por: Cheryl Hagevik
Appalachian State Universidad
La Primavera 2011

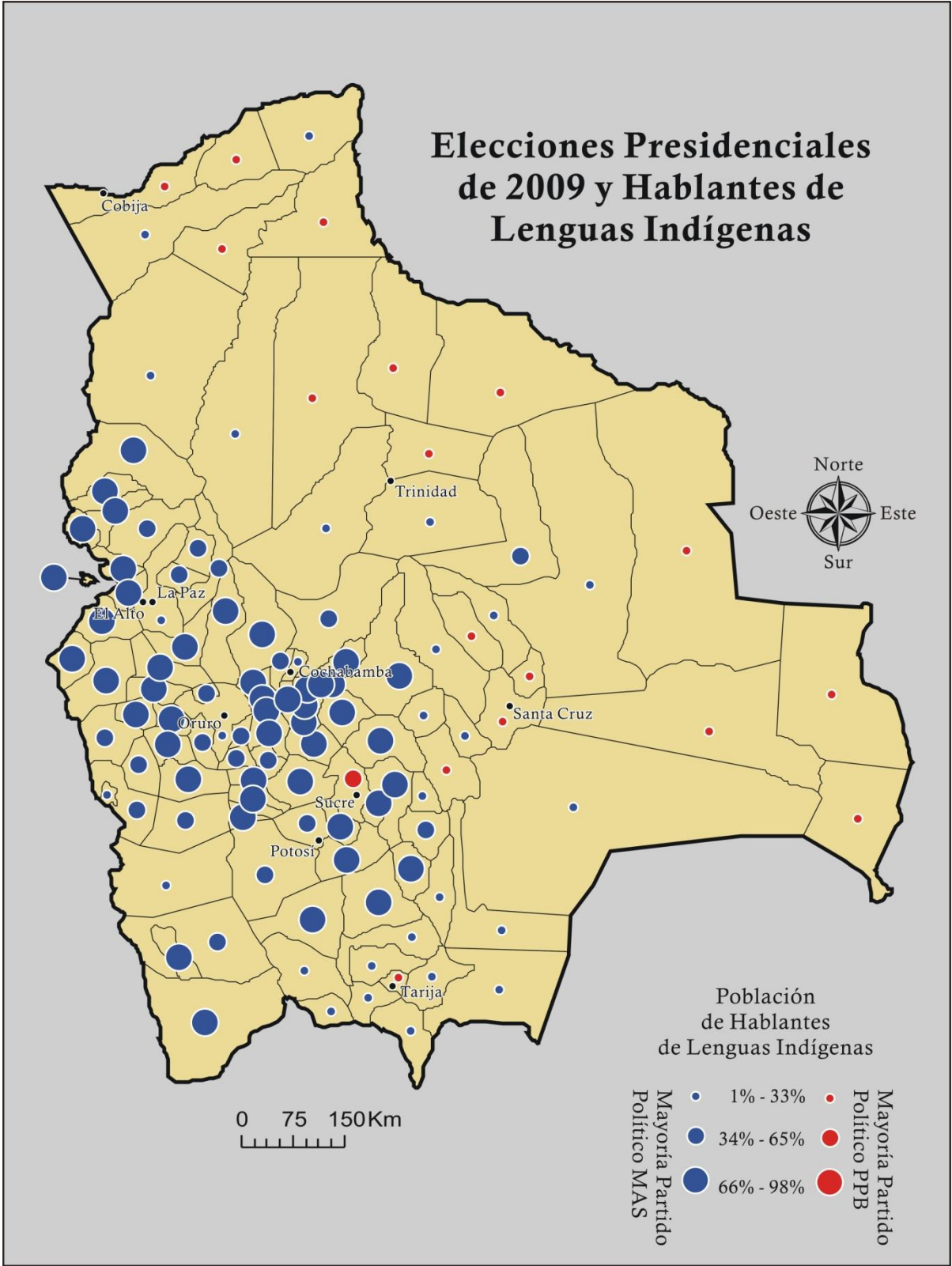


1a

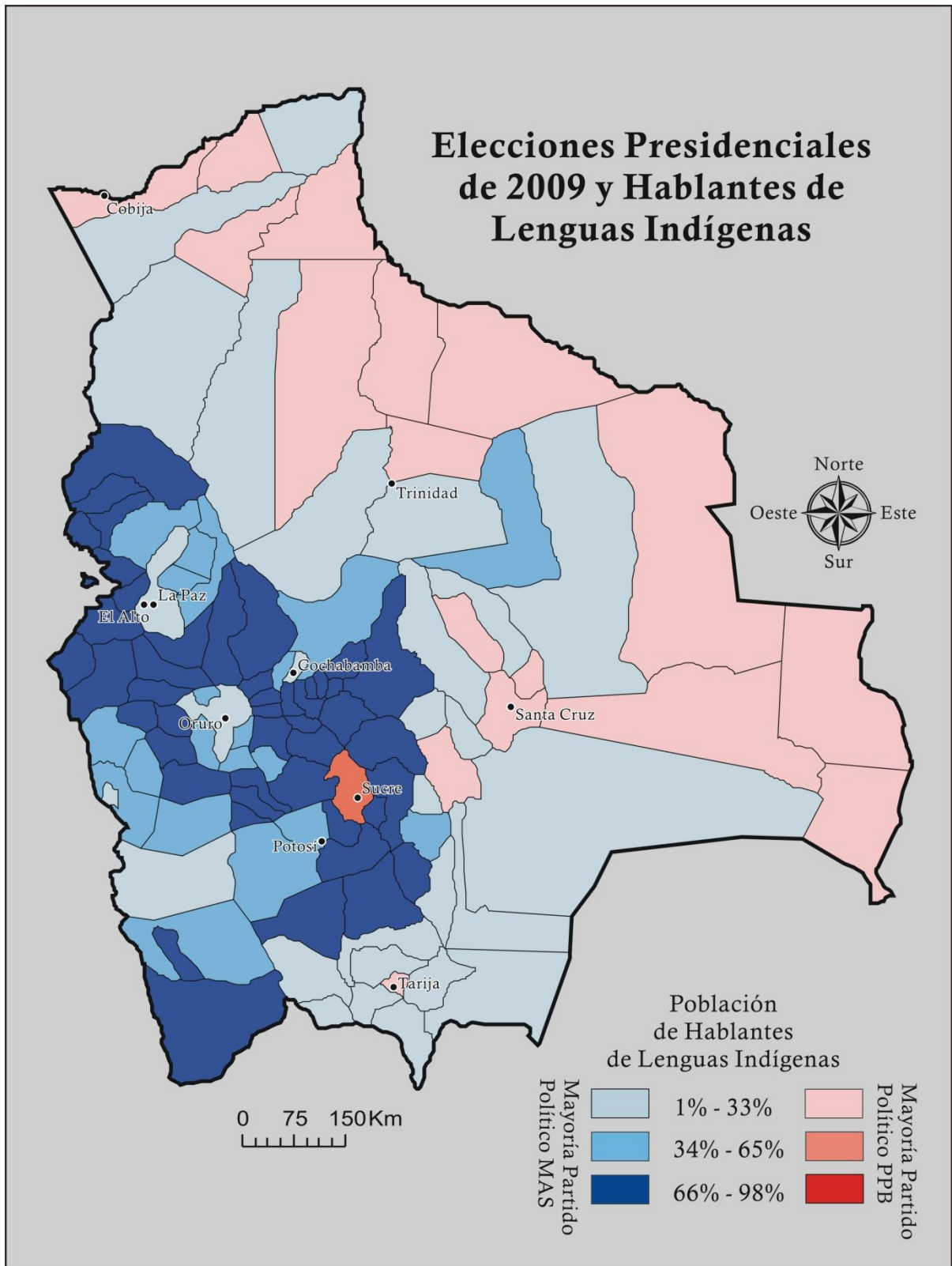


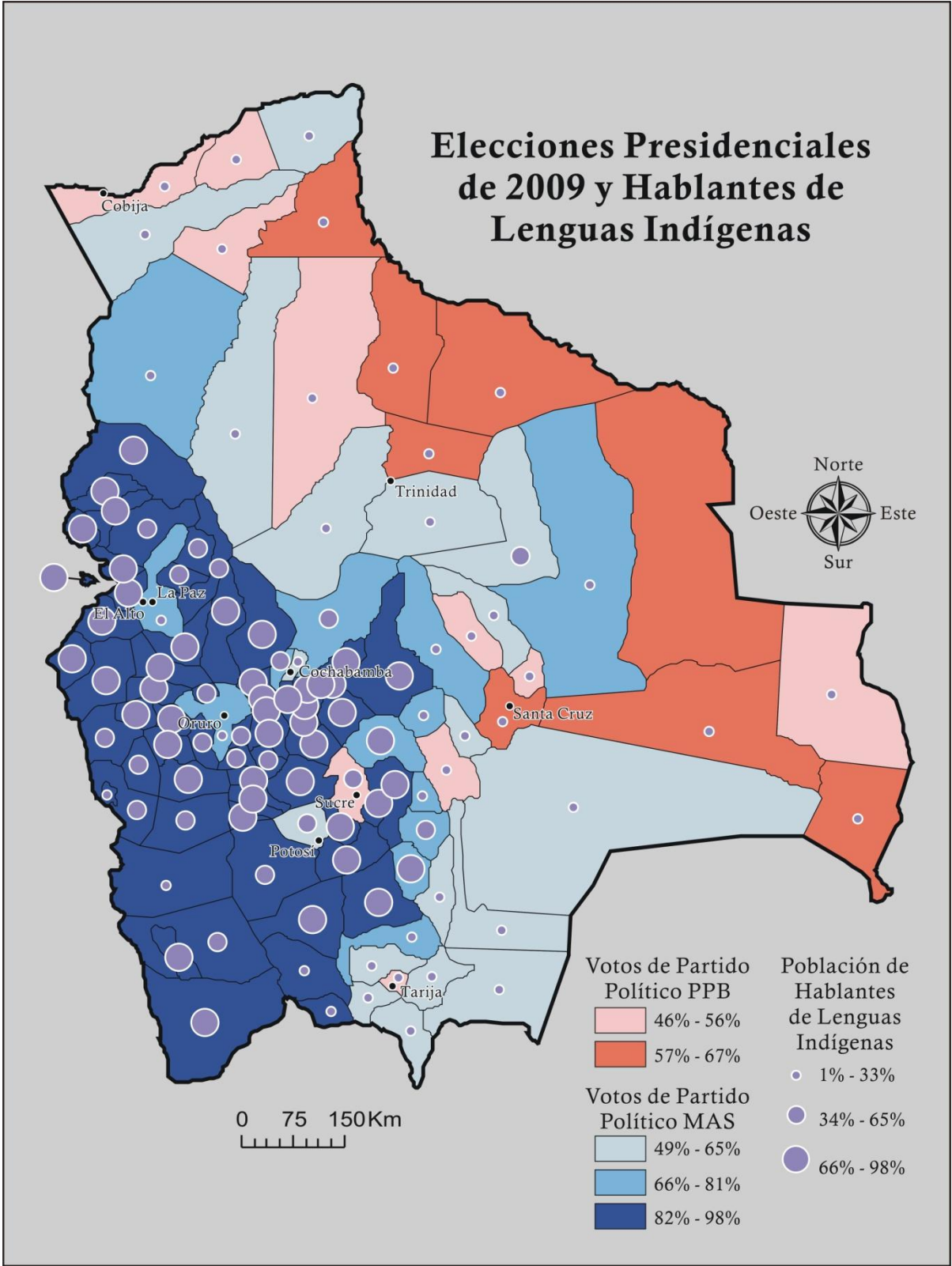
1b

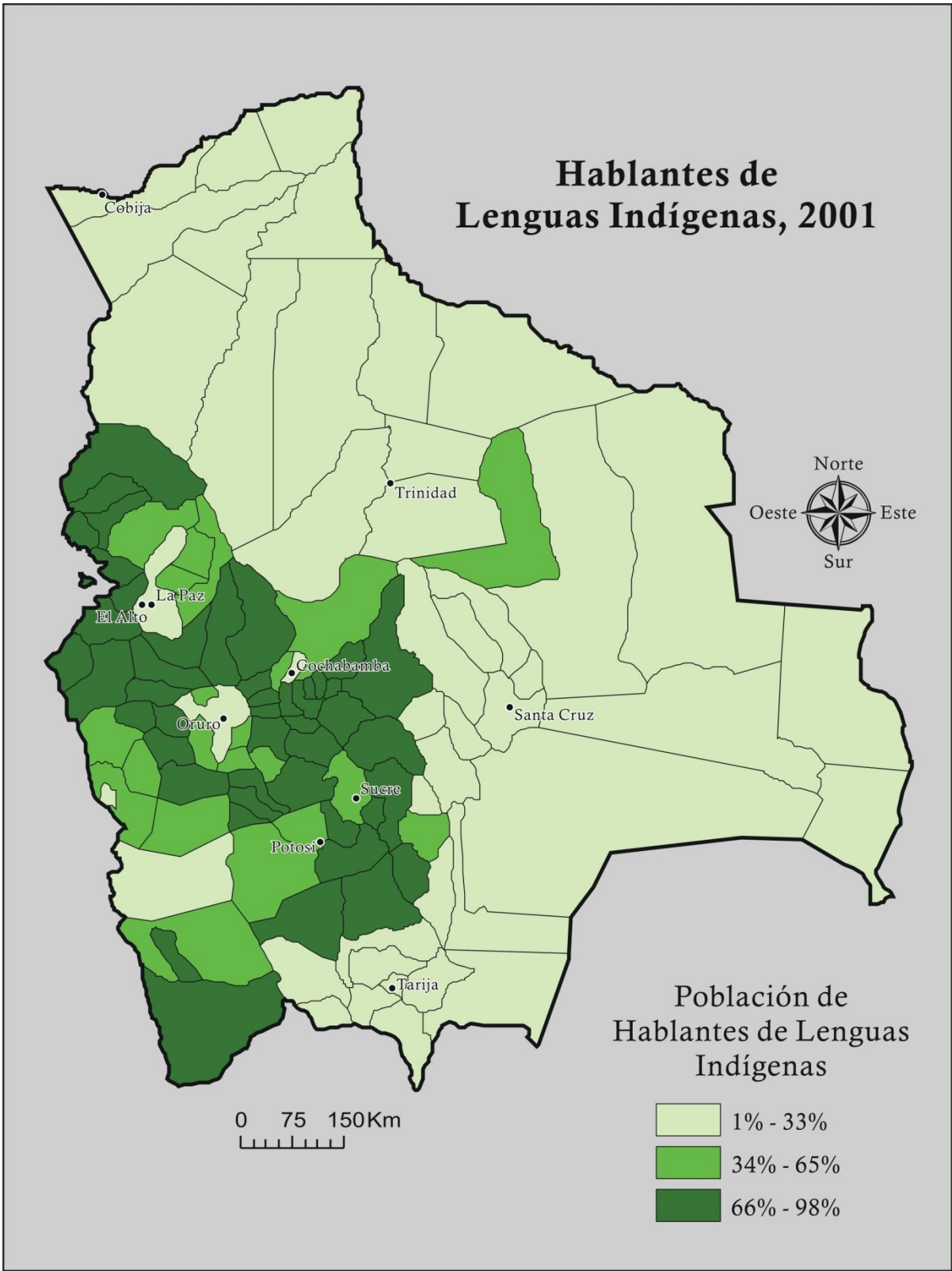




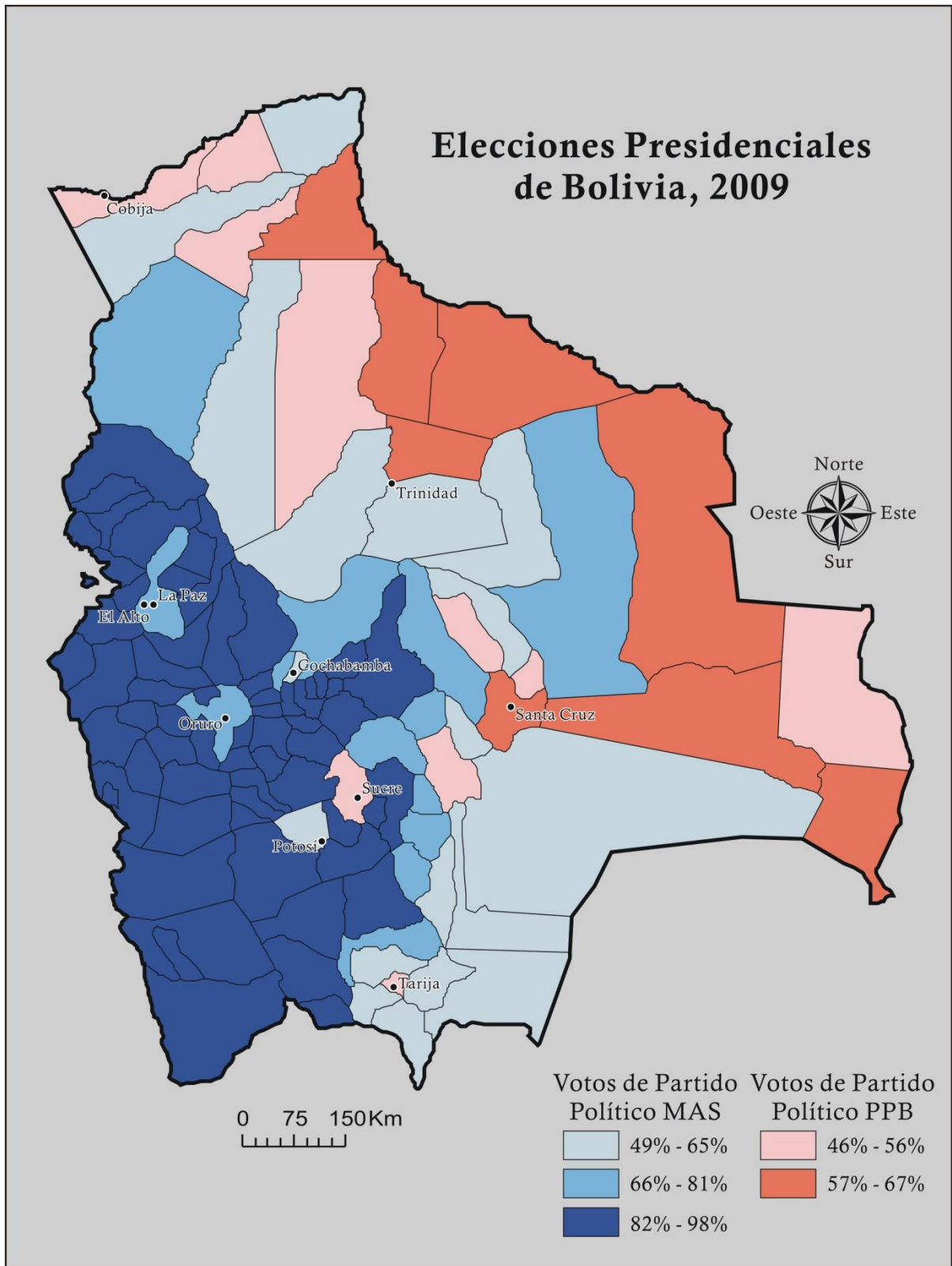
Elecciones Presidenciales de 2009 y Hablantes de Lenguas Indígenas





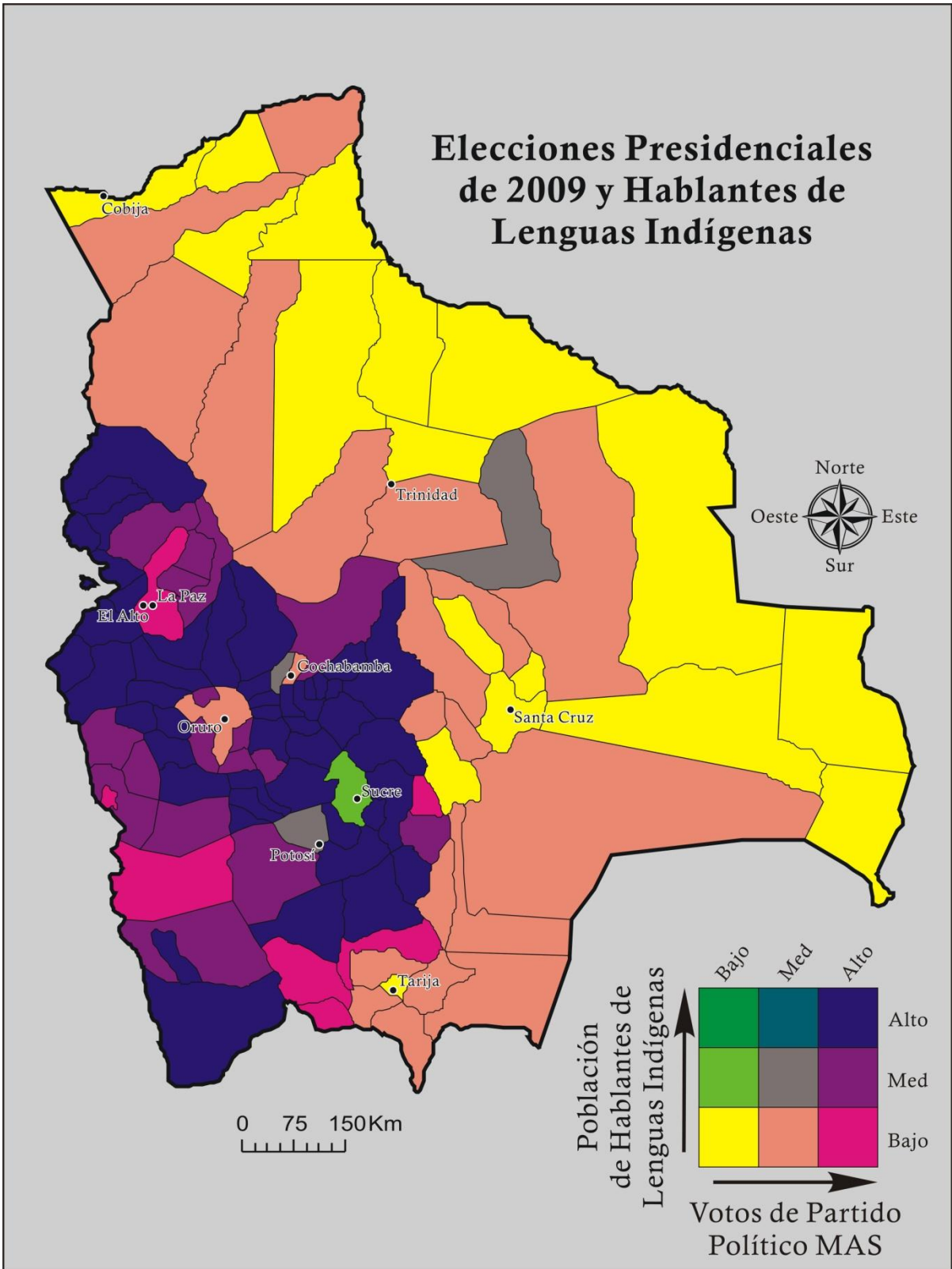


6a

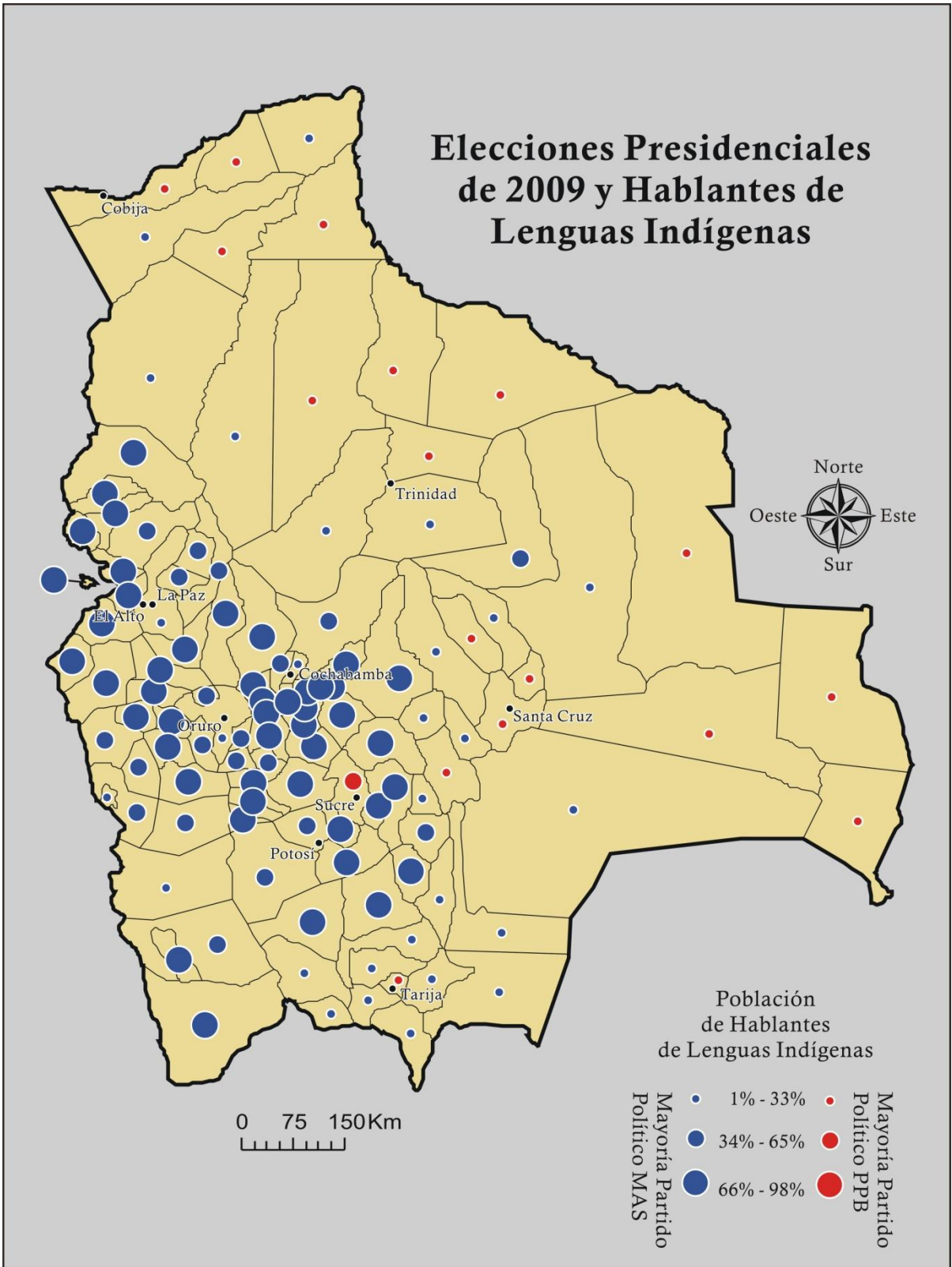


6b

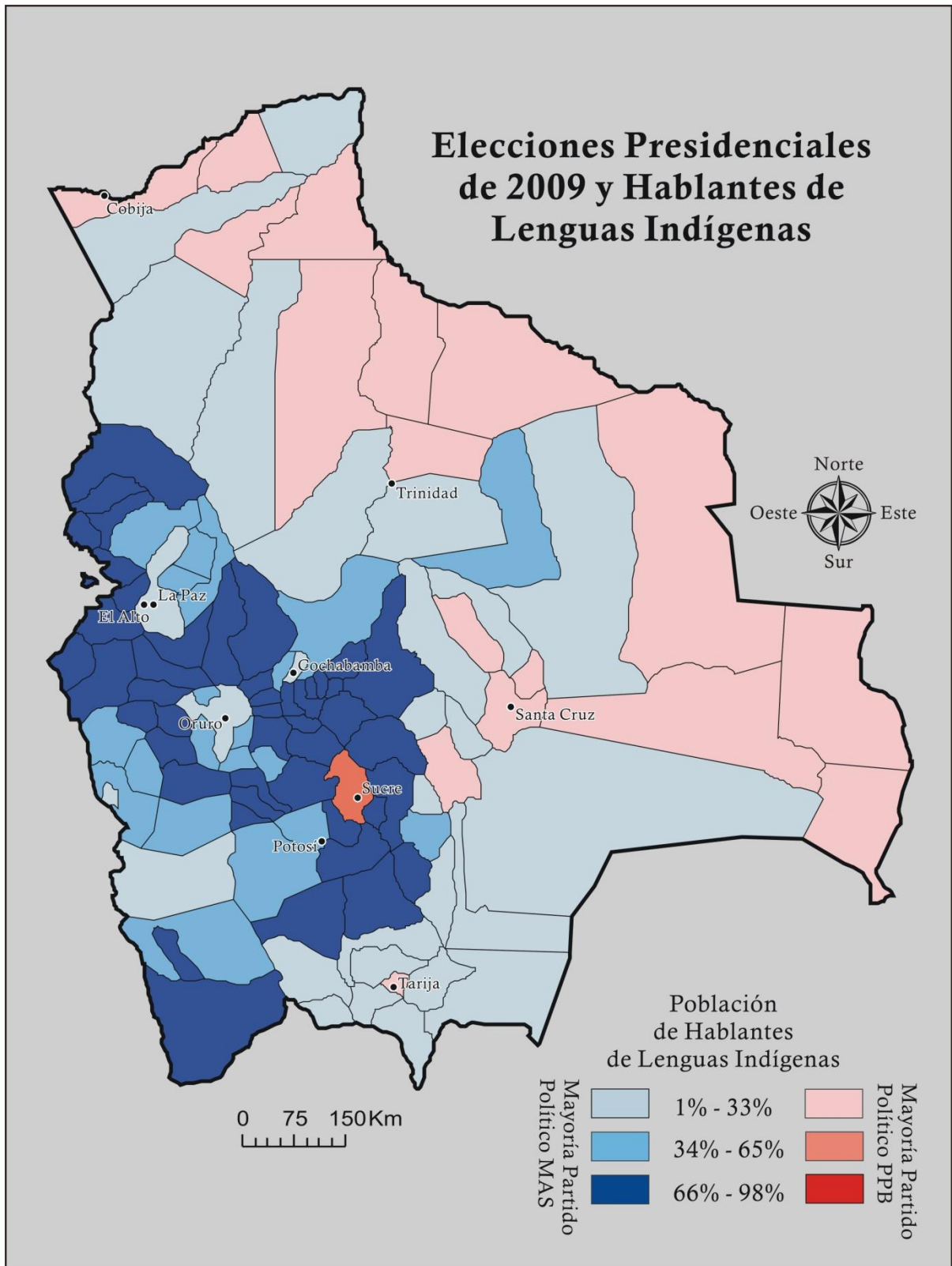
Elecciones Presidenciales de 2009 y Hablantes de Lenguas Indígenas

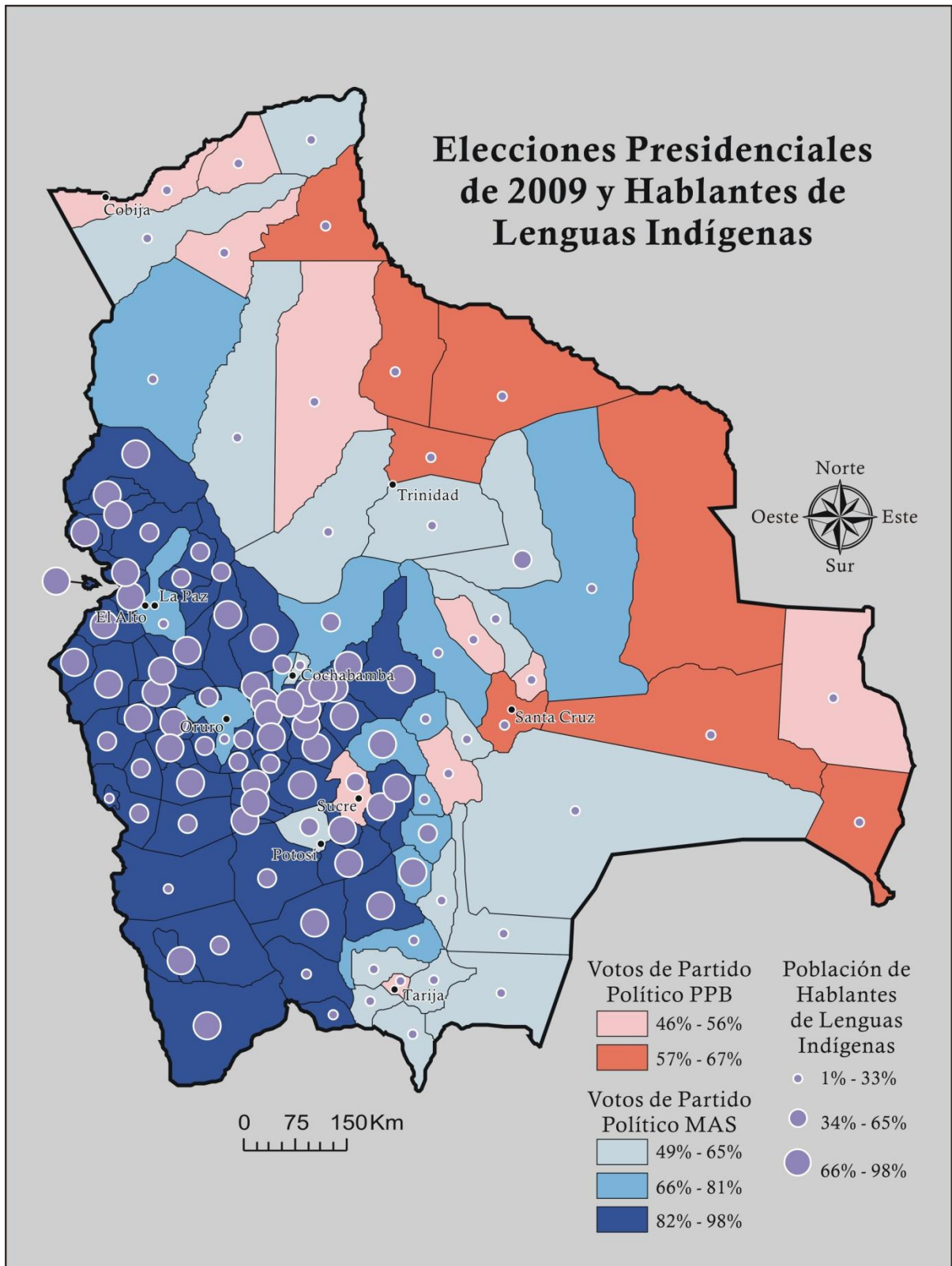


Elecciones Presidenciales de 2009 y Hablantes de Lenguas Indígenas



Elecciones Presidenciales de 2009 y Hablantes de Lenguas Indígenas





APPENDIX D: SPANISH SURVEY QUESTIONS

PARTICIPANTE DE LA ENCUESTA PERMISIO

Consiento en compartir mis opiniones como participante en este proyecto de investigación, *Trazado el mapa del clima sociopolítico de Bolivia: Evaluación de estrategias multivariantes*. Entiendo que mis respuestas serán utilizadas para los datos en un estudio de tesis de maestría, por Cheryl Hagevik de la Facultad de Geografía y Planificación en Appalachian State University. También entiendo que mis respuestas serán confidenciales y mi nombre no será utilizado con respecto a publicaciones que resultan de esta encuesta. Doy a Cheryl Hagevik propiedad a mis respuestas y entiendo que serán guardadas en la posesión de la investigadora. Entiendo que las respuestas e información de esta encuesta serán publicadas. Entiendo que no recibiré compensación por mi participación y Entiendo que la encuesta es voluntaria y que puedo terminarla en cualquier momento sin consecuencia. También entiendo que si hago preguntas sobre este proyecto de investigación, puedo llamar a Cheryl Hagevik en 001-828-773-9527 y hagevikca@appstate.edu, Dr. Christopher Badurek en 001 (828) 262-7054 y badurekca@appstate.edu, o La Oficina de Protecciones de Investigaciones de Appalachian State University's en 001-828-262-7981 y irb@appstate.edu.

Cheryl A Hagevik Christopher A Badurek _____
Nombre de la Investigadora Nombre del Asesor de Facultad Nombre del Participante (letra)

Firma de la Investigadora Firma del Asesor de Facultad Firma del Participante

Fecha de Finalización

Sección 1: Los demográficos. Ponga un círculo la respuesta correcta, por favor.

8. El sexo:
- c) Masculino
 - d) Femenino
9. Grupo de Edad:
- f) 19 y menor
 - g) 20 a 30
 - h) 31 a 40
 - i) 41 a 50
 - j) 51 y mayor
10. Primera lengua nativa:
- g) Inglés
 - h) Castellano
 - i) Aymara
 - j) Quechua
 - k) Guaraní
 - l) Otra: Identifique, por favor _____
11. ¿En cuál de las siguientes actividades políticas participa usted? (ponga un círculo todas que aplique):
- e) Ve las noticias (televisión, periódico, etc.)
 - f) Voto
 - g) Hacer una campaña política
 - h) Político activo
12. ¿Con qué frecuencia participa usted en la política? (Por ejemplo: hacer una campaña, voluntario político, votación)
- | | | | | |
|----------------|----------|---------|----------|-------|
| 5 | 4 | 3 | 2 | 1 |
| Frecuentemente | A menudo | A Veces | Rara Vez | Nunca |
13. ¿Con qué frecuencia usa usted los mapas para buscar las localidades o las rutas?
- | | | | | |
|----------------|----------|---------|----------|-------|
| 5 | 4 | 3 | 2 | 1 |
| Frecuentemente | A menudo | A Veces | Rara Vez | Nunca |
14. ¿Con qué frecuencia usa usted los mapas como una fuente de información? (medioambiente, social, económico, político, etc.)
- | | | | | |
|----------------|----------|---------|----------|-------|
| 5 | 4 | 3 | 2 | 1 |
| Frecuentemente | A menudo | A Veces | Rara Vez | Nunca |

Sección 2: Use el libro de los mapas para contestar las siguientes preguntas. Esta serie de mapas muestra datos de votación y lenguas de las provincias de Bolivia. Ponga un círculo la respuesta correcta, por favor.

6. Abra a las páginas 1a y 1b.
¿Cuál es el número más alto encontrado en la escala del mapa?
 - e) 75
 - f) 100
 - g) 150
 - h) 175

7. Vaya usted a la página 2.
¿Dónde está el título del mapa en relación del espacio del mapa?
 - e) Arriba a la izquierda
 - f) Arriba a la derecha
 - g) Abajo a la izquierda
 - h) Abajo a la derecha

8. Vaya usted a la página 3.
¿Qué indica la brújula?
 - e) El color
 - f) La dirección
 - g) La escala
 - h) La fecha

9. Vaya usted a la página 4.
¿Cuál es la categoría más alta que se encuentra en los porcentajes?
 - e) 1% - 33%
 - f) 34% - 65%
 - g) 66% - 98%
 - h) 78% - 98%

10. Vaya usted a la página 5.
¿En cuántos tamaños se encuentran los círculos morados?
 - e) 1
 - f) 2
 - g) 3
 - h) 4

Sección 3: Siga usando el libro de los mapas para contestar las siguientes preguntas. Esta serie de mapas muestra datos de votación y lenguas de las provincias de Bolivia.

Use las páginas 6a y 6b para contestar las preguntas 1-5.

Ponga un círculo la respuesta correcta:

21. Las provincias del norte de Bolivia muestra una población con:
- d) Alto porcentaje de los votos del MAS
 - e) Bajo porcentaje de hablantes de lenguas indígenas
 - f) Alto porcentaje de hablantes de lenguas indígenas
22. El porcentaje de hablantes de lenguas indígenas es el más alto en las provincias con:
- d) Bajo votos del MAS
 - e) Alto votos del PPB
 - f) Alto votos del MAS

Escriba una respuesta:

23. ¿Cuál es el porcentaje de votos del PPB en las siguientes ciudades?
- Santa Cruz _____%
- Tarija _____%

Ponga un círculo el índice mejor aceptado en su opinión de estos mapas:

24. Agrado Visual:
- Desagradable 1 2 3 4 5 Agradable
25. Legibilidad:
- Difícil de interpretar 1 2 3 4 5 Fácil de interpretar

Por Favor, No Vuelva Atrás

Esta serie de mapas muestra datos de votación y lenguas de las provincias de Bolivia.

Use la página 7 para contestar las preguntas 6-10.

Ponga un círculo la respuesta correcta:

26. Las provincias del norte de Bolivia muestran una población con:

- d) Bajo a mediano porcentaje de los votos del MAS
- e) Mediano a alto porcentaje de los votos del MAS
- f) Mediano a alto porcentaje de hablantes de lenguas indígenas

27. Los tonos azules oscuros representan las regiones del país con:

- d) Bajos votos del MAS y bajo porcentaje de hablantes de lenguas indígenas
- e) Altos votos del MAS y bajo porcentaje de hablantes de lenguas indígenas
- f) Altos votos del MAS y alto porcentaje de hablantes de lenguas indígenas

Escriba una respuesta:

28. En la ciudad de Sucre, ¿Cuál es la tendencia de?.....

Votos hacia el MAS _____ (Alto, Med o Bajo)

Hablantes de Lenguas Indígenas _____ (Alto, Med, o Bajo)

Ponga un círculo el índice mejor aceptado en su opinión de estos mapas:

29. Agrado Visual:

Desagradable 1 2 3 4 5 Agradable

30. Legibilidad:

Difícil de interpretar 1 2 3 4 5 Fácil de interpretar

Por Favor, No Vuelva Atrás

Esta serie de mapas muestra datos de votación y lenguas de las provincias de Bolivia.

Use la página 8 to para contestar las preguntas 11-15.

Ponga un círculo la repuesta correcta:

31. En las Elecciones Presidencia les de Bolivia de 2009, la mayoría de las provincias fueron ganadas por:

- d) El partido político del MAS
- e) El partido político del PPB
- f) Ninguno de los anteriores

32. Se puede encontrar porcentajes altos de hablantes de lenguas indígenas en las regiones con:

- d) La mayoría del partido político del PPB
- e) La mayoría del partido político del MAS
- f) Ambos de los anteriores

Escriba una respuesta:

33. ¿Cuál es el porcentaje de hablantes de lenguas indígenas en las siguientes ciudades?

Santa Cruz _____%

La Paz _____%

Ponga un círculo el índice mejor aceptado en su opinión de estos mapas:

34. Agrado Visual:

Desagradable 1 2 3 4 5 Agradable

35. Legibilidad:

Difícil de interpretar 1 2 3 4 5 Fácil de interpretar

Por Favor, No Vuelva Atrás

Esta serie de mapas muestra datos de votación y lenguas de las provincias de Bolivia.

Use la página 9 para contestar las preguntas 16-20.

Ponga un círculo la respuesta correcta:

36. Las provincias del norte de Bolivia muestran una población con:
- d) Altos porcentajes de hablantes de lenguas indígenas
 - e) Medianos porcentajes de hablantes de lenguas indígenas
 - f) Bajos porcentajes de hablantes de lenguas indígenas
37. Se pueden encontrar las cantidades más grandes de hablantes de lenguas indígenas en las regiones del país con:
- d) La mayoría de votos del partido político del MAS
 - e) La mayoría de votos del partido político del PPB
 - f) Ambos de los anteriores

Escriba una respuesta:

38. ¿Cuál es el porcentaje de hablantes de lenguas indígenas en las siguientes ciudades?
- Oruro _____%
- Potosí _____%

Ponga en un círculo el índice mejor aceptado en su opinión de estos mapas:

39. Agrado Visual:
- Desagradable 1 2 3 4 5 Agradable
40. Legibilidad:
- Difícil de interpretar 1 2 3 4 5 Fácil de interpretar

Por Favor, No Vuelva Atrás

Esta serie de mapas muestra datos de votación y lenguas de las provincias de Bolivia.

Use la página 10 para contestar las preguntas 21-25.

Ponga en un círculo la respuesta correcta:

24. Las provincias del sudoeste de Bolivia en su mayoría muestran una población con:
- d) Alto porcentaje de votos para el MAS y alto porcentaje de hablantes de lenguas indígenas
 - e) Bajo porcentaje de votos para el MAS y bajo porcentaje de hablantes de lenguas indígenas
 - f) Alto porcentaje de votos para el PPB y alto porcentaje de hablantes de lenguas indígenas
 - g) Bajo porcentaje de votos para el PPB y bajo porcentaje de hablantes de lenguas indígenas
25. Por lo general, las regiones con la mayoría de votos del Partido Político PPB muestran:
- d) Alto porcentaje de hablantes de lenguas indígenas
 - e) Mediano porcentaje de hablantes de lenguas indígenas
 - f) Bajo porcentaje de hablantes de lenguas indígenas

Escriba una respuesta:

26. ¿Cuál es el porcentaje de hablantes de lenguas indígenas en las siguientes ciudades?

Cochabamba _____%

La Paz _____%

Ponga un círculo el índice mejor aceptado en su opinión de estos mapas:

24. Agrado Visual:

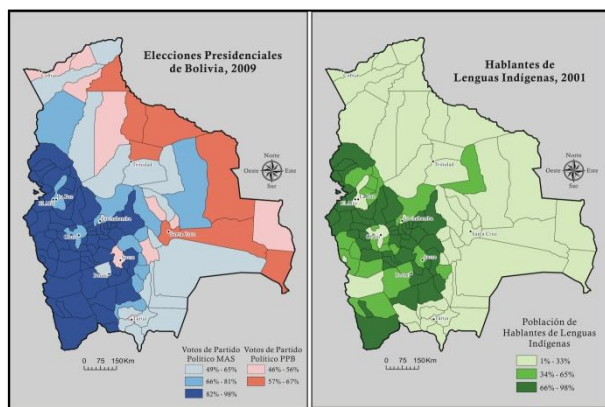
Desagradable 1 2 3 4 5 Agradable

26. Legibilidad:

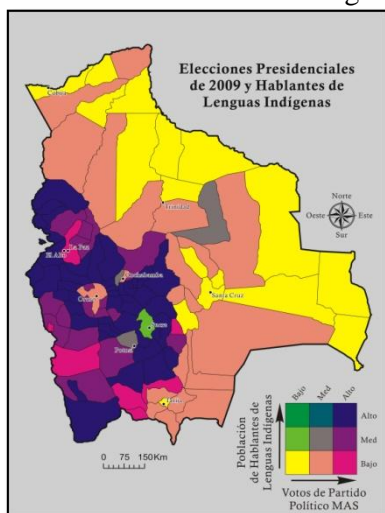
Difícil de interpretar 1 2 3 4 5 Fácil de interpretar

Por Favor, No Vuelva Atrás

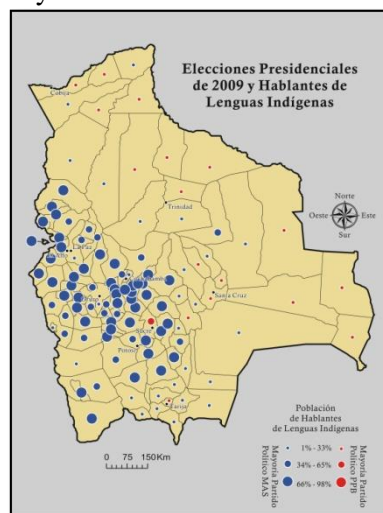
Sección 4: Por Favor, cataloga estos mapas de 1 a 5 (1 los más claros, 2 es su segunda opción, etc.) para indicar su preferencia total en la visión de estos datos. Escriba el número apropiado en el espacio dado. Ahora puede volver atrás a través del libro de los mapas.



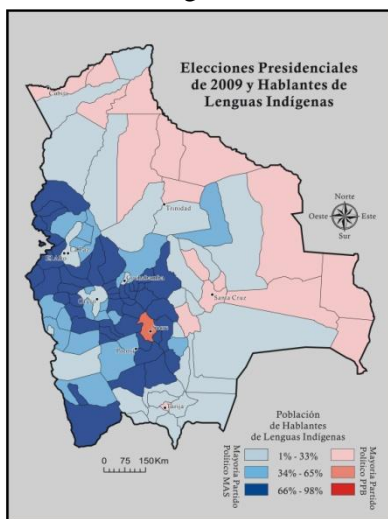
Páginas 6a y 6b



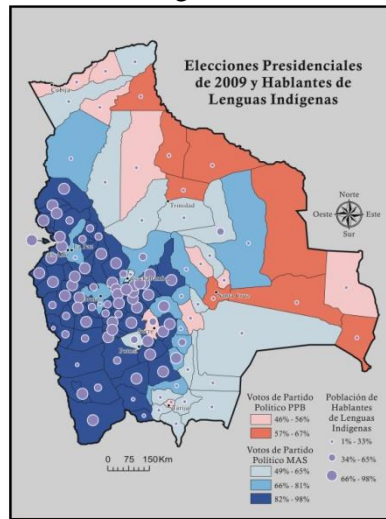
Página 7



Página 8



Página 9



Página 10

Por favor, escriba cualquier comentario adicional de su preferencia de un estilo de mapa representado en esta encuesta:

¡Muchas gracias por su participación!

VITA

Cheryl A. Hagevik was born in Raleigh, North Carolina. She attended Appalachian State University in Boone, North Carolina, where she graduated in December 2005 Magna Cum Laude with a Bachelor of Science degree in Appropriate Technology and a minor in Clothing and Textiles. Continuing her education at this same university, she completed a Master of Arts in Geography, with a concentration in Geographic Information Science and Cartography in August 2011. In addition she has studied fiber manipulation and weaving at Penland School of Crafts in North Carolina.

She has received awards including the North Carolina Arc Users Group Outstanding 2010 Student Research Award and the Conference of Latin Americanist Geographers 2011 Field Study Award. She is a member of Gamma Theta Upsilon International Honor Society in Geography. Her research interests include cartography and visualization as it relates to problem-solving applications. She is especially interested in Latin American cultural issues and hopes to continue field work in South America. Her interests also include land preservation in the creation and protection of public parks. In the future, she hopes to continue to contribute to the conservation of endangered cultural and natural landscapes throughout the world.