An Interdisciplinary Exploration of the Intersection between Economic Value and Ecological Quality to Inform Palouse Prairie Conservation

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by

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Authorization to Submit Dissertation

This dissertation of Kevin A. Decker, submitted for the degree of Doctorate of Philosophy with a Major in Environmental Science and titled "An Interdisciplinary Exploration of the Intersection between Economic Value and Ecological Quality to Inform Palouse Prairie Conservation," has been reviewed in final form. Permission, as indicated by the signatures and dates given below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

The Palouse Prairie is a critically endangered ecosystem located in northern Idaho and eastern Washington. Its successful conservation will require an understanding of its ecological functioning to determine how best to restore function to degraded sites and the social value for conservation to understand the region's priorities and preferences. This dissertation explores the nuances of calculating the economic value of ecological quality in six chapters. The first chapter provides a brief history of the Palouse Prairie and provides context for how it has arrived at its current degraded state. The second chapter assesses the positive and negative effects of alternative methods for presenting ecological quality to respondents within a choice experiment survey; it evaluates the significance of sociodemographic variables on whether residents choose to conserve or not conserve Palouse Prairie, and it compares the relative importance of the attributes on Palouse Prairie conservation. Economic value for Palouse Prairie conservation was determined based on a choice experiment that includes the attributes of size, ecological quality, the giant Palouse earthworm, rare plants, public access, and cost. The third chapter evaluates the interaction between sense of place and economic value. It considers perspectives on whether or not it is appropriate to use a monetary value to inform conservation decisions and it evaluates the importance, qualitatively, of the Palouse Prairie to residents and their families. The fourth chapter uses economic values from the choice experiment and generates a composite measure of ecological quality using factor analysis to assign an indirect willingness to pay for individual measures of ecological quality. The fifth chapter evaluates the importance of culturally significant plants on the Palouse Prairie through an alternative valuation methodology based on semi-structured interviews and a general population survey which focuses on the perspectives of both Indigenous and non-Indigenous populations. The final chapter summarizes the significance of the work and provides an overview of how the results can be integrated into policy. An Interdisciplinary approach was central to the development, analysis, and interpretation of this research.

Acknowledgements

I wish to express sincere gratitude to those who have helped me along my journey. Dr. Philip Watson has provided guidance, support, knowledge, understanding, collegiality, and friendship, all of which has been instrumental in the completion of this research. I would like to thank Dr. Kelly Jones, Dr. Sanford D. Eigenbrode, and Dr. Tim Prather, who have provided substantial advice, encouragement and perspective along the way.

I would also like to thank my interdisciplinary team, Paul Rhoades, Chris Baugher, and Cleve Davis, who brought their disciplinary expertise and provided insight to the research, which contributed significantly to its development and completion.

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Dedication

"Sometimes our light goes out but is blown into flame by another human being. Each of us owes deepest thanks to those who have rekindled this light." – Albert Schweitzer

I dedicate this dissertation to my wife Megan who has been extremely understanding and supportive. Thank you for blowing my light into flame and preventing it from flickering out. Love always and forever, thinking of you always.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

The Palouse Prairie is a critically endangered ecosystem with less than 1% of the original prairie ecosystem remaining (Black et al., 1998; Donovan et al., 2009; Hanson, Sánchez-de León, Johnson-Maynard, & Brunsfeld, 2008; Noss, LaRoe, & Scott, 1995). Over time, the native prairie has been converted to agriculture and exurban development. Planning for the conservation of this unique landscape requires taking into consideration both the human values for conservation and the ecological resilience of the prairie. Including both perspectives has been shown to generate more effective solutions from organizational policy makers and increases adoption by private landowners (Bodin, Crona, Thyresson, Golz, & Tengö, 2014; Oldekop, Holmes, Harris, & Evans, 2015; Rissman & Sayre, 2012). Incorporating both social and ecological dimensions into the decision-making process requires an interdisciplinary approach.

The primary objective of this research is to utilize an interdisciplinary approach to integrate human value and ecological resilience, which for purposes of this research, is evaluated through the lens of ecological quality, to inform policy on conservation of the Palouse Prairie. Four separate studies were conducted to address this primary objective. The first study calculates the marginal effects of changes in characteristics of the Palouse Prairie to residents' willingness to pay for its conservation. These attributes include the size of a prairie site, its ecological quality, the presence or absence of the giant Palouse earthworm or rare plants, and whether there is public access to the site. Special emphasis is placed on evaluating ecological quality due to its complexity and inconsistent method of presentation within survey instruments. The second study seeks to combine two separate measures of human value, economic value and sense of place to identify similarities and departures from congruence. The third study demonstrates an interdisciplinary method to integrate measures of ecological quality and economic value. The final study focuses on valuing the importance of culturally significant plants on the Palouse Prairie by focusing on the perspectives of both Indigenous and non-Indigenous populations and using both quantitative and qualitative approaches.

An interdisciplinary approach for this research was embraced from the outset. A team of four Ph.D. students, along with their advisors, worked together to identify research needs, formulate hypotheses, and analyze and interpret the data. Our research addresses a single ecosystem but brings together multiple disciplines to address research questions. This approach necessitated shared learning by taking coursework together, learning about each other's disciplines, and engaging with other interdisciplinary teams working in different ecosystems to compare methods for successful interdisciplinary integration.

Our team worked in the Palouse Prairie. The Palouse Prairie bioregion covers approximately 16,000 square kilometers in west central Idaho, southeastern Washington, and northeastern Oregon and lies between the western edge of the Rocky Mountains and the Columbia River Basin (Black et al., 1998). The term Palouse is believed to have been derived from the French *pelouse*, meaning lawn or greensward, and was first applied to the region by early Jesuit missionaries (Rees, 1918). The region is characterized by a moderate climate and loess soils deposited on plateaus dissected by rivers deeply incised through layers of bedded basalt (Black et al., 1998). The highly productive loess dunes which characterize the region originate from the Pleistocene (Alt & Hyndman, 1989). These loess hills contain soils that are often more than 100 cm (3.28 feet) deep and can exceed 75 meters (246.06 feet) in depth (Busacca, 1989). The depth and fertility of the soils make the region one of the most productive grain-growing areas in the world (K. R. Williams, 1991).

The geographic boundary of the Palouse Prairie is inconsistent and poorly defined. Caldwell (1961) attempted, but was unable to find a consensual geographic boundary. After overlaying the different boundaries proposed by various experts, Caldwell (1961) was able to define a “core area” of the Palouse where the most overlap occurred, shown in Figure 1-1. The majority of this core area is within the borders of Latah County Idaho and Whitman County Washington.

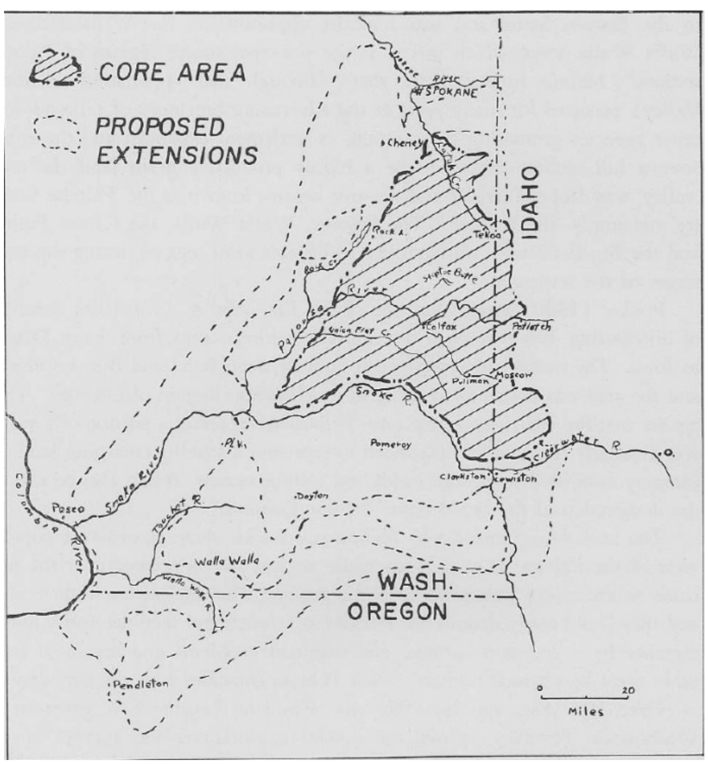

Figure 1-1: Palouse Prairie core area (Caldwell, 1961)

The natural vegetation of the Palouse Prairie was originally dominated by steppe and meadow steppe plant associations (Weddell, 2001). The native grasslands can be categorized into three distinct zones (Daubenmire, 1942; Tisdale, 1961). The more mesic, or wetter, zone occurs on the eastern edge of the prairie boundary and is dominated by Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*) perennial grass species. Climax shrub communities consisting of bluebunch wheatgrass, snowberry (*Symphoricarpos albus*), black hawthorn (*Crataegus douglasii*) and wild rose (*Rosa*) grow on the northern sides of many of the loess hills. Within this zone, moisture is too low to maintain trees except near streams (Lichthardt & Moseley, 1997). The western area of the Palouse Prairie is much more xeric (drier) than the eastern portion but is still dominated by bluebunch wheatgrass (Tisdale, 1961). The third distinctive zone occurs in the Snake River and Clearwater River canyons. These areas are much hotter and drier, and therefore support a more sparse bunchgrass and shrub community (Tisdale, 1986).

Riparian communities are typically restricted to the Palouse and Potlatch Rivers and the broad outwash plains along sections of the Snake and Clearwater Rivers (Black et al., 1998). Within these riparian zones, there is a narrow gallery forest of plains cottonwood (*Populus trichocarpa*), quaking aspen (*Populus tremuloides*), mountain maple (*Acer glabrum* var. *douglasii*), and red alder (*Alnus rubra*). Wetlands are important to the area but are scattered throughout the prairie. Forest communities occupy higher elevation mountains and ridges. On warmer sites, there can be instances of ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*) with an understory dominated by oceanspray (*Holodiscus discolor*), ninebark (*Physocarpus capitatus*), serviceberry (*Amelanchier alnifolia*), snowberry (*Symphoricarpos albus*), and wild rose (*Rosa*). On the cooler north-facing and west-facing canyons, there is western red cedar (*Thuja plicata*), grand fir (*Abies grandis*), and western larch (*Larix occidentalis*) (Black et al., 1998; Daubenmire, 1942; Tisdale, 1986).

The Palouse Prairie region has undergone extensive biophysical and social changes. Black et al. (1998) divide these changes into five distinct time periods: before European-American settlement, European-American settlement (1870 – 1900), horse-powered agriculture (1901 – 1930), industrial agriculture (1931 – 1971), and suburbanization (1972 – present).

The first inhabitants of the Palouse Prairie region were ancestors of the Nez Perce, who probably arrived more than 12,000 years ago (Black et al., 1998; Breckenridge, 1986; Chatters, 2004; Josephy, 1965). Their economy was based on locally harvested wildlife, including salmon, elk, and mule deer, and supplemented by traded goods from the west coast and interior areas (Chalfant & Ray, 1974; Josephy, 1965). In the 1700s, two major events affected the Nez Perce people: European-Americans introduced domesticated horses, and smallpox decimated the indigenous population. The Nez Perce population was between 4,000 and 8,000 in the Northwest until major smallpox epidemics began in the 1780s. By the mid-1830s, their population had diminished to about 2,500 (R. T. Boyd, 1985; Meinig, 1968).

European-American settlement began in the 1860s when prospectors discovered precious metals in streams just east of the forest/prairie interface. By the end of the 1860s, settlers had claimed creek bottom lands around Paradise Valley (which is near present day Moscow, ID), Union Flat Creek, and the upper Palouse River (Black et al., 1998).

The European-American settlement and land-use patterns differed dramatically from Native American practices. Native Americans lived in the river valleys, while European-Americans lived on the prairies. While Native Americans were hunter-gatherers or low-impact agriculturists of native species; the European-Americans were high-impact agriculturists of introduced species (Black et al., 1998). As a result, European-American agriculture resulted in only isolated tracts of the best-developed prairies remaining intact, while hundreds of acres of the drier bunchgrass lands were broken up (Weaver, 1917, p. 3).

Initially, European-Americans used the Palouse hills as pasture, but farmers soon discovered the soil's fertility (Prevost, 1985). Fruit was an important early commercial crop in the Snake River Canyon and other areas in the Palouse. Apples, peaches, prunes, plums, apricots, and pears thrived. However, competition from areas better suited for fruit production and a better return on investment for wheat farming effectively killed the local fruit industry (K. R. Williams, 1991).

Horse-powered agriculture remained the primary method for harvesting into the 1920s. When the Idaho Harvester Company opened in Moscow, ID and began to manufacture a smaller combine machine, it made combine harvesting in the hilly region much more feasible. By 1930, the majority (90%) of Palouse wheat was harvested using combines (K. R. Williams, 1991) which enabled farmers to use land previously left for grazing and as waste. Only the steepest hills and hilltops were left as pasture for cattle and horses (Black et al., 1998).

Between 1931 and 1970, mechanization and industrialization continued and allowed farming to become less labor intensive. By 1970, most farmers used motorized equipment, which removed the need for pasture lands to support horses. Motorized farming equipment could till extremely steep slopes; fertilizers increased production by 200-400 percent, and federal agricultural programs encouraged farmers to drain seasonally wet areas allowing farming in flood plains and seasonally saturated soils. The introduction of industrial agriculture removed the last significant refuge for native communities, leaving less than 1% of the original prairie behind (Black et al., 1998).

Since 1970, migration from town and city residents into more rural areas has caused an increase in population in the region and a change in the composition of the population and land use (Black et al., 1998). Goldberg et al. (2011) looked at patterns of development and showed that the current land use policies and development patterns are extremely detrimental to the ecological quality of the remaining native Palouse Prairie and identified these land use patterns as being the least socially acceptable to residents.

More recently the Palouse Prairie has been threatened by invasive plant species such as downy brome (*Bromus tectorum* L.) and ventenata [*Ventenata dubia* (Leers) Coss.] (Nyamai, Prather, & Wallace, 2011). Remaining parcels of native prairie are subject to weed invasions and occasional drifts of aerially applied agricultural chemicals (Black et al., 1998). Two of the native plant communities are globally rare, and eight local plant species are threatened globally (Lichthardt & Moseley, 1997).

As a consequence of the conversion to agriculture, population encroachment, and invasive species, the Palouse Prairie is currently a critically endangered ecosystem (Noss et al., 1995) with less than 1% of native grasslands remaining (Black et al., 1998). The prairie currently exists as a highly fragmented system within a matrix of production agriculture. Most remnants are less than 2 ha (4.94 acres) and have a high perimeter-area ratio. They are disproportionately found on rocky and shallow soils and predominantly in a few large clusters near rivers and rocky buttes not suitable for agricultural use, and almost all of the remnants are located on private land (Looney & Eigenbrode, 2012). A map of the core area of the Palouse Prairie, along with the location of the remnants is provided in Figure 1-2. It is evident how little native prairie is left and the high degree of fragmentation.

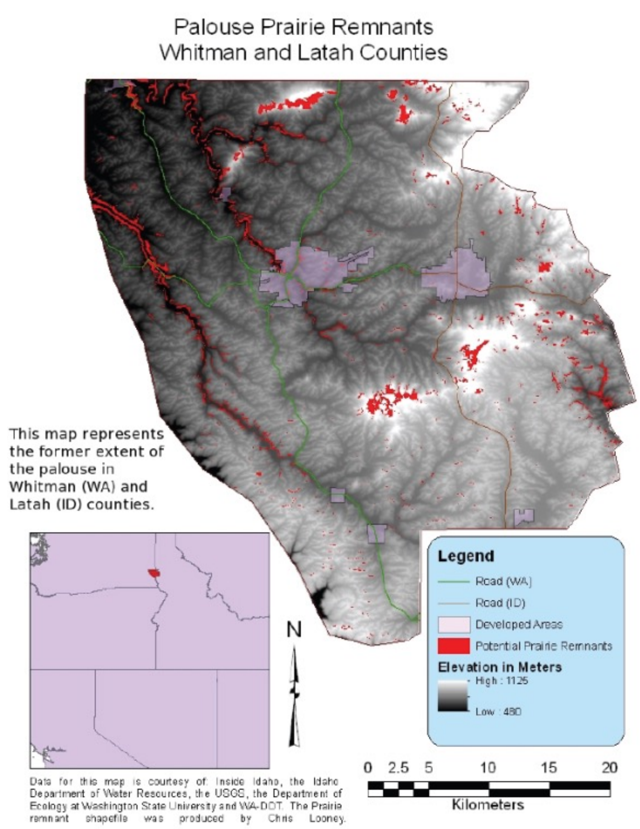

Figure 1-2: Core area of the Palouse Prairie and location of remnants, created by Paul Rhoades, 2012

Because the Palouse Prairie is in such a highly fragmented and degraded state, there is substantial interest in finding ways to conserve what remains, improve its ecological quality, and seek opportunities for expansion. Currently in the Palouse, there are no regional or local policies in place to promote Palouse Prairie conservation. Many in the area believe that such policies are inconsistent with private landowner rights and object to discussing them (Donovan et al., 2009). Policy makers and local nongovernmental organizations (NGOs) have begun to explore protection mechanisms for the remaining native prairie remnants of the Palouse. However, identifying regionally appropriate and acceptable policies that simultaneously maintain prime farmland, protect private landowner rights, provide opportunities for growth, and conserve endangered biological communities has proven difficult (Donovan et al., 2009). There are currently no species in the Palouse Prairie listed for protection under the Endangered Species Act. The giant Palouse earthworm (*Driloleirus americanus*) was previously described as being abundant in the Palouse region close to Pullman, Washington (F. Smith, 1897). However, it was not sighted between 1990 and 2008 (Sánchez-de León & Johnson-Maynard, 2009), leading to speculation that it was extinct. A common concern that producers (private land owners) and conservationists share is the control of invasive weeds as a threat to production and prairie species (Donovan et al., 2009). Conservation of the Palouse Prairie will require an active program, led by NGOs that are actively engaging their constituents and local stakeholder groups. To do so effectively requires knowledge of priorities, value, and ecological functioning of the Palouse Prairie ecosystem.

A survey was created and distributed in July of 2013 to gather information about WTP for conservation, the qualitative value for the Palouse prairie, the value for culturally significant plants, the appropriateness of using a monetary amount to inform conservation decisions, and to assess sense of place. A copy of the survey and theoretical framework underlying the survey are provided in the appendix. A choice experiment (CE) was used in the survey to elicit WTP. A CE is a method for modeling preferences for goods, where goods are described in terms of their attributes and of the levels these take. People are presented with various alternative descriptions of a good, differentiated by their attributes and levels, and are asked to choose their most preferred alternative. By including a price or cost as one of the attributes WTP can be indirectly recovered (King & Mazzota, 2000). A CE measures all forms of value including nonuse values.

The decision problem of interest for this study is the WTP for the conservation of the Palouse Prairie. Conservation of the prairie system is an ongoing management problem and therefore has no temporal termination point. WTP was evaluated per household per year. The attributes and levels are provided in Table 1-1.

Attribute	**Level**				
Size	< 1 acre	1 – 5 acres	>5 acres		
Ecological Quality	Low	Medium	High		
Giant Palouse Earthworm	Not Present	Present			
Rare Plants	Not Present	Present			
Public Access	Yes	No			
Cost/hh/year	$5	$25	$50	$100	$150

Table 1-1: Attributes and levels presented to respondents in choice experiment survey on Palouse Prairie Conservation.

The attributes were determined based on interviews with stakeholders in the area, from field visits, and from a review of the literature. The size attribute was determined based on the range of sizes of the prairie remnants that are typically found in the region. Ecological quality was divided into a qualitative assessment of low, medium, or high for ease of understanding by participants. A short description of ecological quality was provided to respondents to aid in their understanding of the terms in the survey. Biodiversity and species richness (number of species) is commonly used as a proxy for ecological quality in WTP studies of conservation because it can be measured easily and it is an attribute that people typically understand. Many studies use biodiversity as an attribute in choice experiments (e.g. Carlsson et al. (2003), Birol et al. (2006), and Chan-Halbrendt et al. (2007)), but biodiversity alone does not necessarily completely characterize ecological quality. Biodiversity, as defined by the Convention on Biological Diversity, is "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems." This definition fails to incorporate ecosystem function, which is important for resilience. It also fails to consider other components of ecological quality such as abiotic soil characteristics, species abundance and evenness, keystone species, and so on. We anticipate that the ecological quality attribute will encompass more of what people value within an ecosystem and will, therefore, better capture a person's WTP.

People tend to have a high WTP for charismatic species, leading to a higher likelihood of conservation of the charismatic species habitat. The closest thing to a charismatic species in the Palouse Prairie is the giant Palouse earthworm. Charismatic species are generally thought to be large vertebrates which appeal to humans and are focused on to gain support for conservation campaigns (Richardson & Loomis, 2009). The giant Palouse earthworm is the only animal species that is known to inhabit prairie remnants, and that is not typically found outside the region. People may have a positive WTP for the earthworm if they value it as a rare species that is unique to the area, and in need of protection. People may have a neutral or negative WTP if they feel that the worm is not important, or has the potential for being listed under the Endangered Species Act (ESA). If so listed, federal protection of its habitat would be implemented, and landowners would lose the ability to choose how to use their land if it is a potential habitat for the earthworm. The earthworm is being considered separately from ecological quality in this study because, given its scarcity, its presence or absence does not necessarily indicate remnants of higher or lower ecological quality. In addition, stakeholders have consistently mentioned the giant Palouse earthworm as being of great importance, indicating that a direct measure of value would be beneficial to them.

The remaining Palouse Prairie grassland supports six plant species of high conservation concern. These species include: Spaulding’s catchfly (*Silene spaldingii* S. Watson) which is a plant species listed as threatened on the endangered species act, Palouse milkvetch (*Astragalus arrectus* A. Gray), broafruit mariposa (*Calochortus nitidus* Douglas), Palouse thistle (*Cirsium brevifolium* Nutt.), Palouse goldenweed (*Pyrrocoma liatriformis* Greene), and Jessica’s aster (*Symphyotrichum jessicae* (Piper) G.L. Nesom). Each of these species is tracked by the Idaho and Washington Natural Heritage Programs and have very limited distribution across their range in the Palouse Prairie ecoregion. Currently, these plant species and remaining native plant communities are at high risk of extinction due to extensive invasion of non-native plant species, especially annual grasses. People may have a positive value and WTP derived from the existence and option values of these plants. People may negatively value and have a negative WTP if they are concerned that the presence of these plants on their land would ultimately lead to protection, limiting their property right. Currently, plants are not considered under the ESA, and the presence of rare plants does not lead to any protective measures.

Public access was added to determine the value people have for remnants that exist on private land and are not accessible to them versus those that are accessible. The majority of all remnants exist on private property, which means that there is no public access. However, a large WTP for public access to native Palouse Prairie could indicate an opportunity for purchase and provision of public access.

Conservation cost was determined after conducting interviews with numerous stakeholders. WTP for stakeholders ranged between $0 and $100. While a smaller range of values is methodologically preferred, this range reflects actual values provided during the pre-survey design phase. An additional level of $150 was created to try to capture a higher level that may have been missed during stakeholder interviews. Levels were determined to represent the entire spectrum of potential values while simultaneously keeping the number of levels to five or less.

Birds were also mentioned by stakeholders during interviews, but using birds as an attribute in the survey presented some difficulties. The Palouse Prairie has relatively low bird species richness. The larger prairie patches, especially those connected with other habitat types, have the highest species richness. Enhancing degraded patches might increase diversity locally but creating larger contiguous patches would be the preferred method of increasing local diversity and (most importantly) populations of some of these species (Personal Communication, Charles Swift, local bird expert). Since the survey is focused on conservation, and not on expansion or restoration, this makes asking about bird richness and abundance difficult to incorporate into the survey. Based on this problem, birds were excluded from the survey.

Distance to a site is a common attribute in many CE surveys related to conservation; however, this attribute was omitted because there are over a thousand Palouse Prairie remnants spread across a large area. Since the survey was distributed to respondents within the core area of the Palouse, it is likely that all respondents would be located near a prairie remnant, although they may not know it.

The choice experiment presents a set of alternatives with the attributes presented at varying levels. A full factorial design would combine every level of each attribute with every level of all other attributes. Each combination of attributes and levels is called a profile. If the survey were to ask respondents to compare every possible combination of levels against each other, the total number of combinations or profiles would be 360 (3 x 3 x 2 x 2 x 2 x 5) and the number of possible pairwise comparisons among these profiles (dichotomous choice) becomes 129,600 (360 x 360). This is impractical, so to reduce the number of possible profiles, we can use a fractional factorial design, which is a sample of attribute levels selected from the full factorial design without losing information to effectively test the effects of attributes on respondent's preferences. Choice-based conjoint (CBC) software from Sawtooth Software Inc. (Sawtooth Software, 2013) was used to generate the designs. A total of 7 different survey versions were generated. Sawtooth recommends that the number of survey versions times the number of choice tasks be greater than or equal to 80 (Sawtooth Software, 2013). We had 12 choice tasks and 7 survey versions $(12\times7 = 84)$. To test the efficiency of the design, Sawtooth provides an advanced efficiency test that estimates the absolute precision of the parameter estimates under aggregate estimation, based on the combined elements of design efficiency and sample size (respondents x tasks). The estimated standard errors are only absolutely correct if the assumption regarding the underlying part-worths and the error in responses are correct. The test takes into account that design efficiency depends on how the concepts are grouped in sets. The test simulates random respondent answers for the questionnaire, for as many respondents as you plan to interview. The test was run to incorporate both main effects and interaction effects. To evaluate the efficiency, the standard errors are evaluated with the following set of guidelines: 1) standard errors within each attribute should be roughly equivalent, 2) standard errors for the effects should be no larger than 0.05, and 3) standard errors for interaction effects should be no larger than 0.10 (Sawtooth Software, 2013). Based on these guidelines and the design, a minimum sample size of 385 was determined.

Orthogonality means that each attribute and level is independent of each other. It can be argued that while the six attributes are not strictly orthogonal, there was no indication during the survey testing that there was an inability by respondents to consider each of the attributes independently. Therefore, attributes are considered to be independent. The most likely concerns about variable overlap are with regard to ecological quality since it is such a broad concept. Size is considered separately from ecological quality because it follows the economic idea that more of a good is preferred to less of a good. The giant Palouse earthworm is considered separate from ecological quality because a high ecological quality remnant might not necessarily have the earthworm, given its rarity. Threatened plants are also considered separate from ecological quality by the same logic. There is no concern that public access overlaps with any other attributes, or that the presence of the earthworm and threatened plants overlap. Cost is separate and is included to estimate WTP. An example of a possible choice task from the survey is provided in Figure 1-3.

	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Present	
Public Access	Yes	No	
Cost/hh/year	$25	$150	
	❑	❑	❑

Figure 1-3: Example of a choice task within the survey demonstrating potential tradeoffs between attributes and asking respondents to choose one of the alternative prairies for conservation.

Based on data collected from the survey and data collected from research sites of the Palouse Prairie, four chapters are provided that utilize an interdisciplinary approach to explore the intersection between economic value and ecological quality to inform Palouse Prairie conservation.

Chapter 2: Ecological quality, economic value, and perceptions of prairie conservation in a critically threatened ecosystem

By Kevin Decker, Philip Watson, Paul Rhoades, Chris Baugher, Cleve Davis, Sanford D. Eigenbrode, Tim Prather, Jodi Johnson-Maynard, Lisette Waits, and Nilsa Bosque-Pérez

2.1 Abstract

This study addresses how ecological quality influences conservation of threatened ecosystems. It details how varying levels of ecological quality affect people's economic value for conservation of the Palouse Prairie ecosystem of northern Idaho and eastern Washington State, USA. Utilizing a choice experiment administered through a survey of 421 residents of that region and analyzed by a nested logit model, it was determined that a Palouse Prairie site with low ecological quality reduces the annual willingness-to-pay for conservation by $53.17, a site with medium ecological quality increases willingness-to-pay by $12.34, and a site with high ecological quality increases willingness-to-pay by $40.83. Survey respondents were asked to rank six characteristics about the prairie in order of importance. The most important characteristic was ecological quality. The other attributes included, in order of importance: the presence of rare plants, the size of the Palouse Prairie site, the cost of conservation, public access to the site, and the presence of the giant Palouse earthworm, a rare native species. Alternatively, ranking results from the choice experiment show the cost of conservation to be the most important attribute and ecological quality the second most important attribute.

2.2 Introduction

Environmental economics can provide information to conservation biologists and policy makers about why species are endangered, the opportunity costs of protection activities, and the economic incentives for conservation (Shogren et al., 1999). Ecological quality contributes to the total willingness-to-pay (WTP) for the conservation of threatened ecosystems. Although understanding ecological quality is essential to ecosystem management, there currently exists no universal definition of what constitutes ecological quality. The lack of a universal definition is a consequence of the complexity and diversity of ecosystems, and the differing goals of stakeholders concerned with ecological quality. It has been described in both abstract and explicit ways from the perspectives of the economy, social opinion and public health (Robert Costanza, Norton, & Haskell, 1992; Rapport, Costanza, & McMichael, 1998; Smyth, Watzin, & Manning, 2007). Costanza et al (1992) define ecosystem health as a system that "maintains its organization and autonomy over time and is resilient to stress." Although theoretically sound, the properties of maintenance and resilience are difficult to observe and measure. More commonly, ecological quality is described more discretely. Presence or absence of certain important species, diversity or species richness of biotic communities and abiotic characteristics have all been used to measure ecological quality (Firbank, Petit, Smart, Blain, & Fuller, 2008; Karr, 1999; Kremen, 1992). However, such measures of ecological quality often fail to correlate with one another (Billeter et al., 2008; Duelli & Obrist, 2003; Firbank et al., 2008; Jeanneret, Schüpbach, & Luka, 2003; Kremen, 1992; Weibull, Östman, & Granqvist, 2003) calling into question their reliability as indicators of ecological quality. This can create disagreement in determining how to define ecological quality within an ecosystem, leading to different strategies for doing so (Hering et al., 2003).

The elusive definition of ecosystem quality complicates attempts to value it economically. Since ecological quality is a nonmarket good, its economic value can be estimated using a stated preference method such as contingent valuation or a choice experiment, where respondents are asked their WTP for the good or service. This approach, however, can be difficult because the surveyed population may not have a clear or consistent understanding of what constitutes ecological quality, and that understanding may not coincide with viable scientific metrics of ecological quality. This study attempts to overcome these problems by eliciting the economic value for ecological quality by presenting it as an attribute within a broader conservation choice.

Three approaches have typically been used to make WTP estimates for ecological quality: using biodiversity as a proxy variable for quality, utilizing an index of quality or “biotic integrity,” and using categories of quality. The most common approach is to use biodiversity as a proxy variable since species and their habitat are interwoven such that it seems impossible to preserve species within an ecosystem without directly protecting that ecosystem, and measuring biodiversity as an ecological metric is very straightforward. Often, these approaches can be combined. A study conducted to value wetlands by Carlsson, Frykblom, & Liljenstolpe (2003) combined using biodiversity as an attribute and represented biodiversity as the number of rare species that could be found in the wetland with categorical levels of “none,” “few,” or “many.” According to Carlsson, Frykblom, and

Liljenstolpe (2003), these categories were chosen due to difficulty with explaining the complexity of biodiversity in a meaningful and understandable way. In a study to compare flood risk reduction versus habitat conservation (Birol, Phoebe, & Yiannis, 2008), biodiversity was used as an attribute with levels of “high” and “low.” Biodiversity was defined as “the number of different species of plants and animals, their population levels, number of different habitats and their size in the river ecosystem in the next 10 years.” However, no specific values for the number of species, population levels, or a number for habitats or size were provided. Biodiversity can also be presented quantitatively, as the number of species gained or lost due to a policy or program. A study of a control program for *Miconia calvescens* (an invasive plant in Hawaii) used the loss of biodiversity due to invasion as a categorical attribute with levels of 10 native species lost, 45 native species lost, and 100 native species lost (Chan-Halbrendt et al., 2007).

The dependence on biodiversity as a metric for quality is problematic because it is not an ecological endpoint (J. Boyd & Krupnick, 2009). Ecological endpoints, they argue, are biophysical inputs that directly enter the production or utility function. Direct inputs must be experienced, have tangible meaning, and be subject to choice. Biodiversity does not meet these standards because it is an intermediate commodity with value as a leading indicator of system conditions and not an endpoint (J. Boyd & Krupnick, 2009). System condition, or ecological quality, is the terminal endpoint. Biodiversity can serve as a signal of ecological quality, but consumers cannot be expected to understand how biodiversity measures translate into subsequent endpoints they can value (J. Boyd & Krupnick, 2009).

Biodiversity is measured multiple ways, but typically includes species richness (the number of species) and evenness (relative frequency). For valuation studies on conservation, biodiversity has been the predominant proxy for ecological quality (Christie et al., 2006). This measure has the problem of omitting the evenness elements of biodiversity. The importance of evenness for ecosystem functioning, however, is being more widely recognized (Crowder, Northfield, Strand, & Snyder, 2010). A recent WTP study on grassland restoration found that species richness, evenness, and endangered species are all statistically significant attributes individually and suggests that all three measures of biodiversity should be considered in a WTP study (Dissanayake & Ando, 2014). Many studies have found that members of the general public have both a low awareness and a poor understanding of the term biodiversity. Thus communicating relevant information within a stated preference study about biodiversity is difficult. Furthermore, if one is unaware of the characteristics of biodiversity, then it is unlikely that one has well-developed preferences for it which can be uncovered in a stated preference survey (Christie et al., 2006). A study on Danish heath by Jacobson et al. (2008) found that preserving one iconized species is almost as valuable as preserving twenty-five species. With all of these concerns, it becomes apparent that biodiversity is an imperfect measure of ecological quality.

The second widely used approach to representing ecological quality is to use an “index of biotic integrity” (IBI) or similar index that measures the overall ecological health of the system (Karr, 1981). Biological integrity is “the capability of supporting and maintaining a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organization comparable to that of natural habitats in the region”

(Karr & Dudley, 1981). IBIs are developed from data collected across a specified anthropogenic disturbance gradient where undisturbed sites serve as references for high biological integrity, they use patterns of change from the reference conditions to develop and select metrics, and they combine information from multiple metrics into a single value (Karr & Chu, 1998). The IBI is widely used to monitor streams and rivers in the USA, Canada, and Europe by tracking the IBI over time (Pont et al., 2006), but only more recently for terrestrial ecosystems (Diffendorfer et al., 2007). An example of a study that uses an IBI within a choice experiment to determine WTP is on the restoration of migratory fish in a Rhode Island watershed (Johnston, Segerson, Schultz, Besedin, & Ramachandran, 2011). They used an “aquatic ecological condition score” based from the IBI. Levels of the condition score represent a percentage of an undisturbed and natural watershed. The IBI components include overall fish abundance, the number of mussel species, the number of native fish species, the number of sensitive fish species, the number of feeding types in fishes, the percentage of individual fish that are native, the percentage of individual fish that are migratory, and the percentage of individual fish that are tumor free. The levels are presented as a percentage of the reference condition, ranging from 0 –100% (Johnston et al., 2011). Utilizing an IBI attempts to remove ambiguity and increase content validity and under ideal circumstances is more successful than using biodiversity or qualitative descriptors for achieving those goals (Johnston, Schultz, Segerson, Besedin, & Ramachandran, 2012). However, the undisturbed reference condition is often not available, disagreement can occur on how to best weight individual components of quality to transform them into a single index, and policy goals may influence the development of the

IBI. These elements are often obscured by the use of a single measure (Johnston et al., 2011).

The third common approach is to present levels categorically and to describe the levels qualitatively. For example, Hanley, Adamowicz, & Wright (2005) evaluated the effects of changing the price vector in the context of water quality improvements, and used two levels of the attribute “ecology:” “fair” and “good.” “Fair” is described as “only course fish; a poor range of water plants, insects and birds.” “Good” is described as “salmon, trout, and course fish; a wide range of water plants, insects and birds.” “Fair” was characterized as representative of current conditions, and “good” as aspirational under the European Water Framework Directive (Hanley et al., 2005). McGonagle and Swallow (2005) used the ecological quality attribute levels of “unique” and “not unique” in their study of coastal land conservation. The specifications for assigning these levels were not provided to survey respondents in the study, however, which may have introduced error or increased variability among responses.

The method chosen for this study on Palouse Prairie conservation utilizes the third approach. It presents ecological quality categorically, and the survey instrument design describes ecological quality simply while providing policy-relevant data. This method was chosen in order to represent a comprehensive concept of ecological quality instead of only a single element, such as in biodiversity, without adding too much complexity for the respondent. An IBI was not used for three reasons. First, there was no pristine reference site that could be used for calculating the IBI. Second, the heterogeneity within the system would have required multiple IBIs even if pristine reference sites were available. And third, it was important to include abiotic variables including both soil and landscape characteristics within the study.

The Palouse Prairie is a bunch grass prairie located in west central Idaho, southeastern Washington, and northeastern Oregon and lies between the western edge of the Rocky Mountains and the Columbia River Basin (Black et al., 1998). Figure 2-1 shows the core area of the Palouse Prairie region. The loess soils are often more than 100 cm (3.28 feet) deep, and the fertility of the soils makes the region one of the most productive grain growing areas in the world (K. R. Williams, 1991). Over the years, the Palouse Prairie has been converted primarily to agriculture and continues to be threatened by population encroachment and invasive species. It is considered a critically threatened ecosystem (Noss et al., 1995) and has less than 1% of the native prairie remaining (Black et al., 1998). The remaining prairie exists as a highly fragmented ecosystem embedded within a matrix of production agriculture. Most remnants are less than 2 hectares (4.94 acres) and have a high perimeter-area ratio. They are disproportionately found on rocky and shallow soils and predominantly in a few large clusters near rivers and rocky buttes that are not suitable for agriculture. Almost all remnants are located on private land (Looney & Eigenbrode, 2012).

There is considerable interest in conserving what remains of the native Palouse Prairie and improving its ecological quality (Donovan et al., 2009). Nongovernmental organizations and private landowners are the primary stakeholder groups actively engaged in conservation efforts. Understanding the region’s economic value for conservation and value of the primary characteristics about the Palouse Prairie can assist with those efforts and make a WTP framework appropriate and necessary.

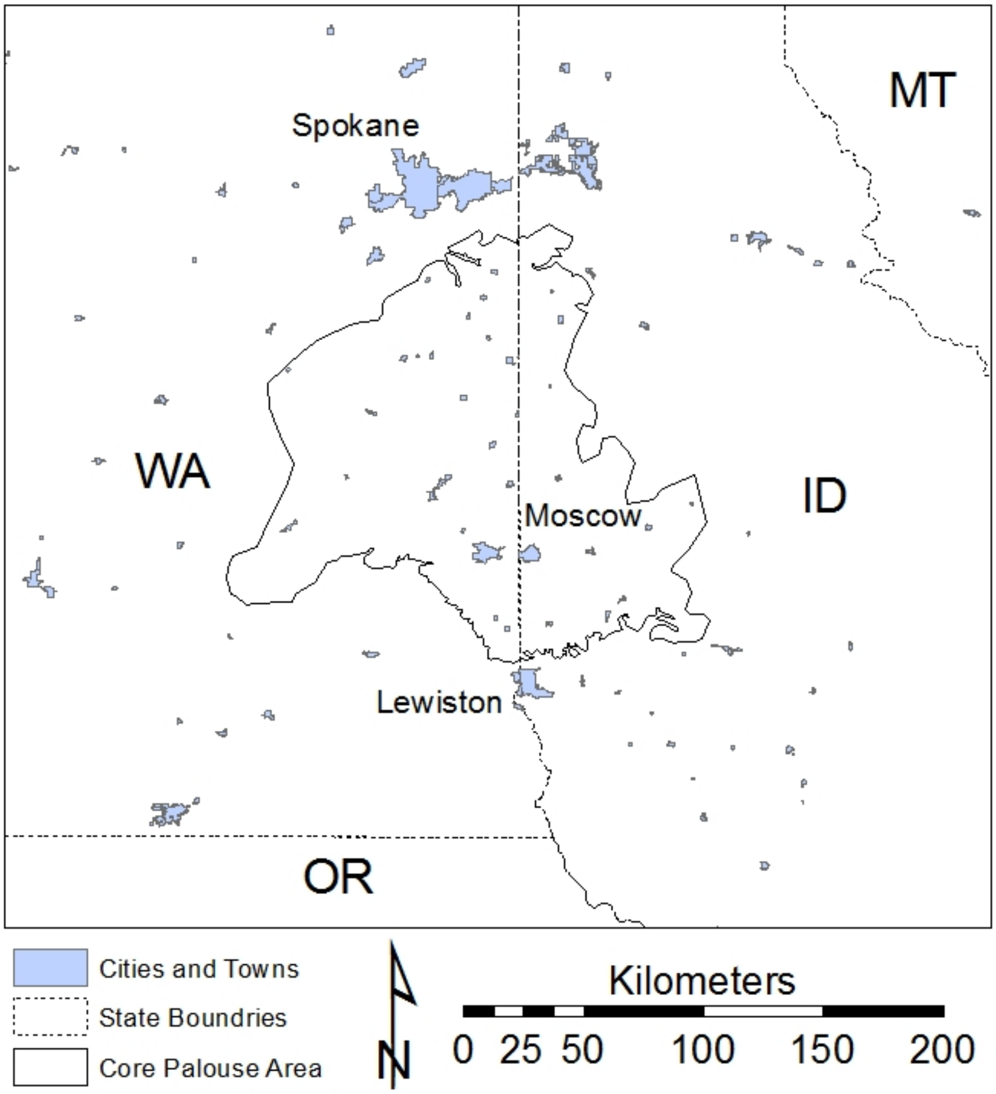

Figure 2-1: Map of Palouse Prairie, created by Paul Rhoades. Data for this map are courtesy of The Montana State Library of Geographic Information, The Washington State Geospatial Clearing House, and Inside Idaho.

2.3 Methods

Data were collected using a modified Dillman method (Dillman, Smyth, & Christian, 2009), utilizing both internet and mail survey options. The mixed-mode study included web and mail components. An address-based sample of 1600 residents in the Palouse area was purchased from Survey Sampling Intl. (Shelton, Connecticut, U.S.A.). A sample of 1300 households was drawn proportionate to population in Latah County, Idaho, and Whitman County, WA. Samples of 100 households were drawn from the Idaho cities of Plummer, Worley, and Lapwai (300 total) in an attempt to increase the response from 'hard to reach' populations on the Palouse, such as ethnic minorities and those in lower socio-economic statuses. A total of 421 surveys were completed with 241 completed online and 180 completed a paper survey.

The demographics of the sample did have some notable differences from the population. When the sample was compared to demographic information from the American Community Survey (ACS), respondents tended to be older, more highly educated, and have higher incomes. These results are because the survey was conducted in May – July when most of the large university student populations from the University of Idaho and Washington State University were absent. This caused proportionate oversampling in most of the other age categories relative to the ACS data. As a consequence, the sample represents permanent residents of the region instead of the more transient student population.

A fractional factorial design was generated using Choice-Based Conjoint (CBC) software from Sawtooth Software Inc. (SSI) (Sawtooth Software, 2013). SSI provides an advanced efficiency test that estimates the parameters based on randomly generated data, expected number of responses and number of choice tasks provided to each respondent. To evaluate design efficiency, standard errors from randomly generated data are evaluated and are expected to be roughly equivalent, no larger than 0.05 for main effects, and no larger than 0.10 for interaction effects (Sawtooth Software, 2013).

Each respondent was provided with a survey that briefly described the Palouse Prairie ecosystem, with emphasis given to descriptions of the attributes. A total of 7 designs, each with 12 choice tasks, were generated for the fractional factorial design. Each choice task contained 6 attributes including size, ecological quality, the giant Palouse earthworm, threatened plants, public access, and conservation cost. Ecological quality was given three categorical levels of low, medium, and high.

Low ecological quality was defined as “a site where soils have been heavily degraded or disturbed. It is isolated from other prairie sites. It is heavily invaded by non-native species. It has very few total species. Of all the species present, some occur frequently and others occur infrequently.” Medium ecological quality was defined as “a site where soils have some degradation or disturbance. It is moderately isolated from other prairie sites. It has been invaded by non-native species but still supports native species. Of all the species present, some species occur more frequently than others.” High ecological quality was defined as “a site where soils have limited or no degradation or disturbance. It is near other prairie sites. It has very few invasive species. It has many native species. All species present occur with about the same frequency.”

A pilot version of the survey provided definitions that were more descriptive about what was included within ecological quality in an attempt to emphasize the ecological concepts and increase content validity. Feedback provided during the pre-test phase of the survey design indicated that providing information in this much detail was unnecessary and overly complex. Numerous respondents saw the background page and immediately skipped it because it looked too daunting. Similar results were reported by Schiller et al (2001) which noted that asking respondents to consider all indicators creates an excessive burden on them. Respondents did not want or need descriptions of what indicators measure. Respondents instead preferred to be presented with types of information that the indicators could provide about the environment. As a consequence, there is a mismatch between the detailed ecological indicators the researchers want to present and the more general environmental characteristics about which respondents are most comfortable thinking.

The analysis was completed using a nested logit model. A choice experiment is based on a random utility maximization (RUM) model, where the choice of an alternative represents a discrete choice from a set of alternatives (McFadden, 1974). Each alternative is represented with a utility function U_i for profile i that contains a deterministic component (V), which is a function of X_i, a vector of attributes associated with profile i; p_i, which is the cost of profile i; and β, which is a vector of preference parameters; and ε_i, which is a stochastic component. The RUM model can be represented by:

Equation 2-1

$$\boldsymbol{U_i = V(X_i, p_i, \beta) + \varepsilon_i}$$

It is assumed that utility is linear in parameters:

Equation 2-2

$$\boldsymbol{U_i = \sum_{k=1}^{1} \beta_k X_{ik} + \beta_p p_i + \varepsilon_i}$$

where β_k is the preference parameter associated with attribute k, X_{ik} is attribute k in profile i and β_p is the parameter on profile cost.

An individual will choose alternative i if $U_i > U_j$ for all $i \neq j$. However, since there is a stochastic component, you can only describe the probability of choosing alternative i, specified as:

Equation 2-3

$$\boldsymbol{P(i|C) = P\left(U_i > U_j\right) = P(V_i + \varepsilon_i > V_j + \varepsilon_j);\ \forall\, j \in C}$$

where C is the set of all possible alternatives. This can be rearranged to show that choices are made based on utility differences across alternatives:

Equation 2-4

$$\boldsymbol{P(i|C) = P\left(V_i - V_j > \varepsilon_j - \varepsilon_i\right);\ \forall\, j \in C}$$

Given 3 discrete choices with 5 attributes and an additional cost attribute, indirect utility (V_i), can be represented by the following set of equations:

Equation 2-5

$$\boldsymbol{\begin{cases} V_1 = \alpha_1 + \beta_1 X_{11} + \beta_2 X_{12} + \beta_3 X_{13} + \beta_4 X_{14} + \beta_5 X_{15} + \beta_p P_1 \\ V_2 = \alpha_2 + \beta_1 X_{21} + \beta_2 X_{22} + \beta_3 X_{23} + \beta_4 X_{24} + \beta_5 X_{25} + \beta_p P_2 \\ V_3 = \alpha_3 + \beta_1 X_{31} + \beta_2 X_{32} + \beta_3 X_{33} + \beta_4 X_{34} + \beta_5 X_{35} + \beta_p P_3 \end{cases}}$$

To evaluate the probability of choosing alternative i, for estimation purposes, the values need to be transformed so they take on a real value that is restricted to the unit interval and can be interpreted as a probability. The multinomial logit model is obtained by applying the transformation to the V_i terms:

Equation 2-6

$$\begin{cases} \boldsymbol{P(1)} = \dfrac{\boldsymbol{e^{V_1}}}{\boldsymbol{e^{V_1} + e^{V_2} + e^{V_3}}} \\ \boldsymbol{P(2)} = \dfrac{\boldsymbol{e^{V_2}}}{\boldsymbol{e^{V_1} + e^{V_2} + e^{V_3}}} \\ \boldsymbol{P(3)} = \dfrac{\boldsymbol{e^{V_3}}}{\boldsymbol{e^{V_1} + e^{V_2} + e^{V_3}}} \end{cases}$$

More generally, the choice probability can be written as:

Equation 2-7

$$\boldsymbol{P(i|C)} = \frac{\mathbf{exp}\,(\boldsymbol{V_i})}{\sum_{j \in C} \mathbf{exp}(\boldsymbol{V_j})}$$

The part-worth marginal value of a single attribute can then be represented as:

Equation 2-8

$$\boldsymbol{WTP_k = -\beta_k/\beta_p}$$

The nested logit model is effective at reducing the negative effects of the independence of irrelevant alternatives (IIA) assumption. In this case, a respondent may first choose between conserving and not conserving. If the individual chooses to conserve then they must choose between Prairie A and Prairie B. This imposes a hierarchy, which is presented in Figure 2-2.

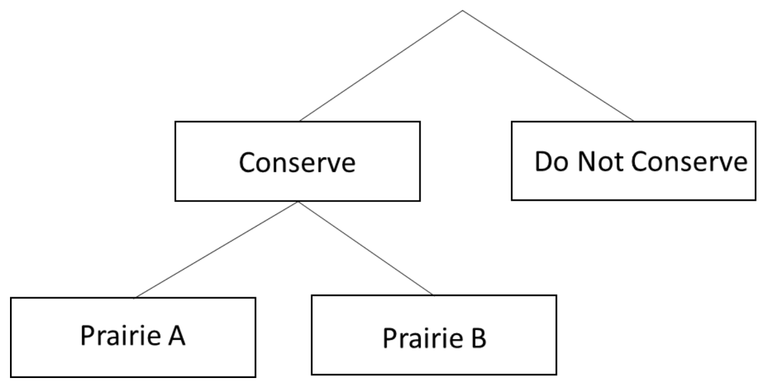

Figure 2-2: Hierarchical structure of choice for Palouse Prairie conservation.

The nested logit model is consistent with random utility theory (Amemiya, 1985), and ultimately resulted in the best fitting model.

The utility of choosing site j in activity m (conserving) can be expressed as:

Equation 2-9

$$\boldsymbol{U_{jm} = U_{j|m} + U_m = V_{j|m} + V_m + e_{j|m} + e_m}$$

Assuming independence between the two error terms, one can show that the joint probability of choosing alternative jm is

Equation 2-10

$$\boldsymbol{P(jm) = \frac{\exp a_m(V_m + V_{m*})}{\sum_{m'=1}^{M}[\exp a_m(V_{m'} + V_{m'*})]} \times \frac{\exp(V_{j|m})}{\sum_{j'=1}^{J}[\exp(V_{j'|m})]}}$$

where V_{m*} is $\left(\frac{1}{a_m}\right)\log\sum\exp(V_{j|m})$ or the “inclusive value” and a_m is the parameter on the inclusive value. The inclusive value term captures the utilities (the expected value of the maximum utility) of the conservation alternatives within the utility associated with the activity conserve. If $a_m = 1$, then the expression collapses to the simple logit expression. An inclusive value parameter of 1 corresponds to equal correlation between the alternatives and an inclusive value between zero and 1 indicates the degree of correlation or similarity between alternatives within a particular activity.

This can also be expressed as the product of probabilities. The probability of choosing alternative j and activity m can be expressed as the probability of choosing alternative j, conditional on choosing activity m, times the probability of choosing activity m.

Equation 2-11

$$\boldsymbol{P(j,m) = P(m) \times P(j|m)}$$

Specifically,

Equation 2-12

$$\boldsymbol{P(Prairie\ A) = P\ (Conserve) \times P(Prairie\ A|Conserve)}$$

$$\boldsymbol{P(Prairie\ B) = P(Conserve) \times P(Prairie\ B|Conserve)}$$

2.4 Results

The results of the nested logit model are provided in Table 2-1. All attributes included in the model are provided for reference. These variables are not part of the ecological quality metric but are the other attributes that comprise WTP for Palouse Prairie conservation. Ecological quality is just one of the multiple attributes that measure overall WTP. All of the attributes are of the expected sign. Mean WTP for low ecological quality is −$53.17, medium ecological quality is $12.34, and high ecological quality is $40.83. Omitted variables were calculated as the negative sum of the non-omitted levels, which was made possible through the use of effects coding. All attributes are significant at $\alpha = 0.01$, except medium size sites, which is significant at $\alpha = 0.1$. WTP for each attribute is provided in Table 2-2.

Table 2-1: Nested logit model coefficients for each level of the attributes of Palouse Prairie conservation, standard error, and z-value, *omitted variable

Attribute	Coef.	Std Err.	z-value
Small Size (< 1 acre)	−0.2895	0.0398	−7.27
Medium Size (1 - 5 acres)	0.0560	0.0319	1.75
Large Size (> 5 acres)*	0.2335		
Low Ecological Quality	−0.4472	0.0431	−10.37
Medium Ecological Quality	0.1038	0.0323	3.21
High Ecological Quality*	0.3434		
Earthworm Present	0.1832	0.0250	−7.34
Threatened Plants Present	0.3280	0.0330	−9.95
Public Access	0.2437	0.0268	−9.10
Cost	−0.0084	0.0008	−10.58

Table 2-2: WTP for each level of the attributes of Palouse Prairie conservation, lower limits, and upper limits, *omitted variable

Attribute	WTP	Lower Limit	Upper Limit
Small Size (< 1 acre)	−$34.42	−$43.09	−$25.75
Medium Size (1 - 5 acres)	$6.66	−$0.73	$14.05
Large Size (> 5 acres)*	$27.77		
Low Ecological Quality	−$53.17	−$62.56	−$43.78
Medium Ecological Quality	$12.34	$5.05	$19.63
High Ecological Quality*	$40.83		
Earthworm Present	$21.79	$16.55	$27.03
Threatened Plants Present	$38.99	$33.05	$44.94
Public Access	$28.98	$23.49	$34.47

Since the nested logit model was used, comparisons can be made about those respondents that chose to conserve and those respondents that chose not to conserve. Statistically significant socio-demographic variables and their effect on choosing to conserve Palouse Prairie are provided in Table 2-3.

Table 2-3: Log odds and odds ratio of significant socio-demographic variables of Palouse Prairie conservation from a Nested logit model

Attribute	Log Odds	Odds Ratio
Age	−0.0090	0.9910
Male	−0.3832	0.6817
African American/Black	−0.6127	0.5419
Asian/Pacific Islander	−0.4197	0.6572
Hispanic/Latino	1.3794	3.9726
Native American/American Indian	0.6300	1.8775
Residency	−0.0043	0.9957
Own Prairie	0.0750	1.0779
Education	0.4044	1.4983
Income	−0.1027	0.9024
Political	−0.1545	0.8569

The probability of choosing to conserve Palouse Prairie increases for Hispanic/Latinos, Native American/American Indians, prairie owners, and as education increases. The probability of choosing to conserve Palouse Prairie decreases as you get older, if you are male, African American/Black, Asian/Pacific Islander, as residency increases, as income increases, and as people become more politically conservative.

Additionally, respondents were asked to rank the 6 attributes from most important to least important. The frequency distribution for the ranking of ecological quality and the associated mean WTP is provided in Table 2-4. There is a strong correlation between mean WTP and ranking of ecological quality, with a coefficient of correlation of 0.983.

Table 2-4: Mean WTP for ecological quality at each level of ranked importance

Ecological Quality Rank	Mean WTP	Observations
1 – Most Important	$69.86	129
2	$48.60	70
3	$50.77	60
4	$39.56	63
5	$22.17	30
6 – Least Important	$11.36	11

An ordinal logistic regression indicates that there are two demographic characteristics that significantly influence how respondents ranked ecological quality. As a person becomes more conservative, ecological quality becomes less important, and as education increases ecological quality becomes more important. Residents were also asked how valuable culturally significant plants were, with 1 being not valuable at all and 5 being extremely valuable. Residents that ranked culturally significant plants as being more valuable to them also tended to rank ecological quality as being more important. The coefficients presented in Table 2-5 can be counterintuitive because the rank value increases as ecological quality becomes less important (1 = most important, 6 = least important).

Table 2-5: Significant socio-demographic variables for ranking of ecological quality

Variable	Coefficient	P > |z|
Political Affiliation	0.1623	0.010
Education	−0.1627	0.021
Cultural Plants	−0.2753	0.001

2.5 Discussion

The concept of ecological quality in economic analysis is difficult from both a theoretical and empirical standpoint. From a theoretical perspective, difficulties arise from potentially ambiguous definitions of ecological quality across different ecosystems and different ecological perspectives. These difficulties presents empirical questions as to which metrics are important to include in a measure of ecological quality and, just as important, which metrics are not included. There have been very few studies that attempt to capture the economic value of ecological quality, and even fewer that attempt to do so in a terrestrial environment where there is much greater heterogeneity than in an aquatic environment. The three most common methods are to utilize a proxy variable such as biodiversity, employ an index such as the index of biotic integrity, or to use categorical variables with a qualitative description. While it is arguably the most ubiquitous proxy for ecological quality, biodiversity is likely to be the least desirable metric because ecological quality is a much more complex concept than just a relative abundance of species. Furthermore, biodiversity suffers from a dual nature as an endpoint and intermediate signal of systemic health, potentially confounding valuations (J. Boyd & Krupnick, 2009). The index of biotic integrity is a good option when there is sufficient ecological data, along with a reliable, pristine reference condition. This method is best suited for reducing the error term and works best for aquatic ecological quality because of its relatively greater homogeneity (Johnston et al., 2012, 2011) (recognizing that water quality metrics can change based on the type of water and intended use). However, not all indices are created equal and sensitive to the variables included in the model and complexity of the underlying mathematical structure. The categorical variable with qualitative descriptors generates the most variation in variables being presented, but it also provides the most flexibility, which is helpful when dealing with the wide variation in terrestrial ecosystems.

2.6 Conclusions

There continues to be inconsistency in presenting ecological quality within the economic valuation literature. This paper demonstrates one variation, utilizing a qualitative description approach. This approach can be used to provide information on the value of ecological quality within an ecosystem without introducing unnecessary complexity to survey respondents. Understanding the underlying intermediate ecosystem services is important to a more comprehensive analysis, but should occur independently and outside of the survey instrument.

This paper highlights a few of the challenges in representing ecological quality and with integrating it into welfare estimation. Reported findings are limited to conservation of the Palouse Prairie, and it is difficult to compare value estimates across ecosystems and studies due to the wide variation in methodology. The descriptions used in this study are generalizable across ecosystems, and future research should look at representing ecological quality similarly so that direct comparisons can be made.

Chapter 3: Economic value and sense of place, working together inform conservation efforts in the Palouse Prairie

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3.1 Abstract

This study provides an assessment of both economic value and sense of place. It also integrates both perspectives to create a more comprehensive assessment of value to better inform conservation efforts of the Palouse Prairie ecosystem. Size, ecological quality, the giant Palouse earthworm, rare plants, public access, and cost are all significant predictors of conservation for the Palouse Prairie. Ranking of the importance of the attributes is fairly consistent between methods, except cost moved from fourth in manual ranking to first when calculated from the coefficients in the choice experiment. Sense of place variables are significantly related to economic value, but mean economic value does not demonstrate a linear relationship with sense of place. The majority of residents were neutral or believed that it was appropriate to use a monetary value to inform conservation of the Palouse Prairie, with only 17% believing that it is inappropriate. A qualitative assessment of value and willingness to pay demonstrate a strong and positive correlation.

3.2 Introduction

The Palouse Prairie, located in northern Idaho and eastern Washington, was once a vast natural bunchgrass prairie system that has been displaced by agricultural production and development over time. Currently, less than 1% of the original Palouse Prairie ecosystem remains (Noss et al., 1995) and is considered critically endangered (Noss et al., 1995; Nyamai et al., 2011). The conversion to agricultural production and the subsequent development is a consequence of the unique loess hills which have soils that are frequently more than 100 cm (3.28 feet) deep and can even exceed 75 meters (246.06 feet) (Busacca, 1989). The deep and fertile soil makes the region one of the most productive grain-growing areas in the world (K. R. Williams, 1991). Despite the almost complete conversion to agriculture, prairie remnants still exist in areas that are not as amenable to crop production. The prairie sites that do exist are highly fragmented, tend to be smaller, have high area-perimeter ratios (Looney & Eigenbrode, 2012) and have been degraded by both domestic livestock grazing and invasive species (Weddell, 2001). Even with the current degraded state of the Palouse Prairie, it still contains plant species that are rare or endangered (Hanson et al., 2008; Lichthardt & Moseley, 1997; Weddell, 2001) and is home to the rare giant Palouse earthworm (Sánchez-de León & Johnson-Maynard, 2009; F. Smith, 1897).

Residents identify closely with the native Palouse Prairie landscape. This association with the landscape has created a “sense of place” that is tied directly to the prairie ecosystem. There are two Tribal Nations (Coeur d’Alene & Nez Perce) in the region with a strong connection to the land and the natural ecosystem. These tribes continue to harvest natural foods and medicines, such as camas (*Camassia quamash*) bulbs, which served as a nutritious food and trade item (Frey, 2011; Palouse Prairie Foundation, 2002). It is apparent that many residents have value for the native Palouse Prairie ecosystem for varied reasons and desire its conservation. Local organizations such as the Palouse Land Trust, Palouse Prairie Foundation, Idaho Native Plant Society, and the Palouse-Clearwater Environmental Institute exist with express objectives of conserving and restoring natural Palouse Prairie. Organizations such as these would benefit greatly from a better understanding of how their members and residents of the region value the Palouse Prairie so that they can evaluate alternative conservation options.

Two dominant frameworks for assessing people's value are economic (monetary) value, also known as willingness to pay (WTP), and sense of place. Both frameworks provide valuable insight but are typically evaluated separately. This study provides an assessment of value from both frameworks individually, and also integrates the analyses to create a more comprehensive assessment of value to better inform conservation efforts of the Palouse Prairie ecosystem.

The Total Economic Value (TEV) framework represents how economists conceptualize value and divide it up into different components. TEV is equal to the sum of the use and non-use values. These values are tied to ecosystem services, which are the benefits to people from nature (J. Boyd & Banzhaf, 2007; R. Costanza et al., 1998; Daily, 1997; Fisher, Turner, & Morling, 2009; MA, 2005). Use value is the satisfaction, or utility, that people receive from using the good or service. Non-use value refers to the value people assign to a good or service even if they have never used or have no intention of ever using it. Use value can be further divided into direct use, indirect use, and option values. Direct use value is when resources are used directly; it comes from provisioning ecosystem services such as food or water, and from cultural services such as recreation. Indirect use value is when resources are used indirectly such as the regulating services of flood prevention and water purification. Option value is the benefit of preserving the possibility of future use, direct or indirect. Option use value can come from any service, but is typically discussed in the context of preserving ecosystems, species, and genes for potential future use. Non-use value can be further divided into existence value, altruistic value, or bequest value. Existence value is derived from knowing that something exists such as a charismatic species, or even an entire ecosystem. This value comes from the habitat or supporting services. Altruistic value comes from the knowledge that other people in the current generation have use of the resource and is derived from all services. Bequest value comes from the knowledge of passing on resources to future generations. While it is theoretically possible to separate value out into component parts and sum them together to derive a total economic value, in practice it is much more difficult to do because of the overlap that occurs between the components when calculating value. A representation of the TEV adapted from The Economics of Ecosystems and Biodiversity (2010) is provided in Figure 3-1.

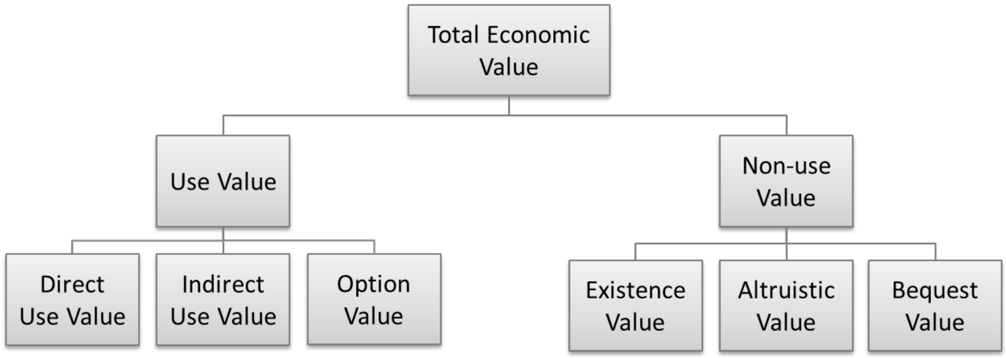

Figure 3-1: The Total Economic Value (TEV) framework provides an all-encompassing measure of the economic value of any environmental asset. It decomposes into use and non-use (or passive use) values. Use value can be further subclassified into direct use, indirect use, and option values. Non-use value can be further sub-classified into existence, altruistic, and bequest values (OECD, 2006).

To calculate the economic value, a choice experiment was used and evaluated with a conditional logit model. The economic conceptual framework for a choice experiment was developed from the characteristics theory of value (Lancaster, 1966). It assumes that a person's utility (benefit) is derived from the utilities of the components of the good or service. McFadden (1974) developed the econometric model that combines hedonic analysis of alternatives and random utility maximization known as the conditional logit model. The conditional logit model is a specific case of the multinomial logit model and is based on Thurston's (1927) random utility which was linked to Luce's (1959) choice axiom by Marschak (1960).

A choice experiment is based on a random utility maximization (RUM) model, where the choice of an alternative represents a discrete choice from a set of alternatives. Each alternative is represented with a utility function U_i for profile i that contains a deterministic component (V), which is a function of X_i, a vector of attributes associated with profile i; p_i, which is the cost of profile i; and β, which is a vector of preference parameters; and ε_i, which is a stochastic component. The RUM model can be represented by:

Equation 3-1

$$\boldsymbol{U_i = V(X_i, p_i, \beta) + \varepsilon_i}$$

It is assumed that utility is linear in parameters:

Equation 3-2

$$\boldsymbol{U_i = \sum_{k=1}^{1} \beta_k X_{ik} + \beta_p p_i + \varepsilon_i}$$

where β_k is the preference parameter associated with attribute k, X_{ik} is attribute k in profile i and β_p is the parameter on profile cost.

An individual will choose alternative i if $U_i > U_j$ for all $i \neq j$. However, since there is a stochastic component, you can only describe the probability of choosing alternative i, specified as:

Equation 3-3

$$\boldsymbol{P(i|C) = P\left(U_i > U_j\right) = P(V_i + \varepsilon_i > V_j + \varepsilon_j);\ \forall\, j \in C}$$

where C is the set of all possible alternatives. This can be rearranged to show that choices are made based on utility differences across alternatives:

Equation 3-4

$$\boldsymbol{P(i|C) = P\left(V_i - V_j > \varepsilon_j - \varepsilon_i\right);\ \forall\, j \in C}$$

Given three discrete choices with 5 attributes and an additional cost attribute, indirect utility (V_i), can be represented by the following set of equations:

Equation 3-5

$$\boldsymbol{\begin{cases} V_1 = \alpha_1 + \beta_1 X_{11} + \beta_2 X_{12} + \beta_3 X_{13} + \beta_4 X_{14} + \beta_5 X_{15} + \beta_p P_1 \\ V_2 = \alpha_2 + \beta_1 X_{21} + \beta_2 X_{22} + \beta_3 X_{23} + \beta_4 X_{24} + \beta_5 X_{25} + \beta_p P_2 \\ V_3 = \alpha_3 + \beta_1 X_{31} + \beta_2 X_{32} + \beta_3 X_{33} + \beta_4 X_{34} + \beta_5 X_{35} + \beta_p P_3 \end{cases}}$$

To evaluate the probability of choosing alternative i, for estimation purposes, the values need to be transformed so they take on a real value that is restricted to the unit interval and can be interpreted as a probability. The multinomial logit model is obtained by applying the transformation to the V_i's:

Equation 3-6

$$\begin{cases} \boldsymbol{P(1)} = \dfrac{\boldsymbol{e^{V_1}}}{\boldsymbol{e^{V_1} + e^{V_2} + e^{V_3}}} \\ \boldsymbol{P(2)} = \dfrac{\boldsymbol{e^{V_2}}}{\boldsymbol{e^{V_1} + e^{V_2} + e^{V_3}}} \\ \boldsymbol{P(3)} = \dfrac{\boldsymbol{e^{V_3}}}{\boldsymbol{e^{V_1} + e^{V_2} + e^{V_3}}} \end{cases}$$

More generally, the choice probability can be written as:

Equation 3-7

$$\boldsymbol{P(i|C)} = \frac{\mathbf{exp}\,(\boldsymbol{V_i})}{\sum_{j \in C} \mathbf{exp}(\boldsymbol{V_j})}$$

The marginal value of a single attribute can then be represented as:

Equation 3-8

$$\boldsymbol{WTP_k = -\beta_k/\beta_p}$$

Sense of place is a different and complementary concept to economic value for assessing the value people have for the Palouse Prairie ecosystem. One of the first scientists to refer to people's tendency to develop attachments to specific areas as sense of place was Yi-Fu Tuan (1974, 1977) who characterized it as the "affective bond between people and a place or setting...space is transformed into place when it acquired definition and meaning…when we endow it with value." From an anthropological perspective, sense of place (place attachment) is a symbolic relationship, it is more than an emotional and cognitive experience, and it includes cultural beliefs and practices that link people to place (Low, 1992). Through personal attachments to place, people can acquire a sense of belonging and purpose (Buttimer, 1980; Moore & Graefe, 1994; Relph, 1976; Tuan, 1980). The loss of such places can alter social process endemic to the community in question (Hester, 1985). Elucidating local sense of place can move these important places from the unconscious to the conscious in the minds of stakeholders, enabling preservation of these cultural resources (Hester, 1985). Establishing sense of place in the context of ecosystem management was fleshed out by Williams and Stewart (1998) who note that sense of place can vary among different groups of stakeholders. Because the definition for sense of place varies so greatly, measuring sense of place is also varied and often nebulous, and the method of analysis is primarily determined by the structure of the question being asked.

There are three studies that have already evaluated sense of place of the Palouse Prairie. In one of these, it was determined that sense of place can be divided into a two-factor structural model of (1) place attachment/dependence, which describes the emotional bond between a person and a particular place and the degree to which a place facilitates some set of objectives when compared to alternative settings and (2) place identity, which describes the bonds between property owners and the regional landscape. The emotional place attachment and behavioral place dependence are inseparable due to the interconnectedness of work, family, social life, leisure and culture in the region (Max Nielsen-Pincus, Hall, Force, & Wulfhorst, 2010). In another values typology study, the spatial overlaps between values were evaluated. The values included: aesthetic, biodiversity, cultural, economic, future uses, intrinsic, historic, learning, life sustaining, recreation, spiritual, subsistence, therapeutic, and preferences for residential development. These values were grouped into two categories: material (socioeconomic quality) and postmaterial (personal/environmental quality) values (M. Nielsen-Pincus, 2011). In the study, respondents were asked to identify spatial areas that were economically important to them. Economic value was defined in Nielsen-Pincus (2011) as "economic benefits provided such as timber, fisheries, minerals, or tourism" which are direct use benefits, which is a limitation of the study since, few of these economic benefits are provided by the native Palouse Prairie ecosystem, which primarily supplies non-use value. Areas identified by participants were also included within the larger geographic context not specific to the Palouse Prairie ecosystem. A third study (Donovan et al., 2009) found that socially meaningful areas did not necessarily overlap with sites that had higher ecological importance, as measured by biodiversity. Large prairie remnants that were well-known to people were frequently identified as being both socially and ecologically important, but hundreds of small prairie sites scattered throughout the region were not frequently identified. There was no concerted effort to include perspectives of indigenous peoples in this study or the Nielsen-Pincus studies. Frequently, sense of place can be different between Euro-Americans and Native people (D. R. Williams & Stewart, 1998).

Three questions were used to assess sense of place, which was limited to prevent respondent fatigue as there was also considerable attention given to evaluating WTP on the survey instrument. These questions attempt to capture place attachment, place identity, and place-related symbolic meaning (Devine-Wright, 2011). Place attachment is an emotional or cognitive bond between a person and a particular setting (Hummon, 1992;

Low 1992). Place-related symbolic meaning helps evaluate how residents perceive the Palouse Prairie and how that perception influences attachment and desire for or aversion to its change.

3.3 Methods

Data collection was conducted by the University of Idaho Social Science Research Unit using a modified Dillman method (Dillman et al., 2009). The mixed-mode study included web and mail components. An address-based sample of 1600 residents in the Palouse area was purchased from Survey Sampling Intl. (Shelton, Connecticut, U.S.A.). A sample of 1300 households was drawn proportionate to the population in Latah County, Idaho, and Whitman County, WA. Samples of 100 households were drawn from the Idaho cities of Plummer, Worley, and Lapwai (300 total) in an attempt to increase the response from 'hard to reach' populations on the Palouse, such as ethnic minorities and those in lower socio-economic statuses.

To increase the survey response rate, pre-postcards were mailed notifying respondents that they would be receiving a link to the web survey in a letter. Next, a letter with the link to the survey and unique password was mailed. A second letter was sent to nonresponsive residents with the link to the survey and contained a $1.00 bill as an incentive and as a token of appreciation. Then, paper surveys were sent with prepaid envelopes to the remaining nonrespondents. A simple random sample of 300 was selected from the remaining nonrespondents, and these were sent a second paper survey by mail. At the end of the data collection period, there was a total of 421 completed surveys (241 completed online, 180 completed paper copy) with a final response rate of 26.34%.

The survey was distributed during the summer in a region with two large universities nearby. The sample does not necessarily conform to the population demographics of the region, since a large subset of the population (students) were away for summer break when the survey was conducted (May – June 2013), which resulted in a sample with an older average age, higher education, and higher income than is reflected in U.S. Census data for the population. The sample has the advantage of representing permanent residents of the region, who have more relevance to the sense of place and economic valuation motivation of the study. Since this was a desirable outcome, no correction was used to compensate for the difference between the sample and the population.

A choice experiment was used to capture economic value. In the choice experiment, residents were provided with a set of choice tasks in which they were asked to choose among three options. Options A and B each described an example prairie site using six attributes: the size of the prairie site, the level of ecological quality, the presence or absence of the giant Palouse earthworm, the presence or absence of rare native plants, whether or not there was public access, and the cost of conservation. The value used to describe each attribute is a level of that attribute. Each attribute could take on multiple levels. If the respondent did not prefer either option A or B, they could choose a “prefer neither” option. An example choice task is provided in Figure 3-2. Each respondent was asked to answer 12 separate choice tasks. There were seven survey designs, each with 12 choice tasks for a total of 84 unique choice tasks. A fractional factorial design was generated using Choice-Based Conjoint (CBC) software from Sawtooth Software Inc. (SSI) (Sawtooth Software, 2013). SSI provides an advanced efficiency test that estimates the parameters based on randomly generated data, expected number of responses and number of choice tasks provided to each respondent. To evaluate design efficiency, standard errors from the generated data were evaluated and expected to be roughly equivalent, less than 0.05 for main effects, and less than 0.10 for interaction effects (Sawtooth Software, 2013). Descriptions of each of the attributes were provided to the residents in a brief summary before the choice tasks.

	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn’t choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Present	
Public Access	Yes	No	
Cost/hh/year	$25	$150	
	❑	❑	❑

Figure 3-2: Example of a choice task presented in the survey in which participant chooses to conserve Prairie A, Prairie B or Neither, depending on their preferences for the six attributes of the Palouse Prairie.

The model was estimated using a conditional logistic regression (McFadden, 1974). The coefficients from the choice experiment can be interpreted as part-worth utilities. The model is only capable for estimating $n - 1$ coefficients, where n is the number of levels (values) that the variable can take. The use of effects coding allows for estimation of the omitted variable by taking the negative sum of the coefficients for a given variable. For example, prairie size can take on three distinct levels: less than 1 acre, 1 – 5 acres, and greater than 5 acres. The omitted level is greater than 5 acres, so the model provides estimates for less than 1 acre and 1 – 5 acres. The coefficient for greater than 5 acres is calculated by adding the coefficients on less than 1 acre and 1 – 5 acres and then multiplying by negative one. Cost is treated as a continuous variable with only a single coefficient estimated. Socio-demographic variables are evaluated by creating interaction variables. Each of the socio-demographic variables was interacted with attributes of the choice experiment to determine if there was a significant relationship. Willingness to pay for each of the levels of an attribute can be calculated by dividing the coefficient on the desired attribute by the coefficient of the cost attribute and multiplying by negative one.

The choice experiment measures compensating variation, which is a measure of marginal change. It provides a value for the change from an initial state to a new state, where attributes of the Palouse Prairie have changed. While the choice experiment provides information on willingness to pay for marginal changes, it does not provide a total willingness to pay for Palouse Prairie conservation. To derive an approximation of the maximum willingness to pay for Palouse Prairie conservation at the household level, the prairies selected by each respondent were grouped, and the highest chosen cost value was assigned. This method acts as a sort of pseudo contingent valuation and has the effect of creating an artificial ceiling on willingness to pay of $150 and also limits the potential values to the available options. This method should provide a good approximation of maximum willingness to pay. A linear regression on the maximum willingness to pay regressed against socio-demographic variables was used to evaluate their effect on economic value.

To evaluate sense of place, on the same survey, residents were asked to respond to three separate statements using a five-point Likert scale: strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, and strongly disagree. The three statements were: 1) I don't want the landscape of the Palouse Prairie to change (landscape), 2) the Palouse Prairie is a part of my identity and heritage (heritage), and 3) nature is unspoiled on the Palouse Prairie (unspoiled). Analyses of the sense of place questions were done using a frequency distribution and one-way ANOVA, and the socio-demographic variables were evaluated using an ordered logistic regression. To assess the relationship between the sense of place variables, a Spearman's rank correlation test was conducted.

To assess the appropriateness of using economic value for conservation decisions on the Palouse Prairie, residents were asked to answer the question: "How appropriate or inappropriate is it to use a monetary amount to inform conservation decisions about Palouse Prairie?" A five-point Likert scale was used with labels on "Not Appropriate," "Neutral," and "Very Appropriate." Analysis of the data was performed using a frequency distribution, one-way ANOVA, and an ordered logistic regression.

There was also a question to qualitatively measure residents' value for Palouse Prairie conservation. Residents were asked to rate how valuable the remaining patches of Palouse Prairie are to them and their family using a Likert scale, with one being not valuable at all and five being extremely valuable. Results are presented using a frequency distribution. One-way ANOVA is used to determine whether the mean of a dependent variable (WTP) is the same between two or more groups and was used to calculate the mean WTP at each level of qualitative value. A linear regression of the socio-demographic variables on WTP was used to determine their significance and influence on WTP.

To evaluate the relationship between WTP and the sense-of-place variables, WTP is cross-tabulated with sense-of-place responses. Sense-of-place variables were integrated into the choice experiment by creating new interaction variables. For example, to understand the relationship between whether or not residents want the landscape of the Palouse Prairie to change and conservation cost, a new variable is created by multiplying the two variables together. The new interaction variable is included in the conditional logit model. The sense-of-place variables can be treated as categorical or as continuous variables. If they are treated as categorical, an interaction variable is created for each level (category) of that variable. To simplify the analysis, the sense-of-place variable is treated as continuous so that only one new interaction variable is generated.

Policy analysts and decision makers have an interest in knowing which features of conservation are most important to residents in the Palouse Prairie region so that these features can be promoted. Residents were asked to rank the six attributes from the choice experiment in order of importance, with “1” being most important and “6” being least important. The ranking of attributes provides ordinal data where we know that a variable is ranked higher or lower than another, but we are unable to determine how much higher or lower. Each attribute’s mean rank was calculated to determine the overall rank. A frequency distribution of rankings is provided and an ordinal logistic regression was used to determine significant socio-demographic variables and their influence on ranking.

A different ranking method used estimated coefficients from the conditional logit model (choice experiment) to derive the average relative importance or preference of the residents towards each attribute. This estimation is done by considering how much difference each attribute could make in the total utility of the prairie. The equation for estimating the relative importance (RI) is detailed in Halbrendt et al. (1995), and is:

Equation 3-9

$$\boldsymbol{RI_i = 100 \times \frac{UR_i}{\sum_{i=1}^{n} UR_i}}$$

where RI_i is the relative importance of attribute i, and UR_i is the utility range of attribute i. Relative importance results provide values at an interval scale. The sum of the relative importance for all attributes will sum to 100. Since the model coefficients are used for this analysis, results are only interpretable for the average respondent.

To evaluate the relationship between relative importance and ranking, a value for relative importance is needed at the individual level. Relative importance at the individual level is calculated based on the individual's part-worth utilities, calculated using an Hierarchical Bayes (HB) Monte Carlo Markov Chain algorithm (Johnson, 2000) in Sawtooth Software (2013).

A Spearman correlation was calculated between maximum WTP and sense of place. Assuming that the predictive direction is such that a person's sense of place determines their willingness to pay and not the other way around, each sense of place variable was run separately in a linear regression with willingness to pay as the dependent variable using robust standard errors. A Spearman correlation was also conducted between the relative importance and WTP and ranking with WTP.

3.4 Results

Results from the conditional logistic regression are presented in Table 3-1. All variables are highly significant except medium size sites (1 – 5 acres), which is significant at alpha = 0.10. The omitted variable, indicated with an asterisk, is calculated manually and provided in the table for reference.

Table 3-1: Coefficients, significance level, and 95% confidence interval (CI) for each level of the attributes from the choice experiment, * = omitted level

Attribute	Coefficient	Significance	95% CI	
Size				
< 1 acre	−0.3222	0.000	−0.3912	−0.2531
1 – 5 acres	0.0570	0.085	−0.0079	0.1218
> 5 acres*	0.2652			
Ecological Quality				
Low	−0.4854	0.000	−0.5552	−0.4157
Med	0.1173	0.000	0.0525	0.1821
High*	0.3681			
Palouse Earthworm				
Present*	0.2021			
Not Present	−0.2021	0.000	−0.2472	−0.1570
Rare Plants				
Present*	0.3636			
Not Present	−0.3636	0.000	−0.4095	−0.3177
Public Access				
Yes*	0.2688			
No	−0.2688	0.000	−0.3131	−0.2245
Cost	−0.0099	0.000	−0.0106	−0.0091

WTP is calculated from the coefficients, and results are provide in Table 3-2, along with lower and upper limits based on the 95% confidence interval. Interacting sociodemographic variables indicate that participants are less likely to choose sites with a higher cost of conservation as they increase in age, as length of residency increases, if there are male, or if they are more politically conservative. Residents are more likely to choose prairie sites with a higher cost of conservation if they are Hispanic/Latino, Native American/ American Indian, or are more educated. Residents are less likely to choose sites with low ecological quality if they are Hispanic/Latino, and more likely to choose sites with low ecological quality if they are politically conservative and as years of residency increase. Residents are less likely to choose sites that contain rare plants as age increases, if they are politically conservative, and if they are Asian/Pacific Islander. Residents are more likely to choose small sites if they are African American/Black or more politically conservative and they are less likely to choose small sites as their education level increases. Asian/Pacific Islanders are more likely to choose medium size sites than any other demographic group. Residents are more likely to choose sites that do allow public access as the length of residency increases. As income increases, residents are more likely to choose prairie sites where the giant Palouse earthworm is not present.

Table 3-2: Willingness to pay for each level of the attribute based on the choice experiment

	Attribute	Willingness to pay	Lower Limit	Upper Limit
Size	< 1 acre	−$32.59	−$39.87	−$25.32
	1 – 5 acres	$5.76	−$0.81	$12.34
	> 5 acres*	$26.83		
Ecological Quality	Low	−$49.11	−$56.71	−$41.51
	Med	$11.87	$5.29	$18.45
	High*	$37.24		
Palouse Earthworm	Present*	$20.44		
	Not Present	−$20.44	−$25.07	−$15.82
Rare Plants	Present*	$36.78		
	Not Present	−$36.78	−$41.65	−$31.91
Public Access	Yes*	$27.20		
	No	−$27.20	−$31.88	−$22.51

Based on manual rankings of the attributes by respondents, ecological quality is the most important attribute of Palouse Prairie conservation with an average rank of 2.54, and the giant Palouse earthworm is the least important with an average rank of 4.37. Rare plants have a mean rank of 3.16 and are, overall, the second most important attribute. Public access has a mean rank of 3.73 and an overall rank of the fifth most important. The cost has a mean rank of 3.68 and an overall rank of fourth most important (Table 3-3). These are ordinal values, and it cannot be determined how much more important one attribute is than another, only that it is more or less important on average. Distributions of the rank chosen by residents is provided in Table 3-4.

Table 3-3: Average rank value and overall rank based on the manual ranking of the six attributes that contribute to Palouse Prairie conservation.

Rank Attribute	Mean Rank	Rank
Ecological Quality	2.54	1
Rare Plants	3.16	2
Size	3.61	3
Conservation Cost	3.68	4
Public Access	3.73	5
Giant Palouse Earthworm	4.37	6

Table 3-4: Tabulated rankings, mean, and overall rank

Attribute	1	2	3	4	5	6
Size	37	68	80	57	57	64
Ecological Quality	129	72	61	63	30	11
Giant Palouse Earthworm	18	32	58	66	66	121
Rare Plants	51	88	86	59	56	24
Public Access	76	45	41	52	57	94
Conservation Cost	73	53	36	56	85	67

Ranking for prairie size do not differ among demographic categories. Residents are more likely to consider ecological quality more important if they are more politically liberal and more educated. The giant Palouse earthworm is more likely to be ranked as important if residents are older, female, more politically liberal, and as the length of residency decreases. Rare plants are more likely to be considered important if residents are older, female, and more politically liberal. Residents are more likely to consider public access to be important if they are more politically conservative. Residents are more likely to consider cost as being important if they are younger, more politically conservative, and as the length of residency increases (Table 3-5).

Table 3-5: Coefficients and significance level of socio-demographic variables on ranking

Attribute	**Coeff.**	**Significance**
Size	None	
Ecological Quality		
Political	0.2203	0.000
Education	−0.1449	0.037
Giant Palouse Earthworm		
Age	−0.0162	0.023
Male	0.4024	0.048
Political	0.1410	0.021
Residency	0.0148	0.014
Rare Plants		
Age	−0.0193	0.001
Male	0.6403	0.002
Political	0.1382	0.021
Public Access		
Political	−0.1592	0.005
Conservation Cost		
Age	0.0207	0.003
Political	−0.3516	0.000
Residency	−0.0184	0.002

Based on the choice experiment coefficients, cost is the most important attribute of Palouse Prairie conservation with a relative importance of 31.55, and the giant Palouse earthworm is the least, with a relative importance of 8.9 (Table 3-6). These are interval values that allow determination of exactly how much more important one attribute is relative to another.

Table 3-6: Relative importance (RI) and ranking of attributes

Attribute	RI	Rank
Conservation Cost	31.55	1
Ecological Quality	18.79	2
Rare Plants	16.01	3
Size	12.93	4
Public Access	11.83	5
Giant Palouse Earthworm	8.9	6

A correlation analysis of the attributes between relative importance (RI) derived from the choice experiment with Hierarchical Bayes (HB) and manual ranking at the individual level indicate some inconsistencies. Size, the giant Palouse earthworm, and rare plants are not statistically correlated while ecological quality, public access, and cost are statistically correlated (Table 3-7).

Table 3-7: Spearman correlation coefficients and significance of attributes

Attribute	Spearman's rho	Significance
RI Size/Rank Size	−0.0859	0.1193
RI Ecological Quality/ Rank Ecological Quality	−0.1481	0.0070
RI Giant Palouse Earthworm/ Rank Giant Palouse Earthworm	0.0139	0.8018
RI Rare Plants/ Rank Rare Plants	−0.0493	0.3722
RI Public Access/ Rank Public Access	−0.1540	0.0051
RI Cost/ Rank Cost	−0.1752	0.0014

The average willingness to pay for Palouse Prairie conservation per household per year is $82.74. Almost 40% of households chose the maximum cost option at least once indicating that they were willing to pay $150 or more for Palouse Prairie conservation. More than one in six residents (17.54%) never chose to conserve any prairie sites and chose the “prefer neither" option for all choice sets, indicating that these participants do not perceive any value for Palouse Prairie conservation (Table 3-8).

Table 3-8: Maximum willingness to pay for Palouse Prairie conservation per household per year based on the highest cost alternative chosen by respondent.

Max willingness to pay	Count	Proportion
$0	70	17.54%
$5	18	4.51%
$25	47	11.78%
$50	50	12.53%
$100	57	14.29%
$150	157	39.35%
	399	100.00%

Significant socio-demographic variables, when regressed on maximum WTP, include political affiliation, Native American ethnicity, and the length of residency. Residents are willing to pay less for Palouse Prairie conservation if they are more politically conservative, or as length of residency increases. Native Americans/ American Indians are, on average, willing to pay more for conservation (Table 3-9).

Table 3-9: Significant SDCs on Max willingness to pay from linear regression

Variable	Coeff.	Significance
Political	−11.512	0.000
Nat. Am.	30.802	0.029
Residency	−0.646	0.000
Constant	146.487	0.000

The three sense of place questions seek to 1) measure if residents want the landscape of the Palouse Prairie to change, 2) determine if residents consider the Palouse Prairie a part of their identity and heritage, and 3) discover if residents believe that nature in the Palouse

Prairie is unspoiled. Over 56% of respondents indicated that they do not want the landscape of the Palouse Prairie to change, 34% are neutral, and only 9% want the landscape of the prairie to change. Overall, 50.82% of males do not want the landscape of the Palouse Prairie to change, but they are more likely (11.03%) than females (6.64%) to want the landscape to change (Table 3-10). Residents that are more politically conservative are more likely to want the landscape of the prairie to change. Gender and political affiliation are the only two significant socio-demographic variables that explain whether or not a person wants the landscape of the Palouse Prairie to change (Table 3-11).

Table 3-10: Example distributions from Landscape

I don't want the landscape of the Palouse Prairie to change					
	Sample	**Male**	**Female**	**Most Liberal**	**Most Conservative**
Strongly Agree	22.16%	17.92%	27.56%	30.79%	14.66%
Somewhat Agree	34.02%	32.9%	36.79%	37.06%	30.24%
Neither Agree nor Disagree	34.54%	38.10%	29.01%	26.41%	41.50%
Somewhat Disagree	6.19%	7.24%	4.43%	3.84%	8.84%
Strongly Disagree	3.09%	3.79%	2.21%	1.89%	4.76%
Total	100.00%	100.00%	100.00%	100.00%	100.00%

Table 3-11: Coefficients, significance level, and cut points of socio-demographic variables of Landscape

Variable	Coefficient	Significance
Male	0.5555	0.004
Political	0.1587	0.007
Cut 1	−0.3489	
Cut 2	1.2082	
Cut 3	3.2615	
Cut 4	4.4083	

More than two out of five residents (41.39%) neither agree nor disagree that the Palouse Prairie is a part of their identity and heritage. Almost one out of three residents (31.87%) believes that the Palouse Prairie is a part of their identity and heritage, and over one-fourth of residents (26.74%) do not believe that it is a part of the identity and heritage (Table 3-12). Residents are more likely to consider the Palouse Prairie a part of their identity and heritage if they are more politically liberal, as length of residency increases and if they are Native American/American Indian (Table 3-13).

Table 3-12: Example distributions from Heritage

The Palouse Prairie is part of my identity and heritage				
	Sample	**Nat. Am.**	**Most Liberal**	**Most Conservative**
Strongly Agree	10.28%	21.84%	14.75%	5.16%
Somewhat Agree	21.59%	33.77%	28.94%	14.45%
Neither Agree nor Disagree	41.39%	33.93%	40.43%	42.88%
Somewhat Disagree	12.60%	5.81%	8.57%	17.47%
Strongly Disagree	14.14%	4.65%	7.30%	20.04%
Total	100.00%	100.00%	100.00%	100.00%

Table 3-13: Coefficients, significance level, and cut points of socio-demographic variables of Heritage

Variable	Coefficient	Significance
Political	0.1929	0.001
Nat. Am.	−1.0789	0.033
Residency	−0.0225	0.000
Cut 1	−2.2240	
Cut 2	−0.7234	
Cut 3	1.1979	
Cut 4	2.0713	

Almost twice as many residents (48.46%) believe that nature is spoiled on the Palouse Prairie than believe nature is unspoiled (24.26%) (Table 3-14). The only significant demographic for this perspective was education, where residents were more likely to believe that nature is spoiled on the Palouse Prairie as education increases (Table 3-15).

Table 3-14: Example distributions from Unspoiled

Nature is unspoiled on the Palouse Prairie			
	Sample	**HS Grad**	**Bachelor's**
Strongly Agree	3.59%	5.6%	3.24%
Somewhat Agree	21.03%	28.72%	19.53%
Neither Agree nor Disagree	26.92%	28.73%	26.28%
Somewhat Disagree	31.28%	25.83%	32.81%
Strongly Disagree	17.18%	11.11%	18.14%
	100.00%	100.00%	100.00%

Table 3-15: Coefficients, significance level, and cut points of socio-demographic variables of Unspoiled

Variable	Coefficient	Significance
Education	0.1907	0.003
Cut 1	−2.4432	
Cut 2	−0.2674	
Cut 3	0.9160	
Cut 4	2.4608	

Residents that do not want the landscape of the Palouse Prairie to change are more likely to consider the Palouse Prairie a part of their identity and heritage and more likely to believe that nature is unspoiled (Table 3-16). The degree to which a resident feels that the Palouse Prairie is a part of their identity and heritage is not significantly related to whether or not they believed that nature on the Palouse Prairie is unspoiled (Table 3-16).

Table 3-16: Spearman correlation matrix of Sense of place variables

	Landscape	Heritage	Unspoiled
Landscape	1		
Heritage	0.3298 (0.0000)	1	
Unspoiled	0.1345 (0.0081)	0.0707 (0.1653)	1

Residents were asked whether or not they felt that it was appropriate to use a monetary value to inform conservation decisions. A large portion of the residents (44.53%) are neutral about whether or not it is appropriate, 17.45% feel that it is inappropriate, and 38.02% feel that it is appropriate. Residents are more likely to believe that it is appropriate as education increases and less likely to think that it is appropriate as length of residency increases and if they are Asian/Pacific Islander.

Table 3-17: Distribution of responses to Appropriateness question

	Response	Count	Proportion	Cumulative
Not Appropriate	1	38	9.90%	9.90%
	2	29	7.55%	17.45%
Neutral	3	171	44.53%	61.98%
	4	79	20.57%	82.55%
Very Appropriate	5	67	17.45%	100.00%
		384	100.00%	

In order to capture value from a different perspective, residents were asked to qualitatively assess the value of the Palouse Prairie. Just over one-fifth (21.47%) of residents believe that the Palouse Prairie is not valuable, almost a third of residents do not feel strongly one way or the other, and almost half (48.86%) believe that the Palouse Prairie is valuable to them (Table 3-18). Residents are more likely to believe that the Palouse Prairie is valuable if they are female, as education increases, and if they are more politically liberal.

Table 3-18: Distribution of Qualitative Value and mean willingness to pay

Qualitative Value	Proportion	Mean WTP
1 (Not Valuable)	8.9%	$23.94
2	12.57%	$45.43
3	31.68%	$73.56
4	29.58%	$104.65
5 (Extremely Valuable)	17.28%	$129.62
Significance		0.0000

All three sense-of-place variables are significantly correlated with willingness to pay. WTP for conservation decreases as residents are more likely to want the landscape of the Palouse Prairie to change. WTP for conservation increases as residents are more likely to believe that the Palouse Prairie is a part of their identity and heritage. Residents that believe that nature on the Palouse Prairie is spoiled are willing to pay more for its conservation (Table 3-19).

Table 3-19: Spearman correlation and significance between willingness to pay and sense of place variables

rho (sig. level)	Landscape	Heritage	Unspoiled
Willingness to pay	−0.2281 (0.0000)	−0.1277 (0.0131)	0.1739 (0.0007)

Evaluating significant relationships between the sense of place questions and the choice experiment through interaction variables indicates that residents that are more likely to choose sites with a higher cost of conservation are also more likely to want the landscape of the Palouse Prairie to stay the same, to consider the Palouse Prairie as a part of their identity and heritage, and to believe that nature is spoiled in the Palouse Prairie. Residents that consider the Palouse Prairie to be a part of their identity and heritage are more likely to choose sites that do not allow public access. Residents that are more likely to believe that nature is unspoiled are more likely to choose small sites or sites with low ecological quality (Table 3-20).

Table 3-20: Significant results of Sense of place interaction variables in choice experiment

Variable	Coefficient	Significance
Cost/Landscape	−0.0038	0.000
Cost/Heritage	−0.0012	0.001
Cost/Unspoiled	0.0021	0.000
Public Access/Heritage	−0.0535	0.008
Small Size (<1 acre)/Unspoiled	−0.0709	0.009
Ecological Quality/Unspoiled	−0.0936	0.001

The relationships between relative importance and responses to sense-of-place questions are only significant in two instances. As rare plants became more important to residents, they are less likely to want the landscape of the Palouse Prairie to change and more likely to believe that nature in the Palouse Prairie is spoiled.

The relationship between ranking and sense-of-place provides the most significant relationships. Residents that are more likely to want the landscape of the Palouse Prairie to stay the same are also more likely to believe that rare plants are more important. Residents that are more likely to want the landscape of the Palouse prairie to change are more likely to think that public access and cost are more important. As ranking of the giant Palouse earthworm and rare plants increases, residents are more likely to believe that the Palouse Prairie is a part of their identity and heritage. As ranking of public access becomes more important, residents are less likely to believe that the Palouse Prairie is a part of their identity and heritage. As ranking of ecological quality becomes more important, residents are more likely to think that nature in the Palouse Prairie is spoiled. As ranking of cost becomes more important, residents are more likely to consider the Palouse Prairie to be unspoiled.

Mean willingness to pay for residents that do not want the landscape of the Palouse Prairie to change is $97.00, residents that are neutral have a mean willingness to pay of $60.39, and residents that do want the landscape of the Palouse Prairie to change are willing to pay $91.94 (Table 3-21).

Table 3-21: Mean Max WTP at each Landscape level

Landscape	Mean Max WTP	Freq.	
1	$108.78	86	$97.00
2	$89.02	127	
3	$60.39	129	$60.39
4	$87.71	24	$91.94
5	$100.42	12	
Total	$84.02	378	

Mean willingness to pay for residents that believe that the Palouse Prairie is a part of their identity and heritage is $96.07, residents that are neutral about identity and heritage are willing to pay $76.99, and residents that do not believe that the Palouse Prairie is a part of their identity and heritage are willing to pay $81.12 (Table 3-22).

Table 3-22: Mean Max WTP at each Heritage level

Heritage	Mean Max WTP	Freq.	
1	$113.72	39	$96.07
2	$87.68	82	
3	$76.99	153	$76.99
4	$86.53	49	$81.12
5	$76.20	54	
Total	$84.24	377	

Mean willingness to pay for residents that believe that nature is unspoiled on the Palouse Prairie is $82.07, residents that are neutral about whether or not nature is unspoiled on the Palouse are willing to pay $60.64, and residents that do not believe that nature is unspoiled are willing to pay $97.76 (Table 3-23).

Table 3-23: Mean Max WTP at each Unspoiled level

Unspoiled	Mean Max WTP	Freq.	
1	$87.31	13	$82.07
2	$81.20	79	
3	$60.64	101	$60.64
4	$93.42	120	$97.76
5	$105.77	65	
Total	$84.02	378	

A linear regression of the sense-of-place variables on WTP indicates that each of them is a significant predictor. The landscape and heritage variables reduce WTP and unspoiled increases WTP for Palouse Prairie conservation (Table 3-24).

Table 3-24: Coefficients and significance of linear regression of Sense of place variables on willingness to pay with robust standard errors

Variable	Coeff.	Sig. Level
Landscape	−11.72	0.001
Landscape Constant	111.40	0.000
Heritage	−6.64	0.015
Heritage Constant	104.10	0.000
Unspoiled	8.99	0.002
Unspoiled Constant	53.62	0.000

The relative importance of three of the six attributes is significant with willingness to pay: ecological quality, the giant Palouse earthworm, and conservation cost. As relative importance for ecological quality and the giant Palouse earthworm increases, average willingness to pay also increases. Intuitively, as the cost of conservation becomes more important, average willingness to pay decreases (Table 3-25).

Table 3-25: Spearman correlations and significance of relative importance on willingness to pay

Relative Imp. rho (sig. level)	**Size**	**Ecological Quality**	**Palouse Earthworm**	**Rare Plants**	**Public Access**	**Cost**
Willingness to pay	−0.0032 (0.9503)	0.2427 (0.0000)	0.2266 (0.0000)	0.0413 (0.4186)	0.0704 (0.1680)	−0.3408 (0.0000)

The manual ranking of all six attributes is significant with willingness to pay. As the attributes of size, ecological quality, the giant Palouse earthworm, and rare plants become more important, average willingness to pay also increases. As public access and the cost of conservation become more important, average willingness to pay decreases (Table 3-26).

Table 3-26: Spearman correlations and significance of ranking on willingness to pay

Ranking rho (sig. level)	**Size**	**Ecological Quality**	**Palouse Earthworm**	**Rare Plants**	**Public Access**	**Cost**
Willingness to pay	−0.1125 (0.0354)	−0.3195 (0.0000)	−0.2675 (0.0000)	−0.1172 (0.0009)	0.2072 (0.0001)	0.3503 (0.0000)

The qualitative value that residents have for the Palouse Prairie and their subsequent willingness to pay for its conservation are strongly linked. Participants who believe that the Palouse Prairie is not valuable to themselves or their families have a mean willingness to pay of $36.46 whereas residents who believe that Palouse Prairie is have a mean willingness to pay of $113.76 (Table 3-27).

Table 3-27: Mean Max WTP at each Qual Value level

Qual Value	Mean Max WTP	Freq.	
1	$23.94	33	$36.46
2	$45.43	46	
3	$73.56	118	$73.56
4	$104.65	113	$113.76
5	$129.62	65	
Total	$84.83	375	

There is also a strong relationship between whether or not residents feel that it is appropriate to use a monetary value to inform conservation decisions and willingness to pay. Residents who believe that it is not appropriate to use a monetary value to inform conservation decision have an average willingness to pay of $59.84, while those who do believe that it is appropriate to use a monetary value have an average willingness to pay of $100.10 (Table 3-28).

Table 3-28: Mean Max WTP at each Appropriate level

Appropriate	Mean Max WTP	Freq.	
1	$40.14	35	$59.84
2	$84.46	28	
3	$79.82	166	$79.82
4	$96.17	77	$100.10
5	$104.63	67	
Total	$84.28	373	

3.5 Discussion

All three sense-of-place questions were significantly correlated with willingness to pay based on the Spearman correlation test and a linear regression of sense-of-place variables on WTP. However, cross-tabulating and graphing the relationship between average WTP and responses to the sense-of-place questions reveal a more parabolic relationship, where WTP initially decreases, and then increases. One potential explanation is that willingness to pay is restricted by ability to pay or some other constraint and could demonstrate that willingness to pay and sense of place are not necessarily interchangeable measures of value.

Despite being found in a previous study that socially meaningful areas do not necessarily overlap spatially with sites that have higher ecological importance (Donovan et al., 2009), this study found that ecological quality is one of the most important attributes to residents when considering conservation of the Palouse Prairie, which is demonstrated in the choice experiment, the relative importance, and the manual ranking of ecological quality.

Four different methods were used to analyze the importance of the six attributes: a choice experiment, relative importance at the mean and individual level (Bayes method), and ranking. The overall ranking of the six attributes differs depending on the method used. According to the manual ranking results, conservation cost is slightly less important than size and ranked fourth overall (Table 3-3). Relative importance provides a conflicting assessment and indicates that cost is the most important attribute, and is actually 2.44 times more important than size (Table 3-6). The correlation between relative importance and manual ranking at the individual level shows that only ecological quality, public access, and cost are significantly correlated between the two methods, while rare plants, the giant Palouse earthworm, and size are not significantly correlated between the two methods.

Fransson and Gärling (1999) reviewed numerous studies about environmental concern and found that overall, socio-demographic variables are not consistently strong predictors of environmental concern or behavior. In our study, political affiliation, the length of residency, and education level were the most frequently significant variables across various methods of analysis. Residents that are more politically conservative are more likely to choose prairie sites that are small, have low ecological quality, do not have rare endemic plants, or allow public access. They are less likely to choose sites with a higher cost of conservation and are willing to pay less for conservation overall. Residents that are more politically liberal are more likely to want the landscape of the Palouse Prairie to change, to consider the Palouse Prairie a part of their identity and heritage, and to believe qualitatively that the Palouse Prairie is valuable. They are more likely than conservative residents to believe that ecological quality, the presence of the giant Palouse earthworm, and rare endemic plants are important. Residents' stated political affiliation was the only demographic variable that was significant across rankings of all of the attributes.

Relph (1976) asserted that attachment to a particular place grows over time as a person's experience with it becomes deeper and more diverse, but this is not always borne out in empirical studies. There is frequently no association between length of residency and attachment or sense of place (Cuba & Hummon, 1993; Stedman, 2002). Newcomers tend to be highly attached to a place via its biophysical or landscape features rather than social networks and local relationships (Brehm, Eisenhauer, & Krannich, 2006; McCool & Martin, 1994). Specific to the Palouse Prairie, Nielsen-Pincus (2010) found that length of residence is not a significant predictor of sense of place. Our results indicate that length of residency is significantly associated with a person’s identity and heritage relative to the Palouse Prairie, but not significant to whether they want the landscape of the Palouse Prairie to change or whether or not they believed that it is unspoiled. As length of residency increases, and residents have lived in the Palouse longer, they are more likely to choose prairie sites that have low ecological quality and do not allow public access. They are less likely to choose sites with a higher cost of conservation and their overall willingness to pay is less. They are more likely to consider the Palouse Prairie a part of their identity and heritage and to believe that it is inappropriate to use a monetary value to inform conservation decisions. As residency increases, the giant Palouse earthworm becomes less important.

It can be argued that attempting to place a monetary value on the conservation of the Palouse Prairie is inappropriate. There are aspects of human relationships to nature that legal, political, and market institutions do not adequately represent in economic and other social transactions (K. M. Chan, Satterfield, & Goldstein, 2012; Kirsch, 2001; Torgerson, 1999). Local places, nature and its resources, serve as repositories of people’s memories, their relationships, and their daily routines which have endowed those places with meaning and significance that cannot be reduced adequately to an economic value (Snyder, Williams, Peterson, & others, 2003). Economic valuation may also be considered inadequate or insensitive to perspectives of certain stakeholders with differing social perspectives (Burger, 2011; Johansson-Stenman, 1998). This study found that as education increases, residents are more likely to believe that it is appropriate to use a monetary value to inform conservation decisions, to choose sites with a higher cost of conservation, to believe that nature is spoiled on the Palouse Prairie, to believe that it is qualitatively valuable, and are less likely to choose small prairie sites.

As age increases residents are more likely to choose prairie sites that do not have rare endemic plants and less likely to choose sites that have a higher cost of conservation. As residents get older they are more likely to believe that the giant Palouse earthworm, rare plants, and conservation cost are important. With age, there is a contradiction surrounding rare plants. As age increases residents were more likely to rank plants as being more important, but they were more likely in the choice experiment to choose sites that did not have rare plants. This is likely caused by tradeoffs that were required in the choice experiment. An attribute that they considered more important than rare plants, such as the cost, overrode their preference for plants. Additionally, younger residents were more likely to rank cost of conservation as being more important, yet frequently chose sites with a higher cost of conservation.

Males were overall more likely to want the landscape of the Palouse Prairie to stay the same, but more likely than females to want the landscape to change. Males were more likely to believe that the Palouse Prairie is qualitatively more valuable, but less likely to choose sites with a higher cost of conservation. Females were more likely to believe that the giant Palouse earthworm and rare plants are important.

Income was only significant with one attribute. As income increases, residents were less likely to choose sites that do not have the giant Palouse earthworm present.

Residents were more likely to choose small prairie sites if they were African American/Black and medium prairie sites if they were Asian/Pacific Islander. Asian/Pacific Islanders were also more likely to choose sites that do not have rare plants and to believe that it is not appropriate to use a monetary value to inform conservation decisions. Hispanic/Latinos are less likely to choose sites with low ecological quality and more likely to choose sites with higher conservation costs. Native American/ American Indians are more likely to consider the Palouse Prairie a part of their identity and heritage and choose sites with a higher cost of conservation.

There are less significant variables with maximum willingness to pay than there are with cost in the choice experiment because, within the choice experiment, there are twelve observations for each individual and the analysis can pick up how they chose across multiple scenarios. Whereas, with maximum willingness to pay, the analysis in limited to only a single observation for each individual, their highest choice.

3.6 Conclusions

This study used two common measures to evaluate people's value for conservation of the Palouse Prairie, willingness to pay and sense of place. Each of these methods is typically conducted individually, although each is insightful to helping inform conservation decisions. By integrating the WTP and sense-of-pace frameworks within the same survey instrument, similarities and complements become visible, but where they diverge is also important. The different statistical methods required to analyze the demographic variables resulted in inconsistencies between the methods, but no outright contradictions. Relative importance and ranking resulted in similar, but still slightly different priorities, indicating that tradeoffs within the choice experiments outweighed their stated priorities.

Both methods represent a perspective of value and each should be considered when making conservation decisions. Quantifying willingness to pay of Palouse Prairie residents can help inform the design of conservation strategies. Results indicate that the nonmarket benefits of Palouse Prairie conservation in the region may significantly outweigh the costs of conservation. Willingness to pay allows the use of a metric, the dollar, that people are comfortable using and makes it easier to compare relative importance of attributes and differences between demographic groups. Sense of place helps us to understand the value of conservation from a different perspective of value. Conservation of Palouse Prairie will only happen through decisions by private land owners and NGOs, as there are no local or regional policies in place (Donovan et al., 2009). This analysis provides valuable information to these decision-makers and particularly to NGOs, because it helps them understand what elements of the Palouse Prairie are most important to residents of the region and to which demographics these characteristics are most important.

Chapter 4: An interdisciplinary approach to assign economic value for ecological quality in the critically endangered Palouse Prairie

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4.1 Abstract

Interdisciplinary research is lacking in methodologies that address direct analysis of complex socio-ecological problems. We present and evaluate the utility of a new method to provide decision-makers a way to prioritize conservation efforts in a specific system, the Palouse Prairie, bridging the gap between economics and ecology. We present this method as a framework that can be applied to similar fragmented grassland systems. To achieve this, we first conducted a choice experiment survey to determine the willingness-to-pay for conservation of remnant parcels of the Palouse Prairie of northern Idaho and eastern Washington State, from a sample of residents within the region. We simultaneously assessed the ecological quality with a plant-centric focus, measuring variables that influence the plant community. These variables include plant diversity, bee species richness, amount of nearby forage area for bees, non-native grass cover, patch area size, and the soil characteristics of soil depth, percent sand, organic matter, nitrogen, and phosphorous. These variables were used to generate an index of ecological quality using exploratory factor analysis. The ecological quality index was assigned to the willingness-to-pay distribution and the relationship between measures of ecological quality and willingness-to-

pay were assessed using scoring coefficients. We submit that these methods, with modifications, can be used to ascertain willingness to pay for ecological quality and its component variables as a tool to value and potentially incentivize conservation measures on private land.

4.2 Introduction

Ecological quality, sometimes referred to as ecological health, condition, or integrity, can be difficult to define (Doran & Parkin, 1994; Karlen et al., 1997; Larson & Pierce, 1994; Mausbach & Seybold, 1998; Seybold, Mausbach, Karlen, & Rogers, 1998). It has been described in both abstract and explicit ways from the perspectives of the economy, social opinion and public health (Robert Costanza et al., 1992; Rapport et al., 1998; Smyth et al., 2007). Descriptions of ecological quality are dependent on the goals and perceptions of the people who set them as the substantive criteria used to judge quality may vary greatly from the highly practical to those based on aesthetic, spiritual or moral factors (Freyfogle & Newton, 2002). Understanding the ecology and the characteristics that define the quality of an ecosystem is necessary for its conservation, but is not sufficient. Incorporating stakeholders' value of ecological quality can aid in management decisions by ensuring the standards are socially desirable or acceptable (Smyth et al., 2007).

Arguments for conservation from an exclusively ecological perspective are unlikely to gain substantial traction as there must also be social and political support for conservation action and many individuals are not moved by a purely ecological argument. Many grasslands throughout the world are privately owned, making a private and social value context especially important for their conservation. Economics is an excellent companion to assessments of ecological quality because it can represent an additional measure of the value for conservation. Economic value can be linked to an ecosystem through its ecosystem services, and ecosystem services are determined by the quality of the ecosystem (Harrison et al., 2014). However, economics and ecological quality are frequently assessed independently, making it difficult to assess both in a comprehensive analysis. The purpose of this research is to demonstrate an interdisciplinary approach to measure and allocate willingness to pay (WTP) for ecological quality within a case study system: the Palouse Prairie of northern Idaho and eastern Washington State

Grasslands worldwide provide habitat for a diverse assemblage of native plant and animal communities (White, Murray, Rohweder, Prince, & Thompson, 2000), contribute to the aesthetic qualities of the rural landscapes, increase both recreational and amenity values to the countryside and provide various ecosystem services (Chapman, 2001; Sala & Paruelo, 1997). Ecosystem services are the benefits provided to people from nature (J. Boyd & Banzhaf, 2007; R. Costanza et al., 1998; Daily, 1997; Fisher et al., 2009; MA, 2005; TEEB Foundation, 2010). Despite the ecosystem services that grasslands provide, their inherent suitability for conversion to agriculture has resulted in their loss across the globe. This loss of habitat has endangered the once widespread native flora and fauna (Chapman, 2001; Hassan, Scholes, & Ash, 2005). The Palouse Prairie is no exception to this pattern (Black et al., 1998; Donovan et al., 2009; Looney & Eigenbrode, 2012; Pocewicz et al., 2008).

The hills of the Palouse region are comprised of loess soils that are often more than 100 centimeters and can reach up to 75 meters in depth (Busacca, 1989). These deep and fertile soils make the region one of the most productive grain-growing areas in the world (K. R. Williams, 1991). The extensive agricultural development that primarily occurred during the latter part of the 19th century has resulted in the loss of as much as 99% of the natural habitat, known as the Palouse Prairie (Black et al., 1998; Donovan et al., 2009; Hanson et al., 2008; Noss et al., 1995). There has been a tremendous loss of biodiversity through direct conversion to agriculture, extensive invasion of non-native plants, the effects of chemical drift of aerially applied pesticides, and intense livestock grazing (Black et al., 1998). As a consequence, the Palouse Prairie is considered to be one of the most imperiled ecosystems in the United States (Noss et al.1995, Black et al. 1998, Nyamai et al. 2011).

The Palouse Prairie currently exists as a highly fragmented system embedded within a matrix of production agriculture. Most remnants are less than 2 ha (4.94 acres) and have a high perimeter-area ratio (Looney & Eigenbrode, 2012). They are usually found on rocky and shallow soils and predominantly in a few large clusters near rivers and rocky buttes not suitable for agriculture and almost all of the remnants are located on private land (Looney & Eigenbrode, 2012). Given the current status of the Palouse Prairie, there is substantial interest in conserving the remaining sites and the organisms within them and improving their ecological quality (Cleve Davis, Decker, et al., 2015; Cleve Davis, Rhoades, et al., 2015; Donovan et al., 2009).

Information about ecosystem services, and the ecological quality upon which they depend (Harrison et al., 2014) can be incorporated into a decision making and policy framework (Daily et al., 2009) provided in Figure 4-1. Both economic and cultural value is derived from ecosystem services. By providing information about these values to institutions, they can create incentives and disincentives that influence people's decisions and can inform policy decisions.

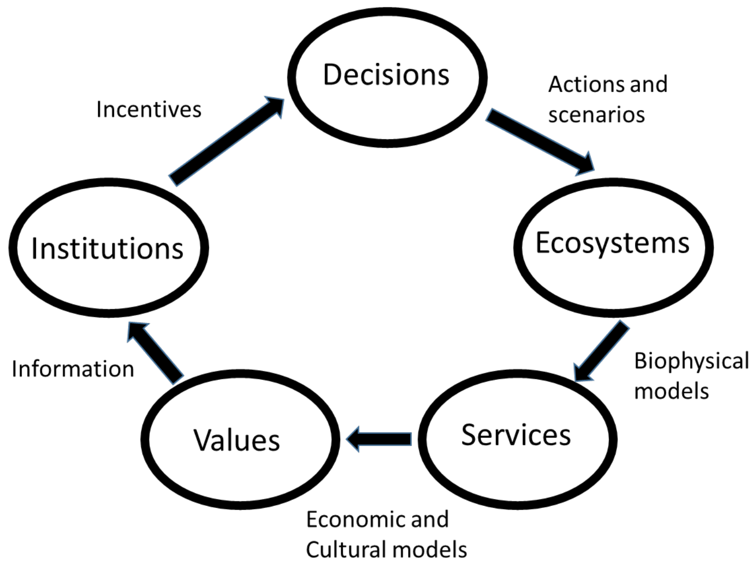

Figure 4-1: A framework demonstrating how ecosystem services can be integrated into decision making (Daily et al., 2009).

In interviews with regional stakeholders, ecological quality of the Palouse Prairie was consistently identified as being highly important. This provides an opportunity to link the social value for conservation of the Palouse Prairie to its ecological quality. A perspective on ecological health from economics is provided by Costanza et al. (1992) who define ecosystem health as a system that "maintains its organization and autonomy over time and is resilient to stress." Although theoretically appealing, organization and resilience are difficult to observe and measure. Much more commonly, ecological quality is described from the perspective of an ecologist. The presence or absence of certain important species, diversity or species richness of biotic communities and abiotic characteristics have all been used to measure ecological quality (Firbank et al., 2008; Karr, 1999; Kremen, 1992). The purpose of this research is to demonstrate an interdisciplinary approach to measure and allocate WTP for ecological quality using the Palouse Prairie as an example.

The Palouse prairie is a unique ecosystem that resulted from its particular geologic history, the soils that formed there, its xeric climate, the topology, and its unique plant communities (Daubenmire, 1942). While all of these factors contributed to the formation of this ecosystem, the Palouse Prairie is defined by its unique plant community. Conservation efforts are framed by the public's plant-centric perspective (Daubenmire, 1942; Donovan et al., 2009). Consequently, as part of our approach to determining the WTP for ecological quality of the Palouse Prairie, we focused on characteristics of its plant community and ecological attributes that influence it: native bee communities and soil characteristics.

The variables measured to represent ecological quality of the Palouse Prairie are provided in Table 4-1. Although these measures are not comprehensive in measuring the full dimensionality of ecosystem quality in the Palouse Prairie, the metrics we selected, pertain to soil quality and bee communities on which are well established for their linkages to the richness and diversity of plant communities that constitute a healthy Palouse Prairie.

Table 4-1: List of variables used to represent ecological quality of the Palouse Prairie.

Variable	Description
Plant Diversity	Averaged Shannon-Weiner diversity by plant cover of all sites within 1km of the integrated sites
Non-Native Grass Average Cover	Average non-native grass cover within 1 km of the integrated study sites
Bee Richness	Rarefied bee species richness
Suitable Forage	Amount of useful habitat for bees within 1,250 m
Patch Area	Average patch area for all patch types
Soil Depth	Depth to root-restrictive layer
Percent Sand	Proportion of the sand sized mineral fraction
Organic Matter	Organic matter by loss on ignition
Nitrogen	Nitrogen as nitrate and ammonium
Phosphorous	Phosphorus by Morgan extraction

Floral and bee communities are interdependent. Presence of adequate nesting and floral resources are necessary for diverse communities of native bees (Kremen, Williams, Bugg, Fay, & Thorp, 2004). Calculation of average patch size is dominated by large patches of continuous agriculture, not by prairie patches, so this variable measures the amount of field margins which can provide resources for bees but are difficult to identify in aerial photographs (Kells, Holland, & Goulson, 2001).

A species-rich and diverse community of bees is necessary to pollinate forbs which form the cornerstone of the Palouse native plant community as pollen limitation may be an important cause of reproductive failure of flowering plants in fragmented habitats such as the Palouse (Aguilar, Ashworth, Galetto, & Aizen, 2006; Hoehn, Tscharntke, Tylianakis, & Steffan-Dewenter, 2008; Klein, Steffan–Dewenter, & Tscharntke, 2003; Vergara & Badano, 2009). Seed production in most flowering plants is, at least in some years, pollen limited (Burd, 1994). Increased species and functional diversity of floral visitors can increase seed production in plants (Hoehn et al., 2008; Klein et al., 2003; Vergara & Badano, 2009). The diversity of a flowering plant community is closely linked to the functional diversity of a complementary community of pollinating insects (Fontaine, Dajoz, Meriguet, & Loreau, 2005). Moreover, bees have been used as indicators of biological quality and are known to be sensitive to environmental change (Kevan, 1999; Tscharntke, Gathmann, & Steffan-Dewenter, 1998; Westrich, 1996).

Because of the nature of soils, it has in the past been difficult for soil scientists to agree on a common set of soil quality indicators (Doran & Parkin, 1994; Larson & Pierce, 1994). Indicators must be ecologically relevant and scientifically defensible. Logistics and practicality are also criteria for choosing soil quality indicators (Keddy, Lee, & Wisheu, 1993). Most samples sites for this study are privately owned and all are critically endangered remnants. Nevertheless, recent interest in the degradation of soils worldwide has spurred a great body of literature suggesting a so-called minimum set of soil quality indicators (Kimble, 1998; Larson & Pierce, 1994).

We chose a set of soil quality indicators that are widely accepted as both ecological relevant and scientifically defensible. We also chose indicators that were relatively easy to measure, can easily be incorporated into future studies, and were practically achievable given the time and access constraints. This set of soil quality indicators represents a reasonable compromise among the many criteria and constraints. The soil variables include: texture (represented by % sand), depth to root restrictive layer, plant available N, plant available P, and soil organic matter.

In the Palouse Prairie soils are a primary determinant of plant communities. While the plant–soil feedback mechanism remains to be adequately described, soils have a profound effect on plant assembly types. Soil variables are highly interdependent (see Dominati, Patterson, & Mackay, 2010 for a review). The texture of a soil affects many ecosystem functions including infiltration of water into the soil profile, percolation, or the movement of soil through the soil profile, drainage of water from the soil profile, and aeration of the root zone. Soils that are high in clay or those like the Palouse Prairie that are influenced by volcanic ash, are able to hold more water. Soils high in sand are able to drain water from the soil profile more quickly. The depth to root restrictive layer indicates the available volume of soil available for plant roots. When the density of soil becomes too great, at depth, plant roots are unable to penetrate deeper in the soil profile. This affects the amount of both soil water and nutrients available to the plant. Soils also contain plant nutrients. The most important of which are nitrogen, phosphorus, and potassium. Soil organic matter is an important indicator because it too affects the movement and storage of water in soils. It is also important because it is a pool for nutrient cycling of nitrogen and phosphorus as well as other plant nutrients.

4.3 Methods

Integrating economic value with ecological quality of the Palouse Prairie was completed in a six step process: 1) the willingness to pay for conservation of the Palouse Prairie was quantified using a survey, in which ecological quality was defined and identified as contributing to the value of conservation, 2) data were collected from 29 Palouse Prairie remnant sites on components of ecological quality aligned with the definition provided on the survey, 3) a composite measure of ecological quality was created based on the data acquired in step (2), 4) composite measures of ecological quality were mapped onto the economic value for ecological quality, 5) the relationship between changes in measures of ecological quality and their effect on the economic value for ecological quality was evaluated, and 6) WTP for conservation was assigned to each of the remnants.

4.3.1 Survey

A total of 1,600 residents of the Palouse region were surveyed by mail. Most of the surveys (1,300) were sent to households in Latah County, Idaho and Whitman County, Washington with the subsamples drawn proportionate to their respective populations. The remaining 300 surveys were sent to households in the Idaho cities of Plummer, Worley, and Lapwai to increase responses from hard-to-reach populations in the Palouse region (Native American Tribes). Data were collected using a modified Dillman method (Dillman et al., 2009), utilizing both internet and mail survey options. A total of 421 surveys were completed with 241 completed online and 180 completed from a paper survey.

Each respondent was provided with a survey that briefly described the Palouse Prairie ecosystem, with emphasis given to descriptions of five important attributes that contribute to the value for conservation and a cost attribute in order to calculate WTP. Each choice task contained the six attributes including size, ecological quality, presence of the Giant Palouse earthworm, presence of threatened plants, public access and conservation cost. Size was presented as less than 1 acre, 1 – 5 acres, and greater than 5 acres. Ecological quality was given three categorical levels of low, medium, and high, which were defined as:

Low ecological quality: a site where soils have been heavily degraded or disturbed. It is isolated from other prairie sites. It is heavily invaded by non-native species. It has very few total species. Of all the species present, some occur frequently and others occur infrequently.

Medium ecological quality: a site where soils have some degradation or disturbance. It is moderately isolated from other prairie sites. It has been invaded by non-native species but still supports native species. Of all the species present, some species occur more frequently than others.

High ecological quality: a site where soils have limited or no degradation or disturbance. It is near other prairie sites. It has very few invasive species. It has many native species. All species present occur with about the same frequency.

Both the Giant Palouse earthworm and rare plants were displayed as present or not present. Public access was displayed as yes or no. Cost is the conservation cost that a respondent would be willing to pay in their household (hh) per year toward Palouse Prairie conservation for that specific prairie site. It was presented in dollar values of $5, $25, $50, $100, and $150. A choice experiment survey with seven designs, each with 12 choice tasks, was generated using a fractional factorial design. An example of a choice task is provided in Figure 4-2. Each respondent was given 12 choice tasks. Respondents were asked to indicate the prairie site they preferred by checking the appropriate box. If they did not prefer either prairie site option, they had the ability to choose “Neither.” If they preferred both prairie sites equally, they were asked to only choose one of them. Each choice was considered independently.

	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Present	
Public Access	Yes	No	
Cost/hh/year	$25	$150	
	❑	❑	❑

Figure 4-2: Example of a choice task presented in the survey in which participant chooses Prairie A, Prairie B or Neither, depending on their preferences for the five attributes listed.

Survey data were analyzed with a nested logit regression using Stata (StataCorp, 2011). Effects coding was used, which allows for the estimation of the omitted variable by taking the negative sum of the coefficients for a given variable. The part-worth marginal value of a single attribute can then be represented as the negative of the ratio of the coefficient of the attribute of interest and the coefficient of the cost attribute. The nested logit model is effective at reducing the negative effects of the independence of irrelevant alternatives (IIA) assumption. In this case, a respondent may first choose between conserving and not conserving. If the individual chooses to conserve, then they must choose between Prairie A and Prairie B. This imposes a hierarchy as presented in Figure 4-3. The nested logit model is consistent with random utility theory and ultimately resulted in a better fitting model than the conditional logit model. It was also chosen over the mixed logit model because it allowed evaluation of the hypothesized hierarchical structure of choice.

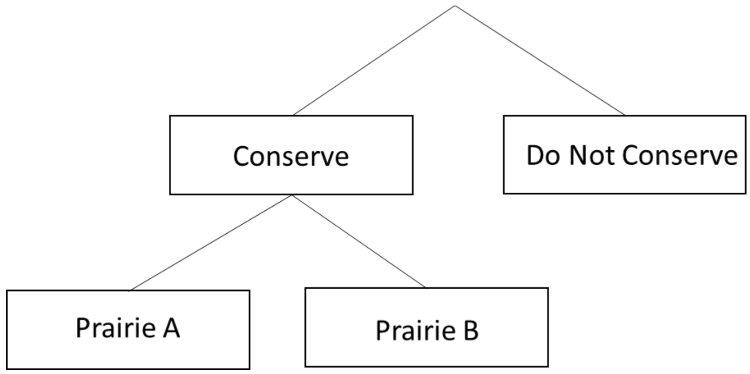

Figure 4-3: Hierarchical structure of a choice experiment where a respondent first chooses if they are willing to conserve or not willing to conserve a site. If the respondent chooses to conserve a site, they then choose between the two prairie options.

4.3.2 Ecological data

Plot-based data were collected from prairie patches in Latah County, Idaho and Whitman County, Washington. Samples sites were selected to represent the range of conditions that currently exist on the Palouse Prairie with Prairie fragments varying greatly in size, isolation, plant community characteristics and general ecological quality. Those remnants that are public or accessible through affiliation with a university tend to be much larger. Additional sites that were smaller and more isolated were found through contacts at local organizations focused on the Palouse Prairie such as the Palouse Prairie Foundation (Moscow, ID) and the Palouse Conservation District (Pullman, WA). With the exception of two remnants in Washington (i.e., Steptoe Butte and Kamiak Butte), all patches were privately owned. Permission to sample on privately owned land was obtained prior to sampling. Although we strove to select sites randomly, site selection was constrained by landowner permission. To minimize spatial autocorrelation sites were located at least 1 km apart. Using these constraints, a total of 29 study sites were sampled within 25 remnants.

Primary sampling sites within each remnant was determined using the Create Random Points tool in ArcGis 9 (ESRI, Redlands CA). If the point fell within a thicket of shrubs or small trees that would inhibit sampling it was moved 5m beyond the nearest edge of the thicket. Multiple sampling locations were placed in the three largest remnants. These sampling sites were used for bee, soil and plant cover data collection. Plant species cover estimates (including biological soil crusts) were measured at each of the 29 sites following Daubenmire's (1959) canopy-coverage method. Sample units were 0.50 by 0.25 m rectangular quadrats and transect direction was obtained randomly using a random number generator. The long axis of the quadrat frame was oriented away from the transect line. Within each quadrat, the percent cover of species was recorded in classes on the following scale: 0.01 — <5%, 5— <12.5%, 12.5 — <25%, 25 — <50%, 50 — <75%, and 75 — 100%. The mid-point value of these cover class estimates was used to determine cover by species. Only one observer was used to make estimations. Plant species data were collected in May–July during 2012 and 2013 when most plant species could be easily identified. Transect orientation of all plots was chosen randomly. Species were identified in the field or collected and identified by comparison with herbarium specimens at the University of Idaho Stillinger and Washington State University Marion Ownbey herbaria. To account for site variability, 77 additional plots were established near the shared sampling sites using a random design, stratified by aspect and elevation. Aspect and elevation are major drivers affecting plant species composition on the Palouse Prairie (Hanson et al., 2008). To the extent possible, these sites were spread proportionally to available strata area. Overall, 104 transect plots were sampled to determine cover by species. Total cover of non-native grass species and the Shannon's diversity index were calculated for each plot after data collection using the R software environment for statistical computing and graphics (R Core Team 2014). Cover values for non-native grasses were averaged to estimate the percent cover of non-native grass species for each plot. The Shannon's diversity index was also calculated using species cover estimates for each plot. The Shannon's diversity index was chosen because it is more sensitive than the Simpson diversity index to the presence of rare species (Hill 1973). To account for the variability of floral diversity and abundance of non-native grass around pollinator trapping sites, Shannon's diversity indices (Plant Diversity) and non-native grass cover (Non-native grass) estimates for plots within 1 km of each trapping site were averaged.

Bee collection occurred between May and July in 2011. Blue vane traps filled with soapy water (Springstar Inc., Woodinville, WA) (Stephen & Rao, 2007), colored pan traps, and an aerial net were used. Traps were placed for 24 hours four times. Netting took place for 5 minutes at the time of trap placement and removal (80 minutes of collection at each site). Netted bees were frozen before pinning and identification. Bees collected in blue vane traps or pan traps were rinsed in ethanol and then placed in a Whirl-Pak® bag (Nasco, Fort Atkinson, WI) and covered with ethanol for temporary storage. Bees stored in ethanol were then washed, dried and pinned (methods adapted from Droege 2009). Bees were identified to genus, or to species when possible. Bee species richness was rarefied using individual based rarefaction with the VEGAN package in R (Oksanen et al. 2015, R core team, 2015) to account for different levels of trap effectiveness in different environments.

Amount of suitable bee forage was determined by combining data from several sources. The USDA-cropscape data layer (USDA-NASS-CDL 2010, 2011) was used in conjunction with NAIP imagery and high-resolution aerial photographs (taken from google maps) to heads-up-digitize polygons delineating different types of land cover using ArcGis 9 (ESRI, Redlands CA). Sixteen categories were initially used: dense forest, open forest, highly developed land, lightly developed land, hay/pasture/CRP, natural land, spring wheat, winter wheat, beans, canola, garbanzos, dry peas, lentils, barley, grass seed, and alfalfa. Areas were designated as 'natural land' if they appeared to have heterogeneous plant cover when viewed in a high-resolution aerial photograph. Resulting polygons were converted to raster format using the Feature to Raster tool in ArcGis 9 and then reclassified using the Reclass tool in ArcGis 9 to into areas of suitable bee forage (open forest, natural land, and lightly developed land) and areas of not suitable forage (everything else). A 1,250m circle was delineated around each sampling site using the Ring Buffer tool in ArcGis 9 and the amount of suitable forage was quantified using the Tabulate Area tool in ArcGis 9. This data was then log transformed.

Soil depth to root restrictive layer was measured by averaging four points along a 12 meter transect using a manual probe at each of the 26 sites. Soil was collected from a single point, air-dried, and milled. Soil texture was determined by the hydrometer method (Bouyoucos, 1962). Organic matter was determined by the loss-on-ignition method (Nelson & Sommers, 1982). Nitrogen as nitrite and ammonium were determined by 1N KCl cadmium reduction (Gavlak et al., 1994). Phosphorous was determined by Morgan extraction (Gavlak et al., 1994).

4.3.3 Factor analysis

Exploratory factor analysis was used to assess the ecological quality of the Palouse Prairie ecosystem and to calculate a composite measure. This method provides a mechanism to evaluate the underlying structure of the variables that make up ecological quality by defining it as a set of variables that are highly interrelated and reduces the variables into a single composite measure called a factor or latent construct. Factor analysis is typically used as a data reduction technique, where the goal is to identify the fewest number of factors through analysis of the scree plot and eigenvalues. However, our goal was not data reduction, but rather generating a composite measure of ecological quality. To accomplish this, the model was constrained to a single-factor solution to represent ecological quality. Variables of the model were chosen using expert opinion and an iterative process of evaluating models against each other and choosing the model that provided the highest loadings, was theoretically consistent, and provided a balance of measures representing plants, bees, and soil characteristics. If not constrained, the model would have resulted in in a 4 or 5 factor solution. A hierarchical model was not feasible for this study due to the smaller sample size. However, this would be the recommended method for larger datasets. The factor analysis was completed using maximum likelihood estimation and no rotation was necessary since the model was constrained to a single factor. The ecological quality variables are measured with different units, making direct comparisons between them difficult. Therefore, standardized coefficients (scoring coefficients) were used. The standardized regression coefficients convert the observed variables into a standardized format that accounts for differences in their range and variance. The result is that the observed variables are presented in terms of the number of standard deviations the variable is from its mean.

The calculated composite measures of ecological quality were mapped onto the economic value for ecological quality by first generating a model of WTP for ecological quality and then assigning the composite scores of ecological quality to WTP values. WTP for low, medium, and high ecological quality were mapped as a scatter plot and a quadratic regression was used to generate a fitted line. The quadratic regression was chosen over a linear regression because the relationship between ecological quality and WTP for its conservation is nonlinear, i.e., it increases at a decreasing rate. Ecological quality factor scores were then assigned to WTP values. First, the factor scores were divided into ranges of low, medium, or high. Within the collected dataset, there were no apparent natural breaks and there is also no ecological theory or historical context available to assign breaks. As a result, the ecological quality composite scores were assigned by dividing the distribution into three equal parts. The minimum composite score was assigned to WTP for low ecological quality, the middle composite score was assigned to medium ecological quality, and the largest composite score was assigned to high ecological quality. A new quadratic regression was run using the replaced values. Using the new regression, WTP for ecological quality of an individual site can be determined by substituting the factor score estimate into the regression. This allows estimation of WTP along a continuum rather than being binned into one of three fixed values.

4.3.4 Coupling ecological and survey data to determine WTP

The relationship between changes in measures of ecological quality and their effect on the economic value for ecological quality was evaluated using the scoring coefficients. Scoring coefficients provide results such that a one standard deviation increase in the independent variable (measure of ecological quality) results in a beta increase or decrease in the standard deviation of the dependent variable (factor). While directly comparable, this result is often difficult to understand and integrate into policy analysis. Therefore, a more interpretable measure of the average change in WTP for conservation was calculated for each measure of ecological quality. This was accomplished through multiple steps. First, standard deviation was calculated for each variable so that real value of a standard deviation change was known. The average change in the standard deviation of ecological quality was found by multiplication of the scoring coefficient and the standard deviation of ecological quality. While the change in ecological quality is linear, its impact on WTP is not. WTP values were calculated across the ecological quality composite score distribution at 125 equidistant points and used as base values. The analysis only required 125 data points because increases in the number of data points used did not result in any additional accuracy when rounded to two decimal places. All 125 base ecological quality scores were increased by the average change in ecological quality for the independent variable. New WTP values were calculated using a quadratic regression based on the new ecological quality scores. The difference between the new and base WTP values were averaged to arrive at an average change in WTP based on the average change of the independent variable.

Finally, WTP for conservation of individual study sites was calculated. For each site, WTP was calculated for each of the five attributes: size, ecological quality, presence of the GPE, presence of rare or threatened plants, and public access. These values are summed together to provide a total WTP for conservation of that site in its current condition.

4.4 Results

Mean WTP values and lower and upper limits for each attribute of conservation are provided in Table 4-2. The attributes that only list a single WTP value, including the GPE, threatened plants, and public access only had two alternatives: e.g., present or not present. The WTP value for the GPE is positive if it is present and will increase WTP for conservation of a site by $21.79. The negative of this value is the amount that WTP for conservation will decrease if the GPE is not present.

Table 4-2: WTP for each level of the attributes, lower limits, and upper limits in dollar amounts (WTP per hh per year). The asterisk (*) indicates an omitted variable.

ATTRIBUTE	WTP	LOWER LIMIT	UPPER LIMIT
SMALL SIZE (< 1 ACRE)	−$34.42	−$43.09	−$25.75
MEDIUM SIZE (1 - 5 ACRES)	$6.66	−$0.73	$14.05
LARGE SIZE (> 5 ACRES) *	$27.77		
LOW ECOLOGICAL QUALITY	−$53.17	−$62.56	−$43.78
MEDIUM ECOLOGICAL QUALITY	$12.34	$5.05	$19.63
HIGH ECOLOGICAL QUALITY *	$40.83		
GPE PRESENT	$21.79	$16.55	$27.03
THREATENED PLANTS PRESENT	$38.99	$33.05	$44.94
PUBLIC ACCESS	$28.98	$23.49	$34.47

The results of the nested logit model indicate that the WTP for low ecological quality is −$53.17 medium ecological quality is $12.34, and high ecological quality is $40.83 per hh per year. The interpretation of these values is fairly straightforward. If a Palouse Prairie site is considered to have low ecological quality, this decreases the total willingness-to-pay for conservation of that site by $53.17 per year. The total value of conservation of that site may still be positive, since WTP for conservation of the site is a function of the size, ecological quality, presence of the Giant Palouse earthworm, presence of rare or threatened plants, public access, and other unmeasured and unobserved factors. A site that has medium ecological quality will increase WTP for conservation of that site by $12.34 and a site that has high ecological quality will increase WTP for its conservation by $40.83.

The loadings, uniqueness, communality and scoring coefficients from the factor analysis are provided in Table 4-3. Loadings are the correlation between the measured variable and the factor. Uniqueness is the variance of each variable that is unique to that variable and not explained or associated with other variables in the factor analysis. Communality is the total variance of a variable that is shared with all other variables in the analysis, and is calculated as the square of the loading.

Table 4-3: Loadings, uniqueness, and communality of variables from factor analysis, and the proportion of variation explained by all of the variables.

VARIABLE	LOADING	UNIQUENESS	COMMUNALITY
PLANT DIVERSITY	0.7970	0.3647	0.6353
BEE RICHNESS	0.5578	0.6889	0.3111
AVG NON-NATIVE GRASS COVER	0.4712	0.7780	0.2220
SUITABLE FORAGE	0.8256	0.3185	0.6815
PATCH AREA	0.7014	0.5081	0.4919
SOIL DEPTH	−0.1150	0.9868	0.0132
PERCENT SAND	0.3875	0.8499	0.1501
ORGANIC MATTER	−0.1892	0.9642	0.0358
NITROGEN	0.1213	0.9853	0.0147
PHOSPHOROUS	0.1389	0.9807	0.0193
		7.4251	2.5749
PROPORTIONAL VARIATION EXPLAINED			25.75%

The regression of the observable variables on the composite score estimate is provided in Table 4-4. Since the variables are measured using different units, it is difficult to compare these coefficients against each other. Therefore, the standardized regression coefficients, or scoring coefficients, are also provided in Table 4-4.

Table 4-4: Regression coefficients, and standardized (scoring) regression coefficients of ecological quality variables on the factor scores.

VARIABLE	COEFFICIENT	SCORING COEFFICIENT
CONSTANT	−7.423	--
PLANT DIVERSITY	0.707	0.319
BEE RICHNESS	0.021	0.118
AVERAGE NON-NATIVE GRASS COVER	0.004	0.088
SUITABLE FORAGE	0.432	0.379
PATCH AREA	0.004	0.202
SOIL DEPTH	−0.0004	−0.017
PERCENT SAND	1.042	0.067
ORGANIC MATTER	−1.629	−0.029
NITROGEN	0.003	0.018
PHOSPHOROUS	0.002	0.021

Using plant diversity as an example, the unstandardized coefficient can be interpreted to say that a one-unit increase in plant diversity results in a 0.707-unit increase in the ecological quality estimate. The standardized coefficient can be interpreted to say that a one standard deviation increase in plant diversity results in a 0.319 standard deviation increase in the ecological quality estimate. The constant of a regression is calculated by inserting a column of ones into the dataset (with mean of 1 and variance of zero). Therefore, in a standardized format the constant drops out of the equation.

A fitted quadratic regression line of WTP for ecological quality is provided in Figure 4-4. Ecological quality resulted in a minimum value of -2.41 and a maximum value of 1.15, and was divided into bins based on the distribution of factor scores. Low ecological quality includes sites with composite scores less than −1.22, medium ecological quality sites include factor scores greater than or equal to −1.22 and less than −0.04, and high ecological quality sites include factor scores greater than or equal to −0.04. The values for the bins were used to replace the categories of low, medium, and high to generate a continuous rather than categorical ecological quality axis.

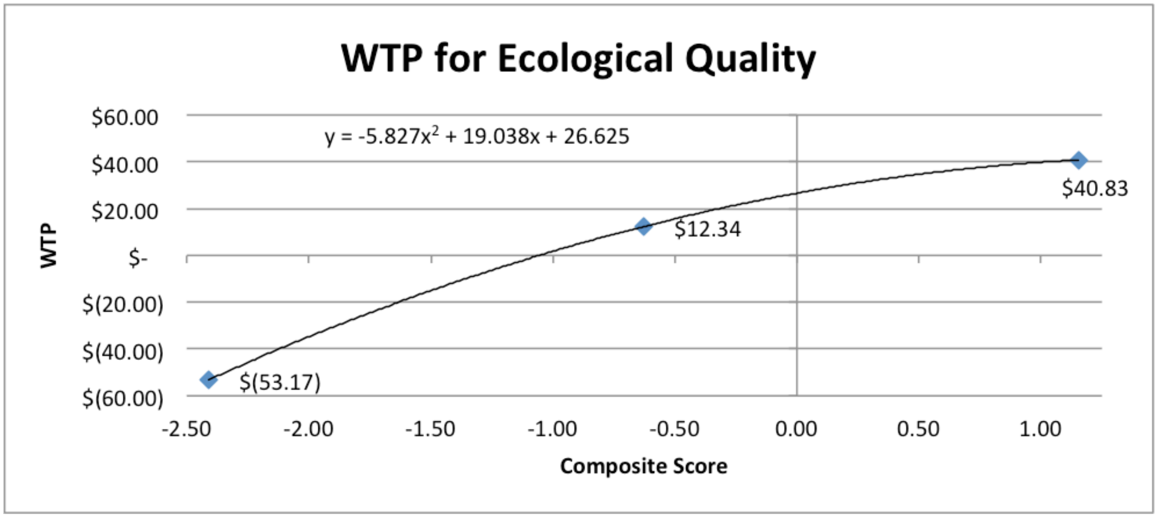

Figure 4-4: Graph of WTP for ecological quality. Ecological quality is represented by the composite ecological quality index on the x-axis. The quadratic regression of WTP (DV) and ecological quality (IV) is also represented. WTP for low, medium, and high ecological quality are -$53.17, $12.34, and $40.83 respectively.

Rather than being constrained by WTP falling into one of three categories and assigning it to the WTP for that category, WTP can now be based on the factor score for the site to allow a continuous determination of WTP. So, in practice, if site A has a composite score of 0.18, substituting this value into the regression results in a WTP for the site of $29.90. This site would have originally been categorized as a high quality site and assigned a WTP of $40.83, overestimating the value of the site by $19.51.

The standard deviations and average change in WTP for each ecological factor in our model are provided in Table 4-5. For example, an increase of one standard deviation in plant diversity is equal to a 0.45 increase in the Shannon-Weiner diversity index. This increase in plant diversity would result in an increase in the average change in WTP for ecological quality by $7.31.

Table 4-5: Variable unit of measure, standard deviation and average change in willingness-to-pay for conservation based on one standard deviation change in the variable.

VARIABLE	UNIT OF MEASURE	ONE STD. DEV.	AVG. CHANGE IN WTP
PLANT DIVERSITY	Shannon-Weiner Diversity Index	0.45	$7.31
BEE RICHNESS	Rarefied Bee Richness Index	5.66	$2.83
NON-NATIVE GRASS COVER	Percentage	20.28	$2.13
SUITABLE FORAGE	Ln Meters^2	0.88	$8.56
PATCH AREA	Meters^2	56.30	$4.74
SOIL DEPTH	Centimeters	42.15	—$0.42
PERCENT SAND	Percentage	0.06	$1.61
ORGANIC MATTER	Percentage	0.02	—$0.71
NITROGEN	mg/kg	7.08	$0.44
PHOSPHOROUS	mg/kg	13.25	$0.51
ECOLOGICAL QUALITY	Factor Score	0.92	

Using data from individual sites, a total WTP for conservation of each site was calculated. The hypothetical best and hypothetical worst possible sites are also provided for reference. All of the sampled sites had at least one positive or negative attribute, preventing them from falling into parity with the best or worst case.

Table 4-6: WTP values for individual attributes of each site (size, ecological quality, presence or absence of the giant Palouse earthworm, presence or absence of threatened plants, and public access) and total WTP for individual sampled sites.

SITE	SIZE	ECOLOGICAL QUALITY	GPE	THREATENED PLANTS	PUBLIC ACCESS	TOTAL WTP
1	$6.66	—$53.17	—$21.79	—$38.99	—28.98	—$136.27
2	$27.77	$39.04	$21.79	—$38.99	—28.98	$20.63
3	—$34.42	—$2.64	—$21.79	—$38.99	—28.98	—$126.82
4	$27.77	$33.52	$21.79	$38.99	28.98	$151.05
5	$27.77	$29.90	$21.79	$38.99	28.98	$147.43
6	$27.77	$36.46	—$21.79	—$38.99	—28.98	—$25.53
7	$6.66	$10.60	—$21.79	—$38.99	—28.98	—$72.50
8	$6.66	$29.35	—$21.79	—$38.99	—28.98	—$53.75
9	$27.77	$19.79	—$21.79	—$38.99	—28.98	—$42.20
10	$27.77	$17.92	—$21.79	$38.99	—28.98	$33.91
11	$27.77	$36.10	—$21.79	$38.99	—28.98	$52.09
12	$27.77	$40.83	—$21.79	—$38.99	—28.98	—$21.16
13	$6.66	$26.64	—$21.79	—$38.99	—28.98	—$56.46
14	$27.77	$40.06	—$21.79	—$38.99	—28.98	—$21.93
15	$27.77	$34.93	—$21.79	—$38.99	—28.98	—$27.06
16	—$34.42	—$14.00	—$21.79	—$38.99	—28.98	—$138.18
17	$6.66	—$29.54	—$21.79	—$38.99	—28.98	—$112.64
18	$27.77	$31.61	—$21.79	—$38.99	—28.98	—$30.38
19	$27.77	$30.93	—$21.79	—$38.99	—28.98	—$31.06
20	$27.77	$33.52	—$21.79	$38.99	28.98	$107.47
21	$27.77	$39.88	$21.79	—$38.99	—28.98	$21.47
22	$27.77	$38.96	$21.79	—$38.99	28.98	$78.51
23	$27.77	$40.38	$21.79	—$38.99	28.98	$79.93
24	$27.77	$37.09	—$21.79	—$38.99	28.98	$33.06
25	$6.66	—$0.33	—$21.79	—$38.99	—28.98	—$83.43
26	$27.77	$34.66	—$21.79	—$38.99	—28.98	—$27.33
27	$6.66	$16.86	—$21.79	—$38.99	—28.98	—$66.24
28	—$34.42	$22.68	—$21.79	—$38.99	—28.98	—$101.50
29	—$34.42	$10.77	—$21.79	—$38.99	—28.98	—$113.41
HYPOTHETICAL WORST	—$34.42	—$53.17	—$21.79	—$38.99	—28.98	—$177.35
HYPOTHETICAL BEST	$27.77	$40.83	$21.79	$38.99	28.98	$158.36

4.5 Discussion

This research developed a method for integrating economic value with ecological quality. It presented an adaptable framework that could be implemented across interdisciplinary teams and in other ecosystems. Further research is needed to understand ecological quality across ecosystems and the relationships between ecological quality indicators. Providing ecological quality information to policy makers is important, but it is often not integrated into the decision making process due to a lack of understanding, the complexity, difficulty in comparing alternatives, and lack of a common metric. Providing information about ecological quality in terms of changes to economic value helps policy-makers understand the contribution that these variables have to the overall ecological quality and how ecological quality contributes to the overall economic value of Palouse Prairie conservation.

The Palouse Prairie ecosystem is endangered (Black et al., 1998; Noss et al., 1995) and finding ways to preserve this unique grassland is a priority for the conservation-minded. Developing methods of conservation requires an understanding of what is important to residents of the region and being able to translate those priorities to decision-makers. One characteristic of the Palouse Prairie that is extremely important to residents is the ecological quality of the remaining sites. However, ecological quality is a complex concept, with multiple measures and is not conducive to standard valuation methods. To approach the problem, ecosystem characteristics that are valued based on services they provide directly, or support ecologically, must be identified. Here we used measures of native plant species richness, the central attribute for defining Palouse Prairie as a conservation target, and related ecological factors that support this community (pollinator communities and soil attributes), as the basis for a metric of ecological quality. We then take a novel approach to integrate these components of ecological quality to determine how they can influence the economic value for Palouse Prairie conservation. A choice experiment was used to determine the economic value for conservation of the Palouse Prairie and of ecological quality. Data on measures of ecological quality were collected and factor analysis was used to evaluate the relationships between the ecological variables and to calculate composite scores and coefficients. Composite scores for ecological quality were translated into WTP values. Scoring coefficients were used to frame the effects of improving the ecological variables on overall WTP, presenting the data into a policy-relevant and interpretable format. WTP for individual sites were presented as points of reference.

Using a choice experiment to calculate economic value is an established method. However, including ecological quality as an attribute is still an uncommon practice. Examples of methods for describing ecological quality within a choice experiment have included: to use biodiversity as a proxy variable (Birol et al., 2006; Carlsson et al., 2003; Chan-Halbrendt et al., 2007), use an index of quality or biotic integrity (Johnston et al., 2011), or use categorical variables (Hanley et al., 2005; McGonagle & Swallow, 2005). It was important to include ecological quality as an attribute in the survey because stakeholders consistently identified it as important. Categorical levels with qualitative descriptions were used rather than a continuous index due to difficulty in creating and describing an index to respondents.

Factor analysis produced an ecologically sensible model. The relationship between total habitat area and bee species richness has been observed before (Kremen, Williams, & Thorp, 2002). Increased plant species richness has been linked to bee species richness

(Tscharntke et al., 1998). The invasion of non-native grasses on the Palouse Prairie has been demonstrated to be negatively correlated with vascular plant, biological soil crust, and pollinator diversity on the Palouse Prairie (C. Davis, 2015). Uniqueness was high reflecting weak correlations between ecological relationships.

Soil depth was the least important variable, just barely below nitrogen. Soil depth and organic matter are negatively correlated with ecological quality, indicating that as the variables decrease, ecological quality increases. This may be explained by the non-random selection of remnants. Most remaining Palouse Prairie fragments are found on steep slopes and rocky ridges since they are unsuitable for industrial cultivation. As such, the hillslope position of these soils is where the least amount of soil development takes place.

Factor analysis has been used extensively to evaluate water quality (Muxika, Borja, & Bald, 2007; Sheela et al., 2012), but has had very limited use in the analysis of terrestrial ecosystems, see Shukla et al. (2006) for a factor analysis of soil quality indicators. Additional examples of factor analysis to evaluate ecological quality include groundwater quality (Liu, Lin, & Kuo, 2003), soil quality (Brejda, Moorman, Karlen, & Dao, 2000; Shukla, Lal, & Ebinger, 2004; Shukla et al., 2006), ecological quality of urban green spaces (Tian, Jim, & Wang, 2014), and ecological quality for white spruce (Wang, 1993). WTP for conservation can be assessed using a choice experiment, and has been used to evaluate forest (Lehtonen, Kuuluvainen, Pouta, Rekola, & Li, 2003), tropical rainforest (Rolfe, Bennett, & Louviere, 2000), wetland (Ghermandi, Van den Bergh, Brander, De Groot, & Nunes, 2008; Kaffashi et al., 2012), and prairie ecosystems (Decker et al., 2016). We are unaware of any other study that combines these two methods to assign economic value to measures of ecological quality.

Factor analysis is especially well suited to disciplines where the relevant variable and their relationships are not well understood, as in ecology (Comrey & Lee, 1973). Exploratory factor analysis is conventionally used to uncover latent variables. It is a common misunderstanding that high numbers of observations and low numbers of variables are required (Comrey & Lee, 1973). However it has been demonstrated through simulations by de Winter et al. (2009) that the number of observations and variables is entirely dependent on the latent factors, which are unknown.

The scoring coefficients were also used to calculate the average change in WTP based on a change to a measure of ecological quality. The change in WTP is not constant, i.e., increases to lower ecological quality sites will be worth more than increases to higher ecological quality sites. The change in WTP resides along a quadratic function, which was calculated from the quadratic regression previously used to assign factor score values to WTP values.

WTP for conservation of individual sites can inform decision makers about the current value of specific sites and to help identify high value sites. Of the 29 sites sampled, 10 had a positive WTP value. These sites were located on Paradise Ridge, Kamiak Butte (hosting 2 sample sites), Rose Creek, Smoot Hill, Steptoe Butte (hosting 3 sample sites), Kramer, and a privately owned site. It should be noted that the only privately owned sites are Paradise Ridge and Rose Creek, which is owned by a local NGO. The other listed sites are owned by either governmental agencies or non-governmental organizations. This reflects the large influence of site access on willingness to pay. Sites with negative WTP values indicate residents have no WTP for conservation of these sites in their current state. However, these sites can be targeted for improvement. Increasing the size or ecological quality of these sites, introducing the giant Palouse earthworm or threatened plants or allowing public access to these sites can increase their economic value to a positive value, and will provide the biggest return on investment. Understanding the attributes that provide value to people and the cost of improving those attributes provides organizations the ability to conduct a benefit-cost analysis on their projects and to demonstrate that they are creating a net benefit to their constituents. The choice experiment method is better utilized for calculating WTP for change rather than a static value. Moving a site from the worst case situation with a WTP value of -$177.35 to the best case situation with a value of $158.36 would be an improvement in value of $335.71 per household per year. However, while this may be representative of the change in value that households have for this improvement, it is unrealistic to expect them to be willing to pay for such a large change in a single year. In fact, while almost 40% of surveyed households chose the maximum cost option at least once, thus indicating that they were willing to pay $150 or more for Palouse Prairie conservation, the average WTP for Palouse Prairie conservation per household per year was $82.74.

4.6 Conclusions

Integrating ecological quality into economic value is necessary because the quality of an ecosystem determines the level of ecosystem services provided, which in turn provides its value. While not an easy task, recognizing and measuring this interconnectivity is essential to informing future conservation efforts. This study demonstrates a methodology to integrate measures of ecological quality into economic value using the Palouse Prairie as a case study. While direct measures of ecological quality, such as plant diversity, are presented with an average change in WTP, it is not recommended that this be interpreted as the value of those measures. Rather, the dollar signs could be removed and the numbers could be interpreted as that variables relative contribution to the overall ecological quality of the ecosystem in a standardized metric. The measured variables that are contributing the most to overall ecological quality are plant diversity, suitable forage, and patch area. However, due to feedbacks within the ecosystem, changes to a single variable are likely to result in changes to all the variables in the model.

This proposed method will need to be further developed in order to generate the best solutions. The results of the factor analysis method is dependent on the variables chosen for the model, and variables chosen need to be based on a sound theoretical foundation. Measures of ecological quality are often hard to gather due to time and budget constraints and difficulty with measuring biota, that don't necessarily want to be measured. Factor analysis measures the covariation between variables, but ecological variables are often influenced by variables outside the model and do not necessarily respond at the same time, with some variables having a lagging response. Additional verification of this methodology will be required across multiple ecosystems in order to validate its usefulness as a tool.

Despite the underlying difficulties with this approach of integration, these results highlight the potential benefits of interdisciplinary collaboration between ecological and social scientists and the value that this method can provide to informing conservation efforts in a more comprehensive and understandable format. The use of this tool, and others like it, can promote an improved understanding of the influence of measures of ecological quality and its contribution on overall economic value for conservation.

Chapter 5: Social values of culturally significant plants on the Palouse Prairie, an endangered grassland in the United States

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5.1 Abstract

Culturally significant plants can provide benefits to humans under multiple ecosystem service categories, yet the value supplied can be difficult to translate into economies and markets. Non-economic valuations can be useful tools for assessing the value in these situations or when economic valuations may be considered inadequate or insensitive to certain social perspectives. This study sought to assess the social value of culturally significant plants on the Palouse Prairie in northern Idaho and southeastern Washington to identify support for the conservation of culturally significant plants and to provide an alternative valuation methodology based upon semi-structured interviews and a general population survey. The study found that Native Americans of the region and 36 percent of the respondents from the general population considered culturally significant plants valuable. In addition, the demographic factors gender, level of conservatism, economic level, self-identified heritage connection with the study area, and views on basing conservation decisions upon a dollar amount each had a statistically significant effect on respondents' views on valuing culturally significant plants. The study differs from other valuations by focusing on the perspectives of both Indigenous and non-Indigenous populations and assessing the social value of culturally significant plants using quantitative and qualitative approaches.

5.2 Keywords

Culturally Significant Plants, Cultural Services, Heritage, Ecosystem Services, Non-Economic Valuations, Native Americans

5.3 Introduction

The ecosystem services framework involves quantifying and valuing conditions and processes through which ecosystems and biodiversity sustain, benefit, and fulfill human life. The global benefits of ecosystem services (ES) are enormous because human societies could not exist without them (Daily, 1997). Ecosystem services can include provisioning, regulating, habitat, supporting, cultural and amenity services (de Groot, Alkemade, Braat, Hein, & Willemen, 2010; MA, 2005). Scientists and policy makers are increasingly describing ecosystems and biodiversity as “environmental capital” or “natural capital” (Holdren & Lander, 2011; Kareiva, Tallis, Ricketts, Daily, & Polasky, 2011). Economic valuations of ES can be used to prioritize conservation (van Berkel & Verburg, 2014) and can be incorporated into markets to inform policy decisions (R. Costanza et al., 1998). Accounting for the value of ES may help guide society in assessing the impacts of degradation and loss of these services (Pascual, Muradian, Rodríguez, & Duraiappah, 2010). The need to quantify and value ES is widely accepted by scientists and policy makers (Daniel et al., 2012).

Despite the acknowledged importance of economic valuations of ES, economic valuations alone are considered by some to be inadequate or insensitive to the perspectives of certain stakeholders with differing social views (Burger, 2011; Johansson-Stenman, 1998). For example, stakeholders who consider the natural environment sacred may reject the notion of quantifying how much they would be willing to pay to sustain a particular ES (K. M. Chan et al., 2012). Indeed, indigenous cultures could view economic valuations as part of the colonial process premised on commoditization of the natural world and hence fundamentally unacceptable. How to value ES in a manner that is sensitive to these social and cultural perspectives but compatible with global economic forces is a significant challenge. To address the inadequacy of a strictly economic valuation of cultural ES, Chan et al. (2012) proposed a multi-metric approach that included non-monetary variables. Our study applied a non-monetary approach to value culturally significant plants, as they do not fit well into any one category of ecosystem services and fact that economic valuation of such plants may be considered insensitive to certain social perspectives.

"Culturally significant plants" are defined here as any native plant, lichen, moss, or fungus that can be used for food, teas, medicine, in ceremonies, or materials used in artisan craft. The value of certain culturally significant plants can be difficult to ascertain due to their wide variety of potential uses (e.g., food, medicine, spiritual enrichment, etc.) that do not fit well into any one ES category. For example, determining the value of a plant used in religious ceremonies may be particularly challenging because its importance to people is not easily translatable to economies and markets. Due to the level of intangibility the value supplied can be difficult to quantify monetarily or even biophysically (Daniel et al., 2012; Milcu, Hanspach, Abson, & Fischer, 2013).

Culturally significant plants are valuable for the cultural services they provide, as defined by (MA, 2005, p. 40): "nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences". Furthermore, their conservation constitutes a cultural legacy from past to future generations. For example, Native Americans utilize culturally significant plants in religious ceremonies, as religious symbols, or as items of inspiration or spiritual enrichment

(Moerman, 1998; Stewart, 1987). Culturally significant plants can also provide provisioning, regulating, and habitat support services. For example, culturally significant plants and plant communities can provide aesthetic beauty or natural scenery, and provisioning ES as sources of wild food, medicine, and raw materials. They can also provide regulating or supporting ES through carbon sequestration and through their effect on minimizing soil erosion and increasing soil fertility. As part of a native plant community, culturally significant plants provide habitat and supporting services to wildlife.

Due to the difficulties with placing an economic value upon culturally significant plants, this study sought to examine a non-monetary approach to their valuation through semi-structured interviews and a general population sample survey. The focus area of the study was the Palouse region of northern Idaho and southeastern Washington (Figure 5-1). The Palouse region provides an ideal locale for examining non-monetary approaches to assessing the value of culturally significant plants, first, since the region was once considered a vast garden for culturally significant plants by the native inhabitants (Scheuerman & Finley, 2008), and second, because plant biodiversity is now severely at risk in the region due to the spread of invasive plants and loss of habitat from agricultural conversion (Black et al., 1998; Looney & Eigenbrode, 2012; Noss et al., 1995; Nyamai et al., 2011). Therefore, the goal of the study was to identify potential social synergies that could be used to influence conservation of culturally significant plants on the Palouse prairie. A social synergy is the interaction of social elements or common values that when combined produce a total effect that is greater than the sum of the individual elements or contributions to achieve a desired outcome.

5.3.1 Study Region

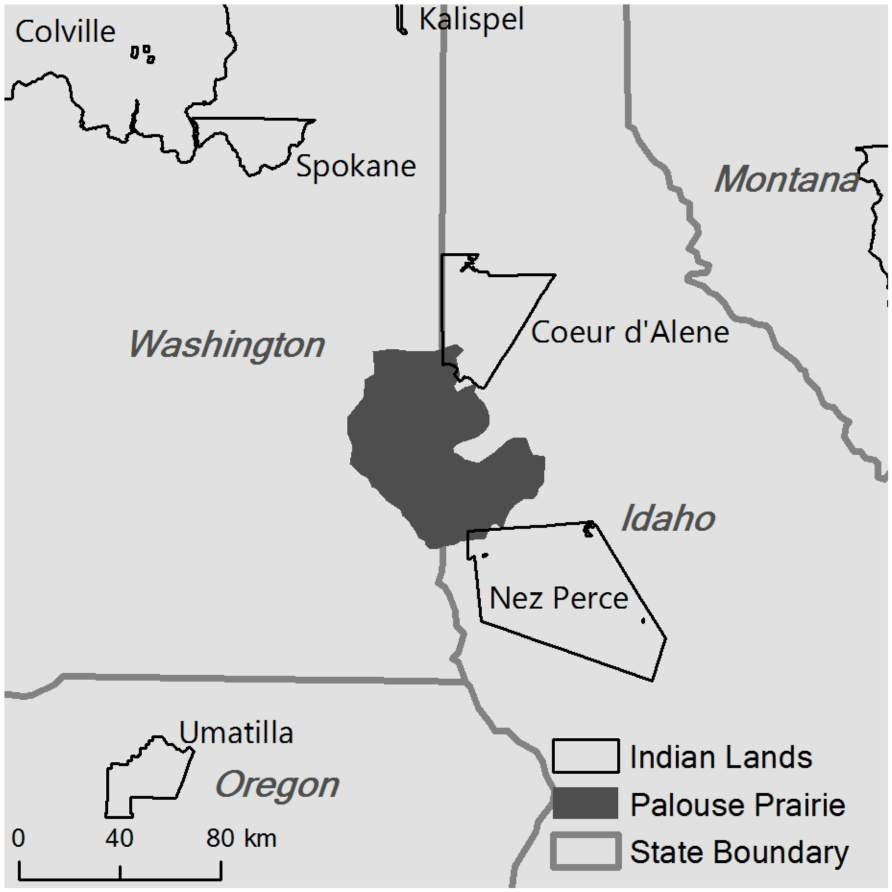

Figure 5-1: The core area of the Palouse prairie region in northern Idaho and southeastern Washington.

The Palouse Prairie grassland is critically endangered because most of its former extent is now dedicated almost exclusively to rainfed farming, mostly grain and pulse crops (Donovan et al., 2009; Hanson et al., 2008; Looney & Eigenbrode, 2012). The Palouse region has an extensive and significant prehistory. Some of the earliest records of humankind in North America have been uncovered in the nearby basalt canyons along the Snake River, so it is likely that there has been some human presence in the Palouse Prairie for at least 12,000 years (Black et al., 1998; Breckenridge, 1986; Chatters, 2004). When Lewis and Clark of the

Corps of Discovery entered the region in 1805, it was inhabited by Palouse (*Naha'ùumpùu*), Nez Perce (*Niimìipuu*), Spokane (*Sqeliz*), and Coeur d'Alene (*Schitsu'umsh*) peoples (Frey, 2011; Scheuerman & Finley, 2008; Sprague, 1998; D. E. Walker, 1998). The Palouse and Nez Perce speak the Sahaptin language and are culturally related.

Subsistence practices of the indigenous populations were based upon hunting, fishing, and gathering, as well as low-impact agriculture of native plant species (Black et al., 1998). The Palouse Prairie was particularly important for the gathering of edible and medicinal plants by the indigenous populations (Frey, 2011; Scheuerman & Finley, 2008; Sprague, 1998). The seasonally wet meadows and prairies of the Palouse Prairie supported high densities of the edible blue camas (*Camassia quamash*). When the horse was acquired in the 1700s, use of the area by Indigenous people diversified to stock raising (Black et al., 1998). However, most of the Indigenous population was severely reduced in size by 1860 through war, disease, and famine that resulted from Euro-American invasion and settlement (Sprague, 1998).

In the late 1800s, the Palouse Prairie underwent an extensive and profound transformation. Euro-Americans used the region in a dramatically different way from that of the Indigenous peoples (Black et al., 1998). Initially, Euro-Americans pastured livestock and grew tree fruits (K. R. Williams, 1991). Within a few decades, competition from areas better suited for fruit production and high returns for wheat production drove a nearly complete transition to grain farming (K. R. Williams, 1991). Since 1900 it has been estimated that as little as one tenth of one percent of the Palouse Prairie grassland remains (Noss et al., 1995). Today, the region is considered to be one of the United States' most productive dryland farming areas

(Duffin, 2005). What remains of the natural Palouse Prairie is considered an endangered ecosystem (Noss et al., 1995), and a large majority of it under private ownership (Black et al., 1998).

Valuations of culturally significant and wild plants involve ascribing value to a particular species using an index scoring system or economic valuation. The aim of many valuation methods for culturally significant plants is to identify the importance of plant species without investigator bias, often with a focus on subsistence use by Indigenous peoples (Cocks & Wiersum, 2003; Godoy, Lubowski, & Markandya, 1993; Hunn, 1982; Phillips, Gentry, Reynel, Wilkin, & B, 1994; Pieroni, 2001; Reyes-García, Huanca, Vadez, Leonard, & Wilkie, 2006; Stoffle, Halmo, Evans, & Olmsted, 1990; Thomas, Vandebroek, & Van Damme, 2009; Turner, 1988). However, we were unable to find any study that valued the importance of culturally significant plants using an integrated analysis of both Indigenous and a somewhat recent dominant immigrant population of Euro-Americans descent populations. In the Palouse, this sort of integrated assessment is appropriate because of the co-occurrence of both Indigenous and non-Indigenous populations.

5.4 Methods

The overall approach for this analysis included conducting semi-structured interviews with Nez Perce Tribal members to gain a better understanding of Indigenous eco-cultural priorities, concerns, and perspectives of the Palouse Prairie; as well as an analysis of sample survey responses by the local populations of the Palouse region. Information gathered via interviews was used to develop survey questions for a quantitative survey of the regional population that included both the Indigenous and non-Indigenous community.

5.4.1 Semi-structured interviews with tribal members

The Nez Perce and Coeur d'Alene Reservations span portions of what we are defining as the core area of the Palouse Prairie landscape. To gain approval to conduct interviews with Native American Tribes, meetings were held with the Nez Perce and Coeur d'Alene Tribal representatives. The interview protocol was approved as posing no significant risks to human subjects by the University of Idaho Institutional Review Board on August 27, 2012. A research permit with the Nez Perce Tribe was approved on June 26, 2012 by the Nez Perce Tribe Executive Committee. Permission to conduct semi-structured interviews with the Coeur d'Alene Tribe was not obtained. Six semi-structured interview sessions were conducted with multiple Nez Perce Tribal members who were identified by the local community as being knowledgeable of traditional language and culture. The interviews took place in 2012 and 2013 on the Nez Perce Reservation in northern Idaho. The questions posed during interviews were standardized, but recorded responses included extended discussions, consistent with semi-structured interview methods.

Responses to questions were recorded and coded based upon theme of the response. As part of the Nez Perce Research Permit, the Tribe was provided an opportunity to review information summarized and a draft of this manuscript to ensure protection of sensitive information of the Tribe. This included two reviews of earlier drafts of this manuscript and a printed hard copy delivered to the Cultural Department of the Nez Perce Tribe.

5.4.2 Sample Survey

Based upon the semi-structured interviews, three survey questions were developed related to valuing culturally significant plants and included in a more comprehensive survey aimed at valuing ES on the Palouse Prairie. The questions were number 28, 29, and 32 of a larger survey. These questions and the response options and provided (Table 5-1). The hypotheses of the sample survey analysis included: 1) culturally significant plants provide little value (i.e., less than 10 percent through sample survey) to the local community; and 2) demographic factors can be used to predict how the respondent values culturally significant plants. To test the first hypothesis respondents were asked to rate the importance of culturally significant plants on a scale of 1 to 5, with 1 being not valuable at all to themselves and their families and 5 being extremely valuable to themselves and their families. Due to low response rates for each level in the scale, responses were aggregated as follows: scores of 1-2 were considered Not Valuable, a score of 3 was considered Neutral, and scores of 4-5 were classified as Valuable. To test the second hypothesis, the importance rating of culturally significant plants was modeled by five demographic variables (i.e., Age Category, Education Level, Gender, Income Level, Political View, Heritage, and Dollar Appropriateness) and responses to questions 29 and 32. Responses to question number 29 were scored directly and not aggregated; the variable is termed "Dollar Appropriateness" from this point forward.

Table 5-1: Question 28, 29, and 32 of the Palouse Prairie sample survey instrument. Questions related to valuing culturally significant plants and were included in a more comprehensive survey aimed at valuing ES on the Palouse Prairie.

Question No. on Survey	Text of Question	Response options
28	Culturally significant plants are defined as any native plant, lichen, moss, or fungus that can be used for food, teas, medicine, in ceremonies or materials in artisan craft. On a scale of 1 to 5, with 1 being not valuable at all and 5 being extremely valuable, please rate how valuable culturally significant plants, lichens, mosses and fungus of the Palouse Prairie are to you and your family	Likert 1-5 with 1 indicating Not Valuable At All and 5 indicating Extremely Valuable
29	How appropriate or inappropriate is it to use a dollar amount to inform conservation decisions about Palouse Prairie	Likert 1-5, with 1 indicating Not Appropriate, 3 indicating Neutral, and 5 indicating Very Appropriate
32	The Palouse Prairie is part of my heritage	Likert 1-5, with 1 indicating Strongly agree, 2 indicating Somewhat agree, 3 indicating Neither agree nor disagree, 4 indicating Somewhat Disagree, 5 indicating Strongly disagree

Question 32 was posed in the survey to identify if the respondent considered the Palouse Prairie as part of their heritage. Respondents were also asked to identify if they “strongly agree”, “somewhat agree”, “neither agree nor disagree”, “somewhat disagree”, and “strongly disagree” with the statement “The Palouse Prairie is part of my heritage”. From this point forward this variable is referred to as “Heritage”. Responses to the question 32 also scored directly and not aggregated. For this point forward this variable is referred to as “Heritage”.

Demographic profile information was also collected to identify the respondents: age category, gender, education level, income level, and political view. Age of the respondent was collected with the question, “What year were you born (YYYY)?” with a blank space for the respondent to fill in. Responses were then categorized by taking the age difference from the year 2014 and tabulating the number of responses within the age categories: 18-25, >25-35, >35-45, >45-55, >55-65, and >65-93. Male or female gender was identified by the respondent selecting a box with “Male” or “Female” below the question “What is your gender?”. Political view was collected with the question, “On a scale of 1 to 7 where 1 is very liberal, 4 is moderate and 7 is very conservative, how would you describe your political views?”. Education level of the respondent was collected with question “What is the highest grade or year of school you completed?”. The respondent could identify education level by selecting the appropriate box with the following categories: “12th grade or less, no diploma”, “High school graduate or GED”, “Some college, no degree”, “Associate’s degree”, “Bachelor’s degree”, “Graduate or professional degree”. Gender, political view, income level, education level, heritage, age category, and dollar appropriateness were verified for homoscedasticity using the Bartlett test and Fligner-Killeen test (alpha 0.05). An eighth demographic factor, “ethnicity/race”, could not be assessed statistically because of a low response rate from minority groups and heteroscedasticity of the data.

The population sampled was people residing within the core area of the Palouse Prairie. This area included all of Latah County, Idaho and Whitman County, Washington. One thousand three hundred households were drawn proportionate to the population size in the two counties. Samples of 100 households were also drawn from Plummer (Benewah County, Idaho), Worley (Kootenai County, Idaho), and Lapwai (Nez Perce County, Idaho) for a total of 300 additional samples. Therefore the frame of this study was an address based sample of 1,600 residents in the Palouse Prairie area. Addresses were purchased from Survey Sampling Inc. of Connecticut. The address purchase was done to capture the perspectives of hard-to-reach populations such as ethnic minorities and those of lower socio-economic status. The towns of Plummer, Worley, and Lapwai are located within the Nez Perce and Coeur d'Alene Indian Reservations. Data collection was conducted by the University of Idaho Social Science Research Unit using a modified Dillman method (Dillman et al., 2009). This method has proven useful for increasing response rates (Hoddinott & Bass, 1986).

The modified method included four stages. At the first stage, a preselected postcard was mailed to all 1,600 households with a notification to expect a survey letter with an internet link to a web-based survey. The postcard with the world-wide-web based survey link followed within a few days. From this sample, 208 were returned as undeliverable. A $1.00 incentive was sent a week and half later to all non-responsive households to complete the survey. A paper survey with prepaid return envelope was sent to all remaining non-respondents as a final measure to increase response rate. Overall, the sampling strategy resulted in 241 surveys completed online and 180 completed paper copies for a total of 421 completed surveys (*n* = 421).

The sample survey was administered during the summer in a region that includes two large land grant universities. As a result the sample does not necessarily conform to the population demographics of the region when school is in session, but does primarily represent the perspectives of permanent residents of the region.

5.4.3 Data Analysis

Survey data were analyzed using the R program version 3.1.1. The analysis focused on the effect of seven demographic factors: Gender, Political View, Income Level, Education, Heritage, Age Category, and Dollar Appropriateness. We modeled these seven factors for predicting a response to a survey question on the value of culturally significant plants to the respondent and the respondent's family, on a scale ranging from Not Valuable (1), Neutral (2), and Valuable (3).

The ordered logistic regression (OLR) was executed using the *polr* command from the MASS package to estimate a model. This analysis is a proportional odds logistic regression to assess how demographic factors influenced the assessed importance of valuing culturally significant plants. P-values were calculated by comparing the regression t-value against the standard normal distribution. The logistic model used to show the function of the probabilities results in a linear combination of parameters is

Equation 5-1

$$\boldsymbol{ln\left(\frac{prob\ (event)}{(1-prob(event))}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k} \ .$$

The logit in this case is the ratio of the number of people who placed a value (i.e., Not Valuable, Neutral, Valuable) on culturally significant plants against those who held a different value. The resulting coefficients on the OLR model tell how much the logit changes based on the values of the predictor variables. The purpose of the model was to identify the relationship between value placed on culturally significant plants by gender, political views, income level, education, heritage, age category, and appropriateness of using a dollar value in conservation decisions related to valuing the importance of culturally significant plants.

Proportional probabilities were calculated independently upon predictor variables found to be significant. This was done by using the *polr* command fitting the value category by the variables found to be significant. These variables included: gender, income, political view, heritage, and appropriateness of using dollar value in conservation decisions. Model predictions were done using *predict* command of the Stats package of R.

5.5 Results

5.5.1 Interviews

The number of times reoccurring themes and issues identified during interviews with Nez Perce Tribal members is provided in Table 5-2. "The importance and names of natural foods" was the most frequently occurring theme. The traditional uses, practices, and values were the second most reoccurring theme. Two individuals also repeatedly identified a distinct difference in culture between the Nez Perce and dominant Western Society.

The use, knowledge, and importance of natural foods and traditional culture to interviewees were articulated during interviews. It was also revealed through the interviews that the epistemological perspectives of interviewees guided harvesting and use practices of the natural products on Palouse Prairie. One interviewee stated that, “The elders say the importance of one plant or animal should not be called out over another. All are important”. Another interviewee stated that, “When you die and your body decays to dust you return to mother earth. This is why the Nez Perce think land is sacred”. Another major theme and issue identified through the interviews was that there is a perceived difference in culture between Indigenous and non-Indigenous people. One interviewee stated:

> The dominant society wants to make the world like Europe. What is there you want to protect? Our natural foods and medicines are important to protect. Once these are gone they are irreplaceable. Where else can you get the natural foods? Nowhere. All our land, food, fish, and forest have been taken away.

Another interviewee stated, “White man thinks only certain points in the system are important, when the whole system is important”. There was concern that natural foods and medicines are being lost through environmental degradation and agricultural production activities. Concerns about the use of pesticides were identified by the interviewees. There is perception that when pesticides are applied that “poison is still there” and pesticide use has eliminated certain plant species.

The Palouse Prairie also represented a sense of place for several of the interviewees, either through knowledge of traditional use or features at a particular location. For example, the region now known as Moscow, Idaho, was known by Sahaptin speaking people as *Tatxinme* the “Fawn Place”. It was called the fawn place because it was a known fawning area for deer. It was also an important trading place for Indigenous people. There is also a very old oral tradition about Steptoe Butte and how the butte was once used to escape a flood. Several of the interviewees also stated that in the past the Palouse Prairie was also important for horse pasture.

Of all the plant species identified by the interviewees, camas was mentioned the most. Loss of camas due to agricultural practices (plowing, livestock grazing) and activities (pesticide use) was a major concern. Due to the loss of camas and worry of ingesting pesticides access to “pure” camas has diminished. One interviewee stated that traditional harvesting of camas is beneficial to camas because the digging tills up the soil. The traditional method of harvesting camas by the Nez Perce is to do so after seed ripening (late summer), and dropping seed into the disturbed soil after harvesting bulbs. Another interviewee stated that only large bulbs are harvested and smaller bulbs are left to grow.

Nez Perce elders expressed the importance of educating tribal youth in traditional language and culture, but there is some concern about sharing the knowledge with outsiders. Access to harvesting and use of natural foods and medicines is becoming more difficult due to development, landownership, and spread of invasive non-native species. Tribal members are traveling further to find harvest locations, usually on public land, that have not been impacted by agricultural activities. Due to the losses associated with agricultural production and invasive species there is a need for restoration and more sustainable use of the landscape.

There is also a perception that climate change has impacted water availability and has made wind and temperature more extreme. Oral traditions maintain that rivers used to freeze over and now they never freeze over. There is also a perception that climate change is altering the seasons and harvest times of natural foods and medicines.

There is a perceived lack of support of Tribal interests by local non-Indian politicians and federal land managers, despite the Tribes' right to exercise off-reservation treaty rights on both federal and private lands. One Tribal member also expressed the desire to reconnect to the Palouse Prairie through hunting, fishing and gathering.

Table 5-2: The number of Palouse Prairie issues and themes identified as priority or concern during interviews with Nez Perce Tribal members.

Theme/Issue	Number of Times Mentioned by Interviewees
Importance and names of natural foods	19
Traditional uses, practices, and values	12
Differences in culture among Natives and non-Natives	10
Degradation/loss of traditional cultural landscape	9
Tribal epistemology (i.e., All of the natural environment is important/connected, Lessons from Animals/Nature, Gifts from Creator)	9
Camas	7
Sense of place	7
Importance of educating Tribal members of traditional knowledge and language	6
Loss of access	5
Natural medicines	4
Seasonal uses	3
Invasive species	3
Pesticide use	3
Need for restoration	3
Traditional methods to promote natural replenishment	3
Climate change	3
Maintenance of Treaty Rights	3
Self-belief(s)	3
Importance of horse pasture	2
Exercise of off-Reservation Treaty Rights	2
Degradation/loss of water	2

Theme/Issue	**Number of Times Mentioned by Interviewees**
Dominant society failure to acknowledge impacts upon Native Americans and ecosystem	2
Importance of Treaty Right consultation	1
Importance of protecting traditional knowledge	1
Desire to reconnect to Palouse Prairie	1
Tactics of colonization	1

Although some of the respondents stated that all native plant or animal species are considered important, some species were specifically identified as being culturally significant (Table 5-3). Native American's interviewed also identified several locations on the Palouse Prairie where culturally significant plants can be harvested.

Table 5-3: List of specific native plants[1] of the Palouse Prairie identified as culturally significant to the Nez Perce Tribe during 2011 and 2013 semi-structured interviews. [1]Although these species were specifically identified during the interviews, Nez Perce Tribal members adhere to oral tradition that all native plants and animals are important.

Life Form Type	Scientific Name	Name Used by Interviewee
Bryophyte	Unknown	*Hoopop,* Pine moss
Vascular Plant	*Camassia quamash*	*Quem'es*, camas
Unknown	Unknown	Indian tea
Vascular Plant	*Vaccinium membranaceum*	Huckleberry
Vascular Plant	*Lomatium cous*	*Cous cous*
Vascular Plant	Unknown	*Qeqeite*
Fungus	Unknown	*Hepau*
Vascular Plant	Unknown	*Weim,* Celery
Vascular Plant	*Balsamorhiza sagittata*	*Pask*
Vascular Plant	Unknown	*Tetineze,* Shiners
Unknown	Unknown	Mountain tea
Vascular Plant	*Allium* sp.	Onion
Fungus	*Morchella* sp.	Morels

5.5.2 Sample Survey

Likert plots were used to show sample survey results by demographic groupings (i.e., age category, gender, education level, income level, and political view), heritage, and dollar appropriateness.

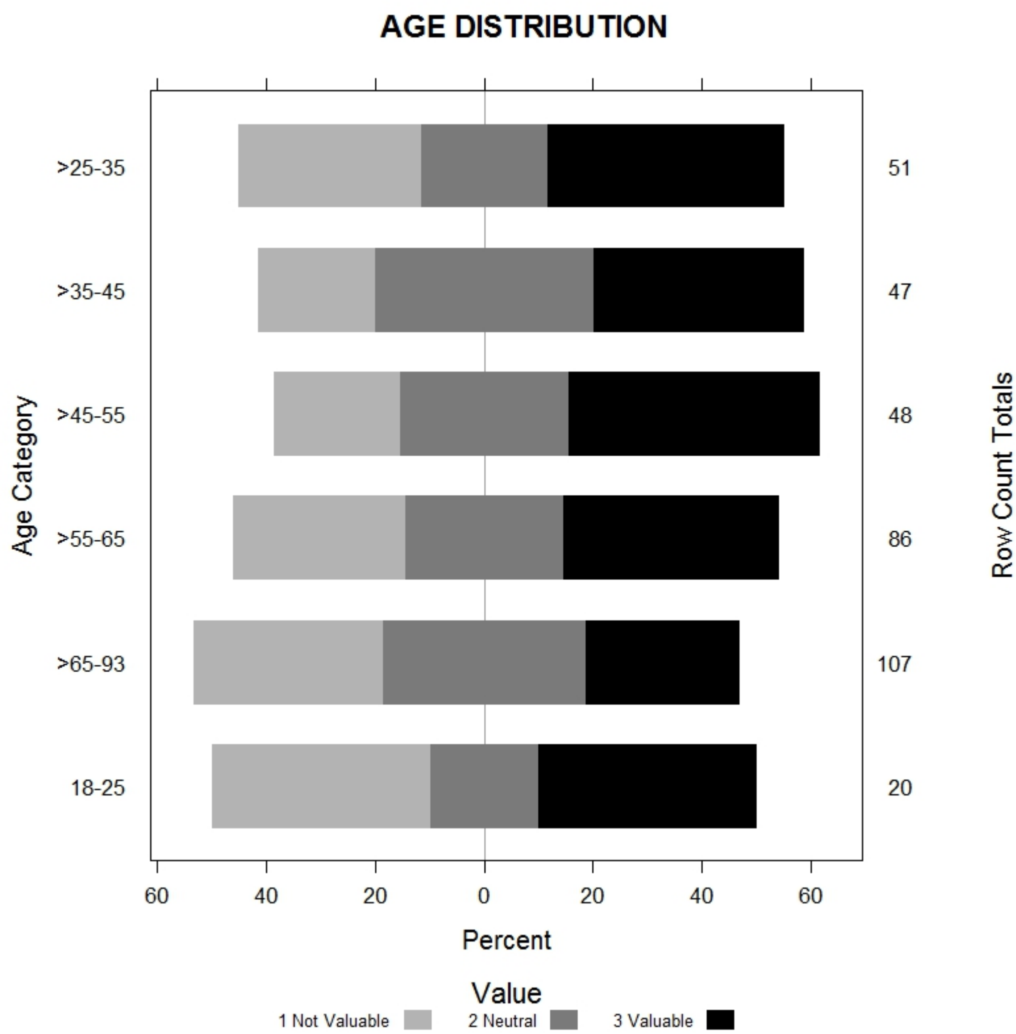

Figure 5-2: Likert plot of the proportions of survey respondents indicating culturally significant plants are not valuable, neutral, or valuable to themselves and their families, sorted by age category. Percentage of responses is provided on the x-axis, age category on the left y-axis and row count totals (tabulations) on the right y-axis.

The age distribution, category of “>45-55” had the highest percentage of respondents who considered culturally significant plants as valuable, while the age-category of “>65-93” years had the lowest (Figure 5-2).

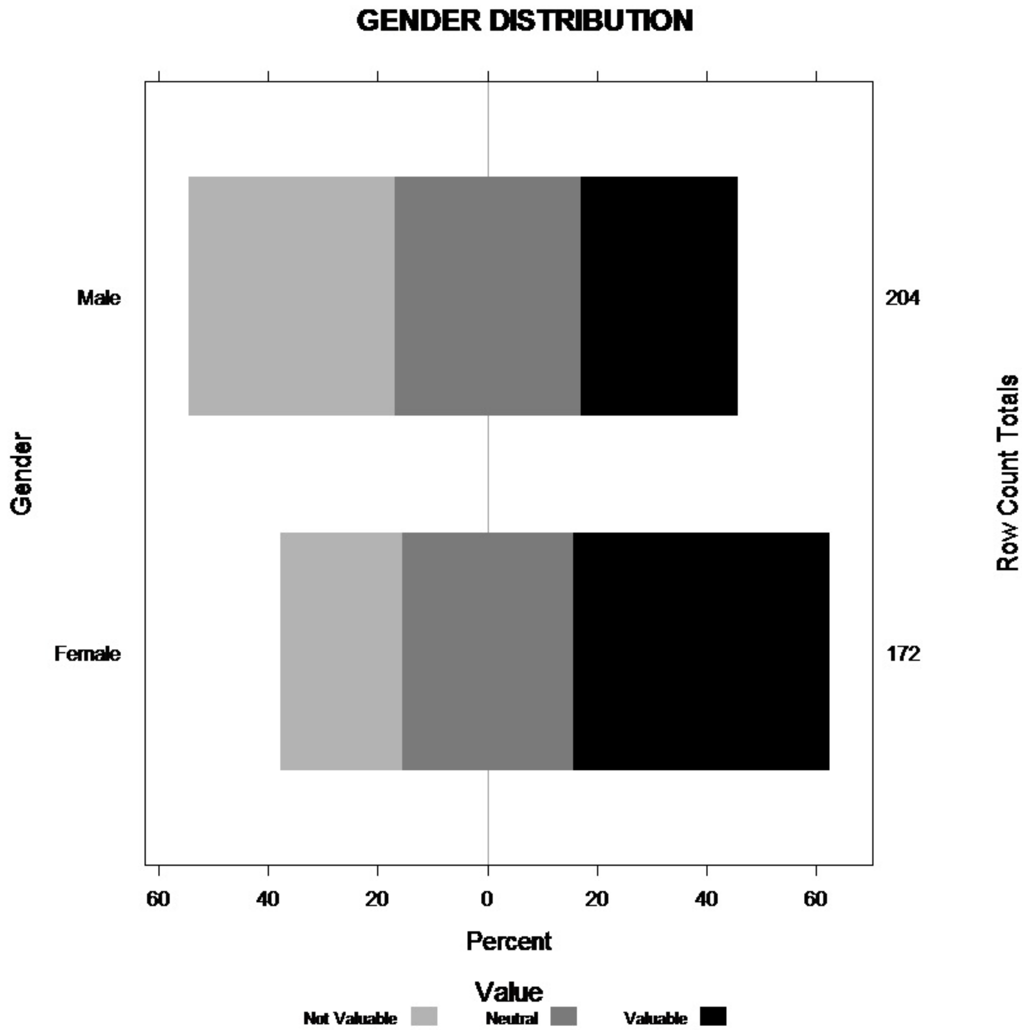

Figure 5-3: Likert plot of the proportions of survey respondents indicating culturally significant plants are not valuable, neutral, or valuable to themselves and their families, sorted by gender. Percentage of responses is provided on the x-axis, gender category on the left y-axis and row count totals (tabulations) on the right y-axis.

Female respondents had a higher percentage that considered culturally significant plants as valuable (Figure 5-3). Males were nearly equally divided between not valuable, neutral, and valuable.

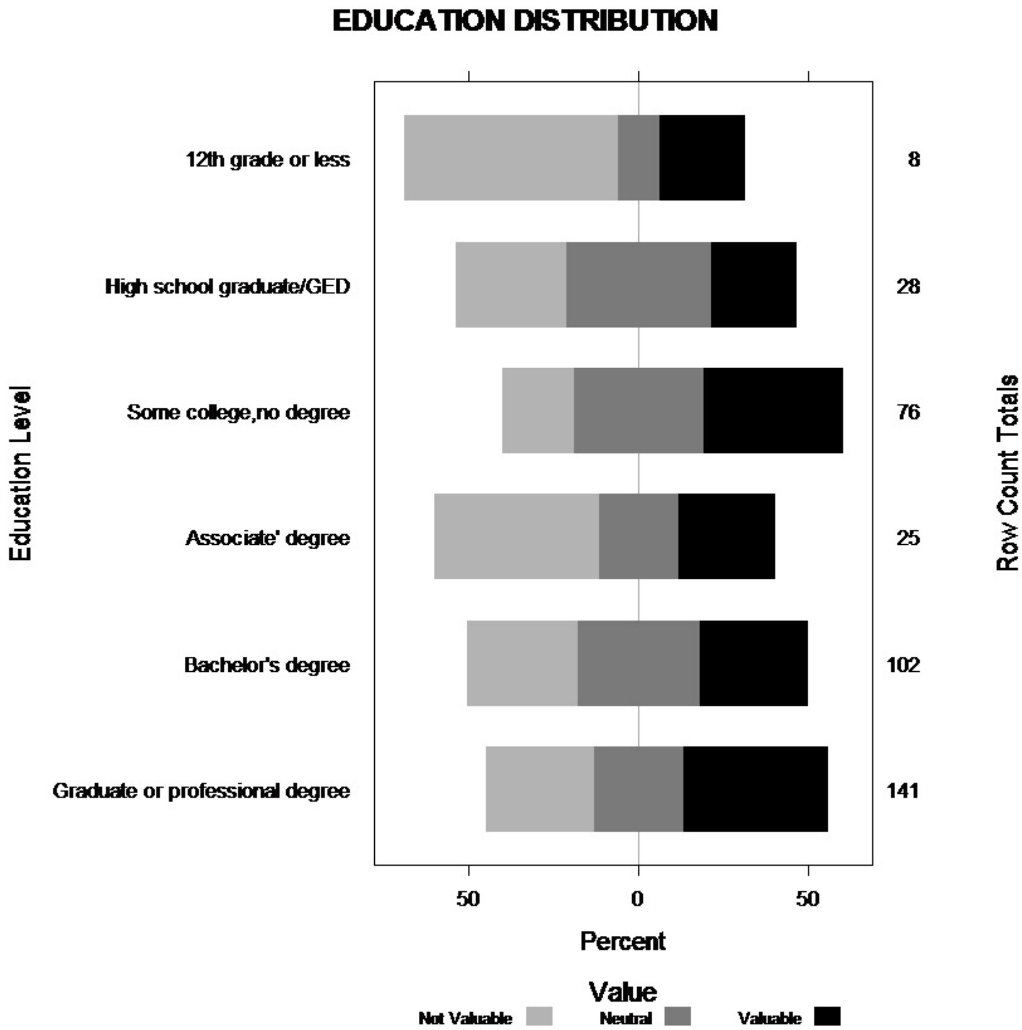

Figure 5-4: Likert plot of the proportions of survey respondents indicating culturally significant plants are not valuable, neutral, or valuable to themselves and their families, sorted by education level. Percentage of responses is provided on the x-axis, education level on the left y-axis and row count totals (tabulations) on the right y-axis.

Within the education category (Figure 5-4) the group that had “Some College, No Degree” had the highest percentage that considered culturally significant plants valuable, while those with “12th Grade or Less” of “High School Graduate/GED” had the lowest percentage.

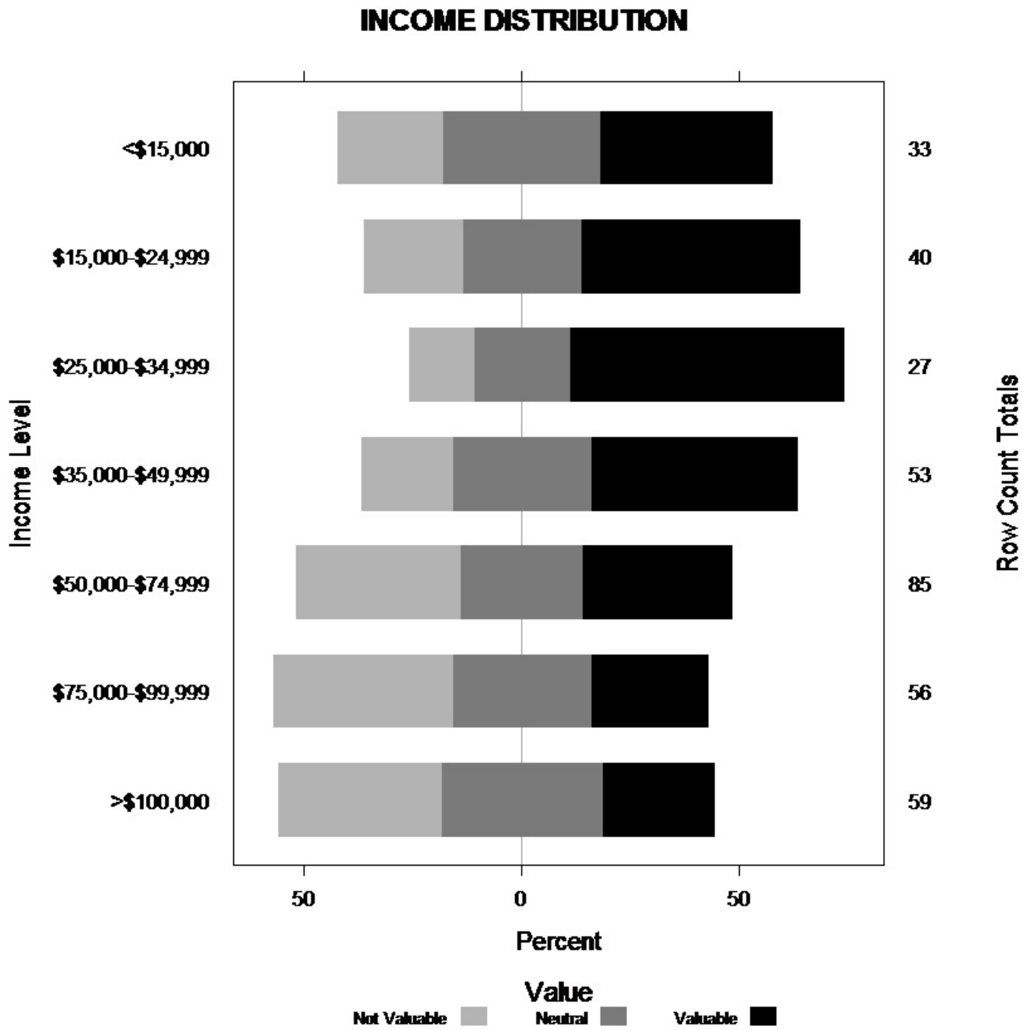

Figure 5-5: Likert plot of the proportions of survey respondents indicating culturally significant plants are not valuable, neutral, or valuable to themselves and their families, sorted by income level. Percentage of responses is provided on the x-axis, income level on the left y-axis and row count totals (tabulations) on the right y-axis.

Overall, the value of culturally significant plants increased with income up to the "$25,000-$34,999" level, but decreased with increasing income levels thereafter (Figure 5-5). Among income level categories those with household incomes of "$25,000-34,999" had the highest percentage considering culturally significant plants valuable, while those with the highest income (i.e., "greater than $100,000") valued culturally significant plants the least.

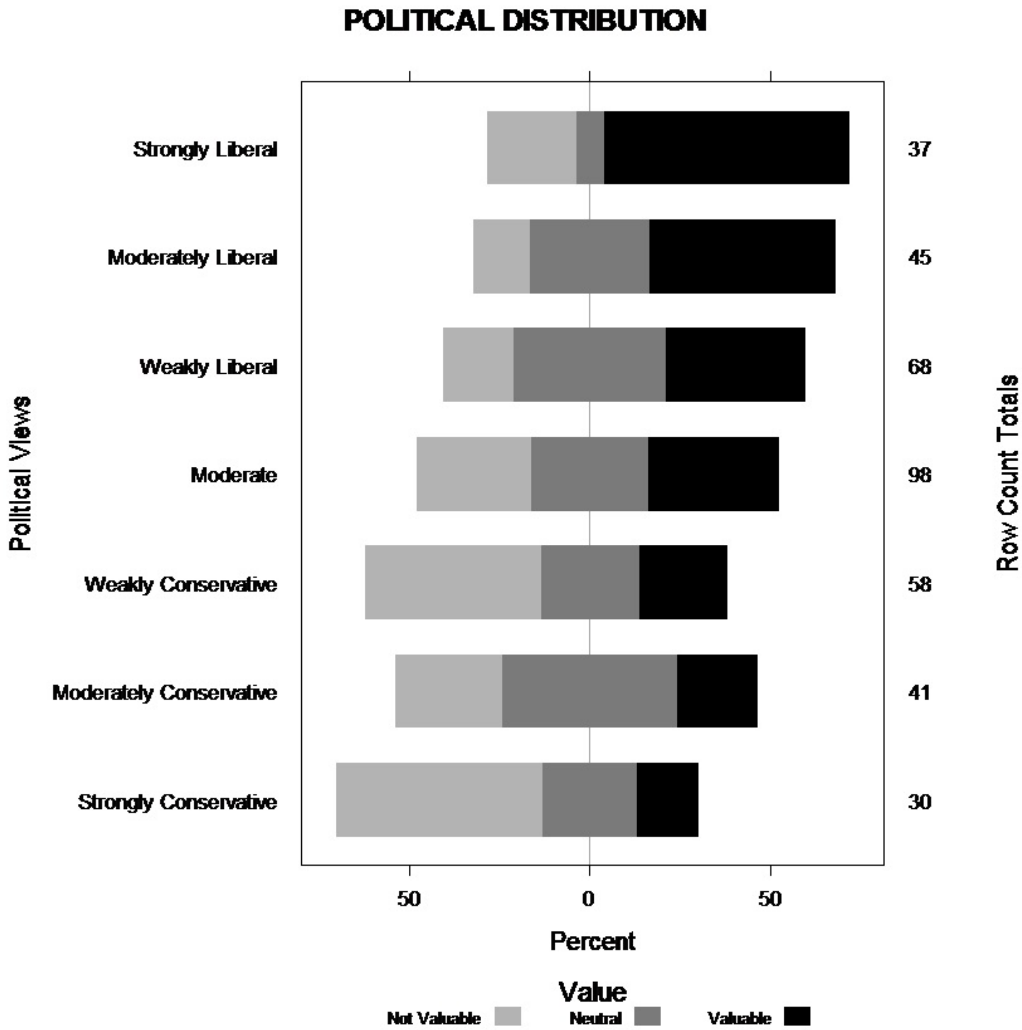

Figure 5-6: Likert plot of the proportions of survey respondents indicating culturally significant plants are not valuable, neutral, or valuable to themselves and their families, sorted by political views. Percentage of responses is provided on the x-axis, political views on the left y-axis and row count totals (tabulations) on the right y-axis.

The Merriam-Webster definition of liberal is defined as “believing that government should be active in support of social and political change” or “not opposed to new ideas or ways of behaving that are not traditional or widely accepted”. Individuals with conservative political views are defined as “believing in the value of established and traditional practices in politics and society”. Among the political view demographic (Figure 5-6), the “Strongly

Liberal" category had the highest percentage of respondents who considered culturally significant plants as valuable, while the "Strongly Conservative" group had the lowest.

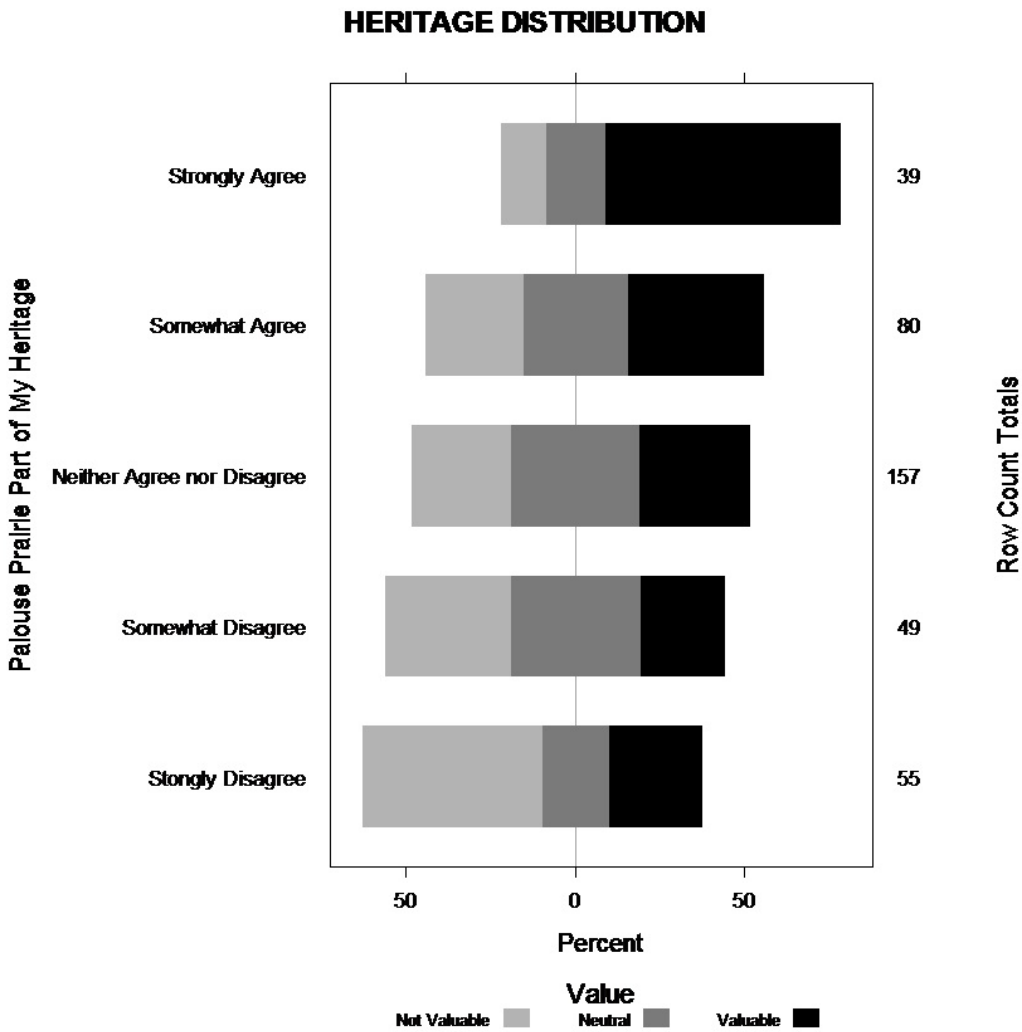

Figure 5-7: The Likert plots show rating scale by heritage value choices of culturally significant plants. Row count totals (tabulations) by category are provided on the right y-axis label of the Likert plots. Percentage of respondents' choice by value rating is provided on the x-axis.

Those respondents who strongly agreed that the Palouse Prairie was part of their heritage had the highest percentage who considering culturally significant plants valuable, while those who "Somewhat Disagreed" had the lowest (Figure 5-7).

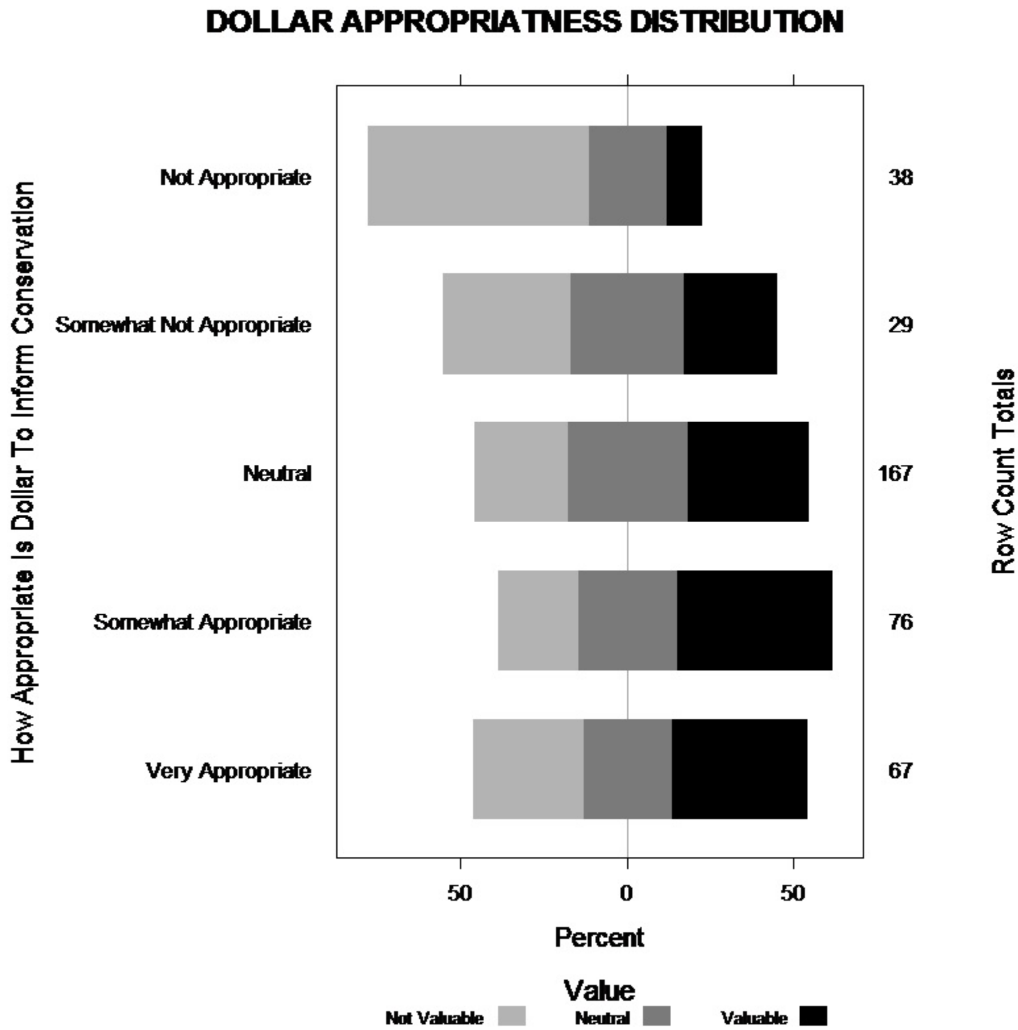

Figure 5-8: The Likert plots show rating scale by dollar appropriateness value choices of culturally significant plants. Row count totals (tabulations) by category are provided on the right y-axis label of the Likert plots. Percentage of respondents' choice by value rating is provided on the x-axis.

Respondents who selected "Somewhat Appropriate" for using a dollar amount to inform conservation decisions about the Palouse Prairie had the highest percentage that considered culturally significant plants valuable, while those that selected "Not Appropriate" had the lowest (Figure 5-8).

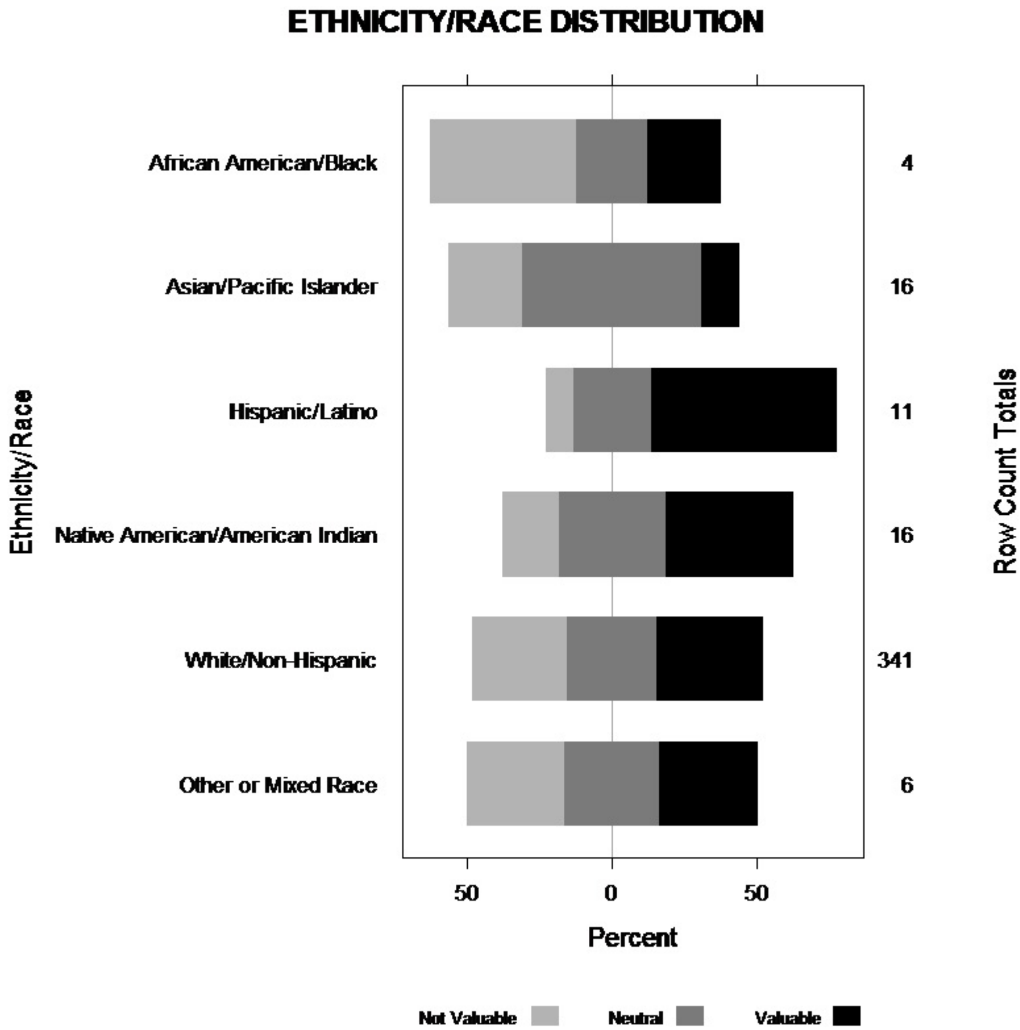

Figure 5-9: The Likert plots show rating scale by ethnicity/race value choices of culturally significant plants. Row count totals (tabulations) by category are provided on the right y-axis label of the Likert plots. Percentage of respondents' choice by value rating is provided on the x-axis.

In regard to ethnicity/race group (Figure 5-9), the "Hispanic/Latino" category had the highest percentage of respondents who considered culturally significant plants as valuable, while the "Asian/Pacific Islander" group had the lowest.

Overall 384 individuals or 36 percent of all respondents to the survey considered culturally significant plants as valuable and 64 percent were equally divided between neutral and not-valuable. In other words, one-third of the population in Latah County, Idaho, Whitman

County, Washington, and three towns (i.e., Plummer, Worley, and Lapwai) located on Native American Reservations consider culturally significant plants valuable. The OLR output modeling the value of culturally significant plants by Age Category, Education Level, Gender, Income Level, Political View, Heritage, and Dollar Appropriateness is provided in Table 5-4.

Table 5-4: Ordered logistic regression output modeling value of culturally significant plants by Age Category, Education Level, Female Gender, Income, Political View, Heritage, and Dollar Appropriateness. Output includes coefficient table including the value of each coefficient, standard error, t-value, estimated p-value, and 95% confidence intervals.

Factor	Coefficient Value	Standard Error	t-value	p-value	2.5%	97.5%
Age Category	-0.01194	0.07332	-0.1628	0.8706	-0.1561	0.1318
Education Level	0.09393	0.08294	1.1325	0.2574	-0.0688	0.2569
Female Gender	0.58374	0.22883	2.5510	0.0107	0.1365	1.0346
Income Level	-0.18625	0.06240	-2.9847	0.0028	-0.3097	-0.0647
Political View	-0.28513	0.06947	-4.1046	<0.0000	-0.4231	-0.1503
Heritage	-0.41513	0.10037	-4.1362	<0.0000	-0.6150	-0.2208
Dollar Appropriate	0.25683	0.09963	2.5778	0.0099	0.0623	0.4536

The odds ratios and confidence intervals for the significant factors are provided in Table 5-5. Based upon the OLR model females are 1.8 times more likely than males to value culturally significant plants as being “Valuable” rather than being “Neutral” or “Not Valuable”, given that all of the other variables in the model are held constant. The second highest odds ratio was dollar appropriateness; as a dollar appropriateness level moved 1 unit, the odds of moving from “Valuable” to “Neutral” or “Not Valuable” (or from the “Valuable” and

“Neutral” categories to the “Not Valuable” category) was 1.3 time greater. Income had a moderate odds ratio of 0.8. The lowest odds ratios were Heritage and Political View, with an odds ratio of 0.7.

Table 5-5: Odds ratios and lower and upper confidence intervals.

Factor	**Odds Ratio**	**2.5%**	**97.5%**
Female Gender	1.7927	1.1462	2.8139
Income	0.8301	0.7337	0.9374
Political View	0.7519	0.6550	0.8605
Heritage	0.6603	0.5406	0.8019
Dollar Appropriateness	1.2928	1.0642	1.5740

Based upon the estimated response probabilities for gender (Table 5-6), males had a higher probability than females of considering culturally significant plants as not valuable while females had higher probability for considering culturally significant plants as valuable; the finding supports a sex-specific difference in ethnobotanical valuation.

Table 5-6: Estimated response probabilities for gender.

Culturally Significant Plants	Male	Female
Not Valuable	0.37	0.22
Neutral	0.34	0.32
Valuable	0.29	0.46

The estimated response probabilities indicate lower income levels place a higher value upon culturally significant plants than higher income levels (Table 5-7). The “<$15,000” income level group had the highest response probability for considering culturally significant plants as valuable. While the lowest income level group valued culturally significant plants the most the highest income level group valued culturally significant plants the least. The income analysis suggests culturally significant plants within the study area are mostly a good valued by the poor.

Table 5-7: Estimated response probabilities by income level.

Culturally Significant Plants	<$15,000	$15,000-$24,999	$25,000-$34,999	$35,000-$49,999	$50,000-$74,999	$75,000-$99,999	>$100,000
Not Valuable	0.19	0.22	0.25	0.28	0.32	0.37	0.41
Neutral	0.28	0.29	0.31	0.32	0.32	0.32	0.31
Valuable	0.53	0.49	0.44	0.40	0.35	0.31	0.28

The estimated probabilities according to political views are provided in Table 5-8. Overall, there was a strong difference in response between self-defined liberals and conservatives. Based upon the estimated response probabilities, “Very Liberal” respondents had the highest probability for considering culturally significant plants as valuable, while “Very Conservative” respondents had the lowest probability for valuing culturally significant plants. The political view analysis suggests that culturally significant plants are mostly valued by individuals with liberal political views, the value of culturally significant plants decreases considerably with conservatism.

Table 5-8: Estimated response probabilities for political view.

Culturally Significant Plants	Very Liberal	Liberal	Moderate Liberal	Moderate	Moderate Conservative	Conservative	Very Conservative
Not Valuable	0.14	0.18	0.24	0.30	0.38	0.46	0.54
Neutral	0.27	0.31	0.33	0.35	0.34	0.33	0.29
Valuable	0.59	0.51	0.43	0.35	0.28	0.21	0.17

The estimated response probabilities for valuing culturally significant plants in relation to how respondent rated their heritage affiliation to the Palouse Prairie is provided in Table 5-9. The response probabilities for considering culturally significant plants as valuable were highest for respondents who selected "Strongly Agree" that the Palouse Prairie was part of their heritage and lowest for the "Strongly Disagree" group. The analysis on heritage affiliation with the Palouse Prairie suggests that those who consider it to be part of their heritage, value culturally significant plants the most, while those who do not consider the Palouse Prairie as part of their heritage value culturally significant plants the least.

Table 5-9: Estimated response probabilities that the Palouse Prairie is considered part of the respondent's heritage.

Value of Culturally Significant Plants	Strongly Agree	Somewhat Agree	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree
Not Valuable	0.16	0.23	0.31	0.41	0.51
Neutral	0.28	0.32	0.34	0.33	0.30
Valuable	0.56	0.45	0.35	0.26	0.19

The estimated response probabilities for valuing culturally significant plants for the question that examined how the respondent felt about basing conservation decisions upon a dollar amount is provided in Table 5-10. The response probability for considering culturally significant plants as valuable was highest for those respondents who selected “Very Appropriate” for using a dollar amount to inform conservation decisions. The response probability was lowest for those individuals who considered it “Not Appropriate” to use a dollar amount to inform conservation decisions.

Table 5-10: Estimate response probabilities on how appropriate or inappropriate it is to use a dollar amount to inform conservation decisions about the Palouse Prairie.

Value of Culturally Significant Plants	Not Appropriate	Somewhat Not Appropriate	Neutral	Appropriate	Very Appropriate
Not Valuable	0.49	0.42	0.34	0.27	0.21
Neutral	0.30	0.32	0.33	0.32	0.30
Valuable	0.21	0.26	0.33	0.41	0.49

5.6 Discussion

5.6.1 Interviews

Although little remains of the natural Palouse Prairie grassland, this study found that Native Americans of the region, as assessed through semi-structured interviews, and 36% of the general population surveyed considered culturally significant plants, lichens, mosses, and fungi of the Palouse Prairie to be valuable. Plant species such as camas were repeatedly identified as being important to the Nez Perce. The Nez Perce also conveyed during interviews that the importance of plants must be viewed in broader context of its function and contribution to the ecosystem. Furthermore, resource policy should consider input from Native Americans, as their knowledge, values, and use of the ecosystem may contribute to replenishment of natural plant foods and ecosystem services. For example, the Nez Perce method of harvesting camas after seed set and replanting of seed after harvesting disturbance or the practice of only taking the larger bulbs and replanting of the smaller bulbs. In some instances ecosystem conservation initiatives of Western Societies may be too quick to strictly exclude Native American human uses, without fully understanding how the practices or use contributes to ecosystem function and resiliency. The urgency of adopting aspects of traditional ecological knowledge of Native Americans into modern policy development may be a powerful tool to combat the profound and widespread ecocide and pollution we are experiencing today (Wildcat, 2009).

5.6.2 Sample Surveys

Ethnobotanical valuations among people are thought to be dependent upon many factors. These factors can include: ethnicity, gender, age, education level, religious and cultural beliefs, abundance and usefulness of plant species, social status, income level, profession or role in the community and at home, mental capacity, as well as control and access to natural resources (Ayantunde, Briejer, Hiernaux, Udo, & Tabo, 2008; Holt, 2005; Sop, Oldeland, Bognounou, Schmiedel, & Thiombiano, 2012). There was no significant difference in value responses for the age and education level demographic variables. However, we did find a pattern that females more frequently agreed that culturally significant plants are valuable. Previous research has indicated that gender difference may be attributed to women's roles in the local community or at home, and profession (Rangel, Ramos, de Amorim, de Albuquerque, & others, 2010; Voeks, 2007). However, further research would be necessary to identify why there was a difference between genders.

There was a valuation difference among differing income levels, as individuals in lower income classes placed a higher value upon culturally significant plants. Our finding is similar to the finding of Benz et al. (2000) who identified the most marginal of the communities in Manantlan, Mexico who used a wider diversity of plants and had more uses of individual species. However, our finding was different in that we assessed how varying income levels valued cultural significant plants as whole. As approximately one third of the local community considered culturally significant plants as valuable, further research towards identifying individual species of the local community and their uses would be highly important for conservation purposes.

The political view analysis suggested that culturally significant plants are mostly valued by individuals with liberal political views and their value decreases considerably with conservatism. We were unable to find any valuation of culturally significant plants that assessed how political views influenced value choices. However, based upon surveys from the World and European Values Surveys, Neumayer (2004) found left-wing orientations embraced pro-environmental issues. If valuing culturally significant plants is considered pro-environmental, our findings that self-identified liberals value culturally significant plants more than conservatives support the findings of Neumayer (2004).

We were unable to find any published study that valued culturally significant plants by assessing how the respondent self-identified heritage connection with the study area. Our findings suggest that individuals with a heritage connection with a region value culturally significant plants higher than those who do not have such a connection. In regard to the valuation of culturally significant plants based upon how the respondent felt about basing conservation decisions upon a dollar amount, individuals who valued culturally significant plants are also concerned about costs associated with conservation. As a result, conservation costs are an important factor to consider during policy development to conserve culturally significant plants.

5.7 Conclusions

Previously reported valuation systems of culturally significant plants are often based upon one or more of the following attributes: number of potential uses, number of participants identifying a particular species, utilitarian purposes, taste appreciation, perceived quality, financial benefits provided, contingent valuations, marginal costs, time and travel spent harvesting and processing, selling price on the market, and value in local markets (Cocks & Wiersum, 2003; Godoy et al., 1993; Hunn, 1982; Phillips et al., 1994; Pieroni, 2001; Reyes-García et al., 2006; Stoffle et al., 1990; Thomas et al., 2009; Turner, 1988). Many of these studies have made an attempt to prioritize value to individual species, and focus on how a single social group (e.g., indigenous hunter gatherer society) values a particular plant taxon. This study differs from most of the previous work on valuation of culturally significant plants in two important respects. Although many prior studies focus on a single social group (e.g., *mestizos* from Tambopata area, Peru; Paiute and Shoshone of the Western, United States) and how its members value a particular plant taxon, this study considers the culturally significant plant community as a whole, and it includes responses from Indigenous and non-indigenous populations of a single region.

Methods that focus on the value of an individual plant taxon in itself inherently reveal an epistemological difference between Western societies and Indigenous people, who tend to view natural systems holistically. For example, similar to the findings in this study, Turner (1988, p. 274) noted that when asking which plants are most important, a knowledgeable Salish tribal elder responded "I'd pick them all – they're all important". On the other hand, existing valuation methods and research developed by Western scientists, which are often done in response to development imperatives, go to great efforts to define cultural significance of a plant taxon based upon the researcher's perceived role it plays within a particular culture.

Based upon the findings of this study, social support to conserve culturally significant plants exists is strongest among females, Nez Perce Tribal members, individuals with liberal political views, people who consider the Palouse Prairie as being part of their heritage, and people within lower income classes. However, in productive landscapes like the Palouse, the agricultural-dependent community is the primary steward of biodiversity, ideally generating co-benefits for regional biodiversity conservation and local peoples (Scherr & McNeely, 2008). This presents a challenge in the Palouse where the agricultural sector demographic does not align with the demographics that most strongly value culturally significant plant. As the demographic groups that are likely best situated to make decisions about agricultural production on the Palouse include wealthy white male conservatives.

One potential strategy to conserve culturally significant plants would be to coordinate conservation efforts with local Indian Tribes. For example, Nez Perce Tribal members identified several locations along major roadways and natural areas on the Palouse Prairie where camas continues to thrive. These areas could be recognized as important features of the cultural and natural heritage of the region, justifying their management as remnants of biodiversity beneficial to the local community, including Native American Tribes. As part of management of culturally significant plants and biodiversity, the local community could also consider impacts associated with agricultural inputs and make efforts to minimize environmental pollution. This is especially important considering that some of the Native Americans interviewees identified a concern about the harvesting of natural foods that have been exposed to pesticides or pollution. Another potential strategy to benefit biodiversity and culturally significant plants of the region would be to analyze existing and potential habitat networks at a landscape scale that can be enhanced to improve ecosystem integrity, structure, and function (Freemark, Boutin, & Keddy, 2002; Scherr & McNeely, 2008). For example, plantings of desirable native species along roadways and field margins could promote habitat connectivity and have little or no impact upon agricultural production. Where possible these networks could be targeted within existing patches with highest biodiversity or natural areas.

Although this study did not emphasize economic valuation of culturally significant plants out of respect for social perspectives that would reject the notion of placing a dollar amount on something considered sacred, the general population survey revealed a tendency to agree with the appropriateness of using a dollar amount to inform conservation decisions. This finding suggests a need to identify restoration and maintenance costs as part of the ecosystem service valuation process, despite the views of some stakeholders that economic valuations can be inappropriate. Overall, the findings highlight the importance of the recommendation by Chan et al. (2012) of using a multi-metric approach to valuing ecosystem services. We therefore hope our result can facilitate valuation that is representative of the diversity of viewpoints among stakeholders of the Palouse Prairie and thus more readily and widely accepted. The results indicate that the importance of conserving culturally significant plants should incorporated into policy development in the Palouse region. Furthermore, this study illustrates the importance of considering the knowledge and philosophies of Indigenous peoples, and the role this knowledge can serve to protect ecosystem services, biodiversity, and culture.

Conclusion

The Palouse Prairie of eastern Washington and northern Idaho was once a vast and contiguous ecosystem with its own unique plants and animals. Today anthropogenic changes to the landscape have degraded the Palouse Prairie to its current state, which is one primarily of low ecological quality with small, fragmented, and noncontiguous sites, with minimal public access. There are six threatened or rare plant species and uncertainty about the abundance of the giant Palouse earthworm. Despite the current state of the Palouse prairie, residents of the region continue to associate the Palouse Prairie as part of the regional identity and numerous local organizations exist with explicit goals of conserving and restoring native Palouse Prairie.

Four articles have been presented that explores the value for conservation of the Palouse Prairie. The first article focuses on valuing ecological quality of the Palouse Prairie, which was consistently identified as the most important characteristic and provides the most economic value to conservation. This article also explores the demographic nuances behind whether residents choose to conserve Palouse Prairie and those characteristics of the Palouse Prairie that are most important to them. The next article explores the interaction between economic value and sense of place, qualitative value, and the appropriateness of using a monetary value to assess the value of conservation. Each perspective provides valuable information towards developing strategies for conservation. The third article measures ecological quality and assigns those measures an indirect economic value based on their overall contribution to ecological quality as measured through factor analysis. The economic value of these measures provides an assessment of their contribution to overall ecological quality and to the total value for conservation of the Palouse Prairie. The fourth article uses semi-structured interviews and a survey question to evaluate the importance of culturally significant plants on the Palouse Prairie. These four articles provide new information about the value of the Palouse Prairie to residents of the region.

The economic values from this research can be used to evaluate the benefits of a potential investments, regulations, or incentives that work towards the conservation of Palouse Prairie and determine if the costs of such a change are justified. These values can be used to compare ecosystem benefits with and without conservation measures to determine the value if the conservation measure are implemented and the value if they are not.

Economic value is not the only consideration of conservation, nor should it be. People value conservation of the Palouse based on a range of other criteria such as ethical, historical, and cultural reasons. This research has capture some of these additional values as well through evaluating sense of place and cultural plants as well as their interaction with economic value.

Terms such as “ecosystem services,” “ecosystem benefits,” and “natural capital” are often used to describe ecosystem processes and their effect on our wellbeing, but these statements are often vague. Insufficient information often results in these concepts either being implicitly assigned a value of zero or infinity. Neither of those values does very much to move the policy conversation forward. This research has provided explicit values of the willingness to pay for conservation of the Palouse Prairie, quantified noneconomic value, and provided a qualitative context that can be used to move the policy conversation forward and work towards the conservation of the Palouse Prairie.

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Appendix A: Theoretical Framework

A.1 Decision making

Daily (2009) presents a framework in Figure A-1 for how ecosystem services can be integrated into decision making. Ecosystem services have impacts on human welfare, which can be represented by different economic valuation methods and put in monetary terms (Arrow et al., 2004; Daily et al., 2000; Repetto, Wells, Beer, & Rossini, 1987). Cost–benefit analyses and other methodologies make it easier to compare alternative options. The information on the value of ecosystem services is provided as information to institutions, which can then create incentives that influence people's decisions.

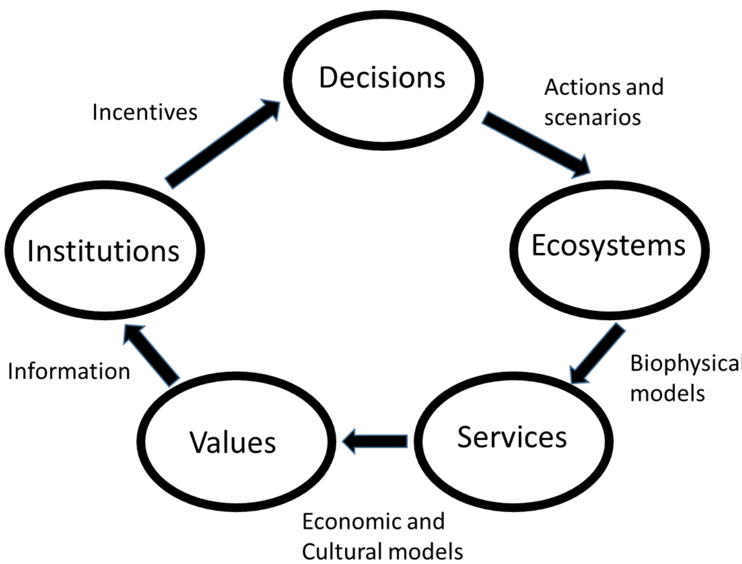

Figure A-1: Integrating ecosystem services into decision making (Daily et al., 2009)

In order to use the decision making framework, it is necessary to understand the links between ecosystems and biodiversity to human well-being and value. Figure A-2 is provided by The Economics of Ecosystems and Biodiversity (TEEB) and is an overview diagram showing the link between the natural and human systems, with ecosystem services located centrally and tying the two together. The diagram shows that ecosystem services stem from ecological structure and processes and their functions in ecosystems. It identifies benefits to people following from services delivered by ecosystems, and separates benefits and value.

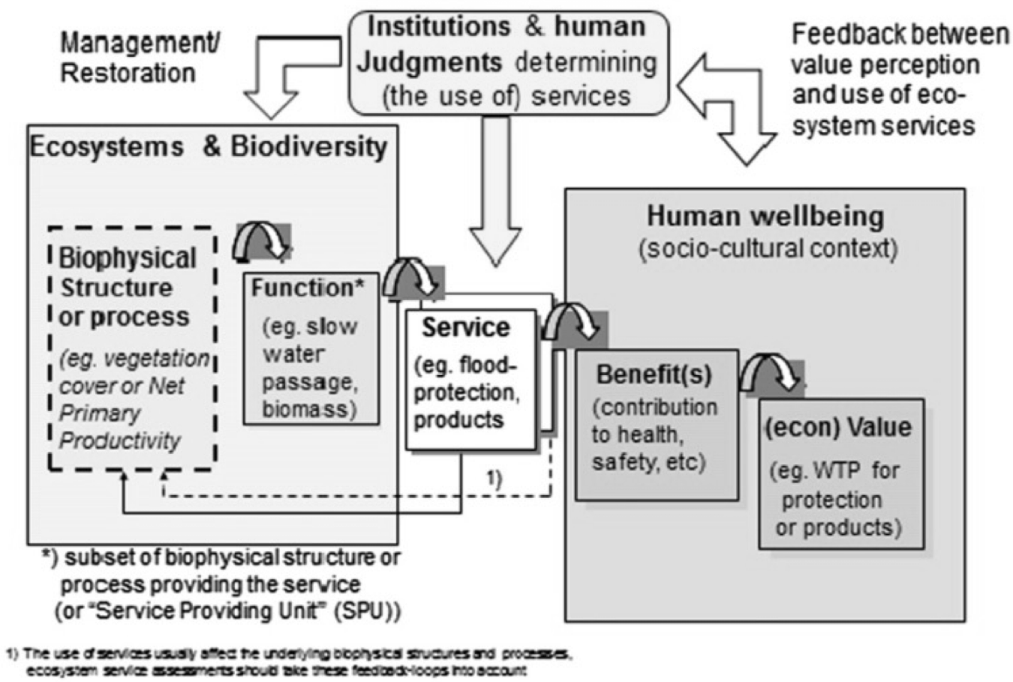

Figure A-2: Link between the natural and human systems (TEEB Foundation, 2010)

A.2 Ecosystem services, economic value, and ecological quality

The Palouse Prairie ecosystem has a unique, and now critically endangered (Noss et al., 1995) vegetation structure. Through its biophysical structure and processes, it provides a multitude of ecosystem functions, which in turn provide ecosystem services. This research evaluates the ecological quality of the Palouse Prairie system to determine how the current structure and function are providing ecosystem services. The primary measures being used to measure quality within the system are the characteristics of the soil, plants, and pollinators. It will also determine how those services provide benefits and economic value, or willingness-to-pay (WTP), for conservation of those services in monetary terms.

Definitions of ecosystem services tend to be similar. Daily (1997) defines ecosystem services as the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. Costanza et al. (1997) defines ecosystem services as the benefits human populations derive, directly or indirectly, from ecosystem functions. Boyd and Banzhaf (2007) define ecosystem services as components of nature, directly enjoyed or consumed or used to yield human well-being. Fisher et al. (2009) define ecosystem services as the aspects of ecosystems utilized (actively or passively) to produce human well-being. The Economics of Ecosystems and Biodiversity (TEEB) Foundation (2010) defines ecosystem services as the direct and indirect contributions of ecosystems to human well-being. Finally, the Millennium Ecosystem Assessment (2005) defines ecosystem services simply as the benefits people obtain from ecosystems. While ecosystem services can be defined in different ways, and may need to be based on your needs, it is important to understand that ecosystem services act as a bridge between ecosystems and people.

For the evaluation of ecosystem services within the Palouse Prairie, this research has adopted the TEEB definition of the direct and indirect contributions of ecosystems to human well-being. TEEB currently lists seventeen ecosystem services separated into four categories of provisioning services, regulating services, habitat or supporting services, and cultural services. Provisioning services describe the material or energy outputs from ecosystems, regulating services act as regulators, habitat or supporting services underpin almost all other services, and cultural services are the non-material benefits people obtain from contact with ecosystems (TEEB Foundation, 2010).

It is important to make the distinction that this research is evaluating economic value that is derived from ecosystem services of native Palouse Prairie, and not agricultural production or other potential purpose. For example, the provisioning of food is low, because originally the prairie provided food in the form of harvesting camas bulbs and hunting elk and mule deer. Currently, it provides very little of those food sources and most of the prairie has been converted for agricultural production. If we evaluated the ecosystem service for food on agricultural land, it would be rated high, because it is one of the most productive grain growing regions in the world (K. R. Williams, 1991). Based on interviews with stakeholders, most of the ecosystem services being provided by native prairie are from cultural ecosystem services.

Economists separate value into multiple categories, the sum of which comprises these values makes up the total economic value. The Total Economic Value (TEV) framework (Figure A-3) (OECD, 2006) is a representation of the way in which these values are categorized.

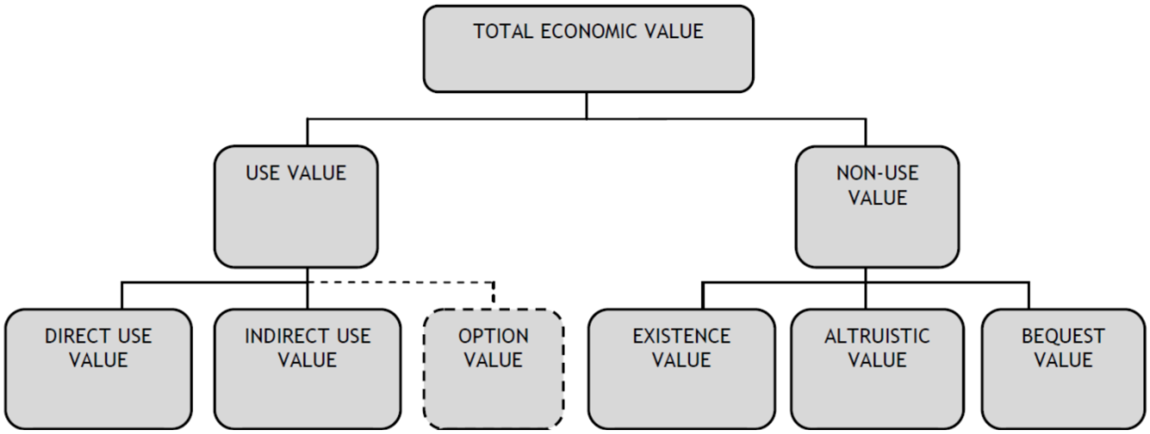

Figure A-3: The Total Economic Value (TEV) framework provides an all-encompassing measure of the economic value of any environmental asset. It decomposes into use and non-use (or passive use) values. Use value can be further sub-classified into direct use, indirect use, and option values. Non-use value can be further sub-classified into existence, altruistic, and bequest values (OECD, 2006).

Use value is the satisfaction, or utility, that people receive from using the good or service. Non-use value refers to the value people assign to a good or service even if they have never used or even have no intention of ever using it. Use value can be further divided into direct use, indirect use, and option values. Direct use value comes from provisioning services such as food or water, and from cultural services such as recreation. Indirect use value attaches to benefits such as the regulating services of flood prevention and water purification. Option value is the benefit of preserving the possibility of future direct or indirect use. Option use value can come from any ecosystem service, but pertains to preserving ecosystems, species, and genes for potential future use. Non-use value can be further divided into existence value, altruistic value, or bequest value. Existence value is derived from knowing that something exists such as a charismatic species, or an entire ecosystem which is derived from the habitat or supporting ecosystem services. Altruistic value comes from the knowledge that other people in the current generation have use of the resource and is derived from all ecosystem services. Bequest value comes from the knowledge of passing on resources to future generations.

Since the majority of ecosystem services being provided by native Palouse Prairie are cultural services, it is important to obtain a more robust definition of them. The Millennium Ecosystem Assessment (MA, 2005) defines cultural ecosystem services as “the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.” Other terms for cultural services include life-fulfilling functions (Daily, 1999), information functions (de Groot, Wilson, & Boumans, 2002), amenities and fulfillment (J. Boyd & Banzhaf, 2007), cultural and amenity services (de Groot et al., 2010; Kumar & Kumar, 2008), and socio-cultural fulfillment (Wallace, 2007). Cultural services are intangible, which explains the difficulty in appraising them (Adekola & Mitchell, 2011; Daw, Brown, Rosendo, & Pomeroy, 2011; MA, 2005). However, their intangibility is also a motivation for better consideration of them in the future (K. M. A. Chan et al., 2011; Chiesura & de Groot, 2003; N. Smith et al., 2011). Cultural services are typically nonmarket goods. Cultural services are often valued ahead of other services in industrialized societies and demand for cultural services is expected to increase in these societies. In traditional communities, cultural services are essential for cultural identity and even survival (Milcu et al., 2013). Cultural ecosystem services research engages disciplines including ecology, economics, and the social sciences, and uses a wide range of research approaches. Despite input from multiple disciplinary, methodological, and theoretical perspectives, there is broad agreement that a satisfactory level of understanding of many important facets of cultural ecosystem services has not yet been attained (Milcu et al., 2013).

In neoclassical microeconomic theory, demand originates from consumers who have the objective of maximizing their utility, but are constrained by their budget and market prices. Each unit of the good or service provides the consumer with an increment of utility known as marginal utility. When more than one unit of a good is consumed in a relatively short period of time, the marginal utility of each successive unit consumed will decline. This phenomenon is known as the Law of Diminishing Marginal Utility. As the price of a good declines, the quantity demanded of that good increases. This inverse relationship is known as the Law of Demand. Figure A-4 shows a demand curve. At price P_1, the quantity demanded is Q_1, and at price P_2 the quantity demanded is Q_2.

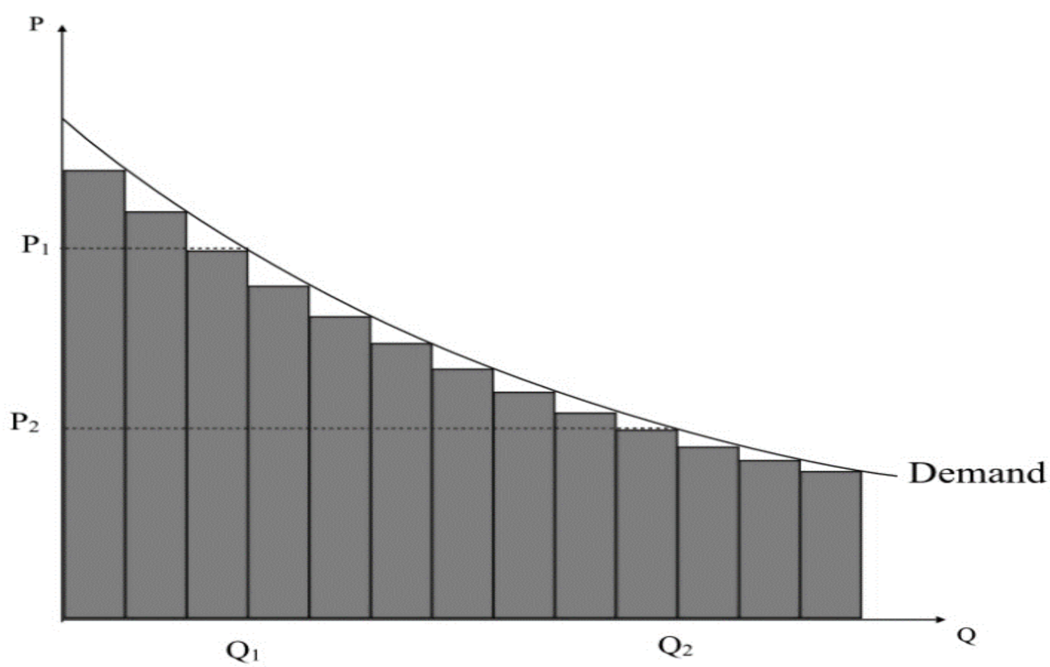

Figure A-4: Demand curve. The bars represent quantity demanded at each price level. At price P_1, the quantity demanded is Q_1, and at price P_2 the quantity demanded is Q_2.

For a nonmarket good, there is no market where an individual may unilaterally choose the level of these goods, so the problem becomes how to obtain the highest possible utility level. There are two constraints for nonmarket goods, income and the levels of the nonmarket good are fixed. The demand curve for nonmarket goods is derived from the willingness-to-pay (WTP). WTP is evaluated from two perspectives, compensating variation and equivalent variation. For compensating variation, if utility is fixed at the pre-change level and a policy will increase someone's well-being then we evaluate the amount that person is WTP for the positive change in the nonmarket good (Figure A-5). For equivalent variation, if utility is fixed at the post-change level and a policy will decrease someone's well-being, then we evaluate the amount that a person is WTP to stop the change from happening to the nonmarket good (Figure A-6). These changes are evaluated using the Hicksian demand curve, which shows the relationship between the price of a good and the quantity demanded of it assuming that the prices of other goods and our level of utility remain constant (Hicks, 1939).

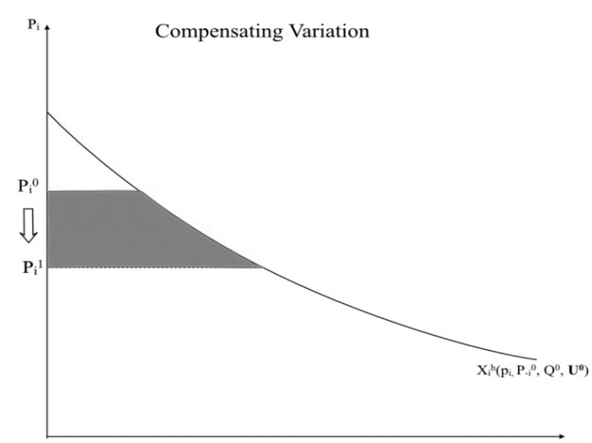

Figure A-5: Compensating variation is equal to the shaded area between the initial price and the new price. Utility is fixed at the pre-change level. If a policy will increase someone's well-being then we evaluate the amount that person is WTP for the positive change in the nonmarket good. Hicksian Demand (X_i^h) is a function of the price of the goods (p_i), price of other goods (P_{-i}^0), quantity (Q^0), and utility (U^0).

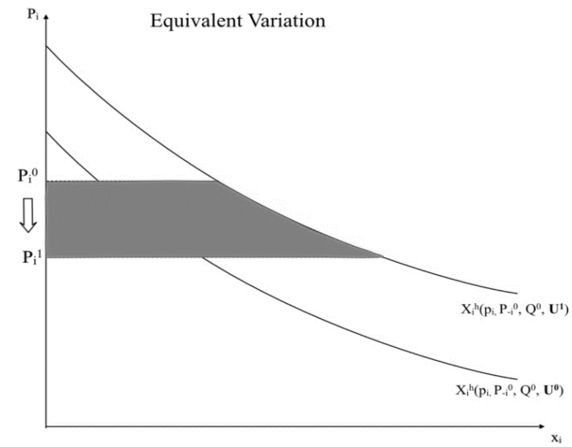

Figure A-6: Equivalent variation is equal to the shaded area between the initial price and utility and the new price and utility. If a policy will increase someone's well-being then we evaluate the amount that person is WTP for the positive change in the nonmarket good. Hicksian Demand (X_i^h) is a function of the price of the goods (p_i), price of other goods (P_{-i}^0), quantity (Q^0), and utility (U^0).

Welfare economics is the analysis and making of policy prescriptions concerning social welfare. The first and second theorem of welfare economics relate to Pareto efficiency. The first theorem of welfare economics states that any competitive or Walrasian equilibrium leads to a Pareto efficient allocation of resources. A Pareto efficient outcome is one in which no person can be made better off without making somebody else worse off. In practice, it is almost impossible to make somebody better off without making somebody else worse off. The Kaldor-Hicks criterion is when those that are made better off compensate those that are made worse off. However, this criterion does not require that compensation is actually paid, only that it could be. This has the consequence of potentially make some people worse off. The second welfare theorem states that any Pareto efficient allocation can be achieved through competition, given an appropriate initial allocation of resources. This theorem allows for a separation of efficiency and distribution. Two of the crucial findings of welfare analysis are 1) there is a large number (in principle an infinite number) of efficient resource allocations and 2) that each efficient and inefficient resource allocation implies a particular distribution of welfare (B. Walker, 1980). However, an efficient allocation, under which it is not possible to make someone better off without making someone else worse off, may not be distributionally acceptable and inefficient allocations may be distributionally superior to feasibly attainable efficient ones (B. Walker, 1980). If society considers some distributions of welfare superior to others and if, as welfare theory demonstrates, each resource (re)allocation has different distributions associated with it, then the degree to which an activity affecting the allocation of resources actually leads to an increase in social welfare depends on the distributional effects of that activity and the criteria by which they are judged (B. Walker, 1980).

A social welfare function is a function that ranks social states as less desirable, more desirable, or indifferent for every possible pair of social states. Inputs of the function include any variables considered to affect the economic welfare of a society. There are three primary types of welfare functions: 1) Pareto criterion, 2) Utilitarian or Benthamite, and 3) Max-Min or Rawlsian. A Pareto criterion social welfare function is when social welfare increases whenever someone is made better off without anyone else being made worse off; thus social welfare is an increasing function of individual welfare. $W = W(U_1, \dots, U_n)$ where $\frac{\partial W}{\partial U_i} > 0, i = 1, \dots, n$. W is social welfare, U_i is individual utility for each of n persons in the society. A utilitarian social welfare function measures social welfare as the total or sum of individual incomes $W = \sum_{i=1}^{n} Y_i$ where W is social welfare and Y_i is the income of individual i among n individuals in society. In this case, maximizing the social welfare means maximizing the total income of the people in the society, without regard to how incomes are distributed in society. Alternatively, society's welfare can also be measured under this function by taking the average of individual incomes: $W = \frac{1}{n}\sum_{i=1}^{n} Y_i$. The Max-Min social welfare function measures the social welfare of society on the basis of the welfare of the least well-off individual member of society: $W = \min(Y_1, Y_2, \ldots, Y_n)$. Here maximizing societal welfare would mean maximizing the income of the poorest person in society without regard for the income of other individuals (B. Walker, 1980).

Benefit-Cost Analysis (BCA) is a method for analyzing all of the benefits and costs of a proposed action and subtracting the costs from the benefits to arrive at the net benefits. The alternative with the highest net benefits is chosen, since by maximizing net benefits to society we are maximizing social welfare. This is based off of the utilitarian or Benthiam social welfare function. While conducting a BCA sounds simple in theory, it is actually quite complex. In order to compare the benefits against the costs, one must have a common metric that is used to measure them. Economists use currency as their common metric. Some benefits and costs are easy to place in the form of currency. If there are market prices available, you simply multiply price and quantity. However, there are many products or services for which there are no market prices and for which quantity is difficult to measure. To assess fully the economic desirability of environmental policies, analysts must estimate the value of non-market commodities. Overlooking or ignoring the services provided by non-market commodities in cost-benefit analyses and other empirical economic studies severely undermine the accuracy and relevance of the results (Carson, Flores, & Meade, 2001).

Environmental non-market commodities include ecosystem services. In addition to these benefits, the losses of these benefits (negative externalities) are also considered costs. Placing a currency value on these services to determine benefits and costs is extremely challenging. When evaluating alternatives, decision makers must also consider when the decision affects more than one thing that matters, if weights should be assigned so that certain consideration carry more weight than others, and how to assess the net effect on the social welfare if a policy makes some better off and some worse off. A BCA only maximizes net benefits and does not consider distribution of those benefits or costs. It can be argued that the gainers could compensate the losers (Kaldor-Hicks), but this adds an additional level of complexity to the analysis. In practice, analysts use the value derived from the mean individual. If value, or WTP, is an increasing function of income, the analysis implicitly underestimates the values of the highest income individuals and overestimates the values of the lowest income individuals. This results in an approximate equivalent to a social welfare function.

There are numerous ways to calculate the economic value of nonmarket goods, and these methods can typically be separated into two categories, revealed preferences and stated preferences. Revealed preference methods examine people's behavior in markets that are related to the environmental good or service and infer economic value from this behavior. Revealed preference methods include the travel cost model, hedonic price method, defensive behavior or damage cost method, and benefit transfer. Stated preference methods use surveys that ask people to state their value, in terms of willingness-to-pay (WTP) or willingness-to-accept (WTA) for a given environmental change. Stated preference methods include contingent valuation and choice experiment (conjoint analysis). The travel cost model uses time and travel cost expenses that people incur to visit a site to represent the price of access to that site. WTP is estimated based on the number of trips that people make at different travel costs. The hedonic pricing method uses the prices of a marketed good that is related to its characteristics or the services that it provides. Characteristics such as viewscape, proximity to amenities, and recreational opportunities are considered. It is most commonly applied to variations in housing prices that reflect the value of local environmental attributes. Defensive behavior or the damage cost method estimate the value of ecosystem services based on either the cost of avoiding damages due to lost services, the cost of replacing ecosystem services, or the cost of providing substitute services. Benefit transfer estimates economic value by transferring available information from studies that have already been completed in another location or context that are very similar. Contingent valuation directly asks people what they are willing to pay for specific environmental services or the amount they are willing to accept to give up specific environmental services. It is called contingent valuation because people are asked their willingness to pay or accept contingent on a specific hypothetical scenario and description of the environmental service. A choice experiment estimates economic value by asking people to make tradeoffs among sets of environmental services or characteristics. Willingness to pay is inferred from these tradeoffs that include a cost attribute instead of directly asking for this value.

Conversations with stakeholders revealed that most of the value for Palouse Prairie is contained within the habitat or supporting services of habitat for species and maintenance of genetic diversity or cultural services of mental and physical health, aesthetic appreciation and inspiration for culture, art, and design, and spiritual experience and sense of place. The most appropriate method to capture the value of these services is through a stated preference method; specifically, a choice experiment to conduct this WTP study (Birol et al., 2006; Dissanayake & Ando, 2014; Morrison, Bennett, & Blamey, 1999). A choice experiment is a type of conjoint analysis where people are asked to choose their most preferred option among a set of alternatives. Conjoint analysis can also include methods that utilize ranking or rating. Choice experiments are also sometimes called choice models, contingent choice models, or attribute-based models (ABM). The most frequently used term in the economic literature is choice experiment (CE). A CE is a method for modeling preferences for goods, where goods are described in terms of their attributes and of the levels these take. People are presented with various alternative descriptions of a good, differentiated by their attributes and levels, and are asked to rank the various alternatives, to rate them, or choose their most preferred. By including a price or cost as one of the attributes WTP can be indirectly recovered (King & Mazzota, 2000). A CE measures all forms of value including nonuse values.

A.3 Choice experiment

The conceptual microeconomic framework for a CE comes from Lancaster's (1966) characteristics theory of value, which assumes that consumers' utilities for goods can be deconstructed into utilities of composing characteristics. A direct approach to predicting choices in the marketplace is provided by discrete choice theory, particularly as formulated for economic analysis by McFadden (1974) and is based on an alternative theory of choice that is used to derive conventional demand curves. McFadden's conceptual foundation is based on Thurstone's (1927) idea of random utility. Luce's (1959) choice axiom was linked to random utility theory by Marschak (1960). McFadden developed an econometric model that combined hedonic analysis of alternatives and random utility maximization known as the multinomial logit (conditional logit) model. The first method of conjoint analysis was introduced to the market research community by Paul Green and colleagues in the early 1970s. It involved asking respondents to rank a series of concept cards, where each card displayed a product concept consisting of multiple attributes (Orme, 2009). The CE technique was originally developed by Louviere and Woodworth (1983), and the first application of CEs to environmental valuation was Rae's (1983) work using rankings to value visibility impairments at Mesa Verde and Great Smoky Mountains National Parks.

CEs asks respondents to state a preference between one group of environmental services or characteristics at a given price to the individual, and another group of environmental characteristics at a different price. Because it focuses on tradeoffs among scenarios with different characteristics, CEs are especially suited to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services. In addition, while CEs can be used to estimate dollar values, the results may also be used to simply rank options, without focusing on dollar values (King & Mazzota, 2000).

There are three formats that are used for CEs. These include ranking, rating, and discrete choice. In a ranking format, the survey asks individuals to compare and rank alternate program outcomes with various characteristics, including cost. People might be asked to compare and rank several exclusive environmental programs under consideration. Each has a different outcome and different costs. Respondents are asked to rank these alternatives in order of preference. In the discrete choice format, respondents are simultaneously shown two or more alternatives and their characteristics and are asked to identify the most preferred alternative. The rating format is a variation of the discrete choice format, where respondents are asked to compare two alternate situations and are asked to rate them in terms of strength of preference. For instance, people might be asked to compare two environmental improvement programs and their outcomes, and state which is preferred, and whether it is strongly, moderately, or slightly preferred to the other program (King & Mazzota, 2000).

There are many advantages of CEs. They can be used to value the outcomes of an action as a whole, as well as the various attributes or effects of the action. The method allows respondents to think in terms of tradeoffs, which may be easier than directly expressing dollar values. The tradeoff process may encourage respondent introspection and make it easier to check for consistency of responses. Respondents may be able to give more meaningful answers to questions about their behavior (i.e. they prefer one alternative over another), than to questions that ask them directly about the dollar value of a good or service or the value of changes in environmental quality. Thus, an advantage of this method over the contingent valuation method is that it does not ask the respondent to make a tradeoff directly between environmental quality and money. Respondents are generally more comfortable providing qualitative rankings or ratings of attribute bundles that include prices, rather than dollar valuation of the same bundles without prices, by de-emphasizing price as simply another attribute. Survey methods may be better at estimating relative values than absolute values. Thus, even if the absolute dollar values estimated are not precise, the relative values or priorities elicited by a CE survey are likely to be valid and useful for policy decisions. The method minimizes many of the biases that can arise in open-ended contingent valuation studies where respondents are presented with the unfamiliar and often unrealistic task of putting prices on nonmarket amenities. The method has the potential to reduce problems such as expressions of symbolic values, protest bids, and some of the other sources of potential bias associated with contingent valuation (King & Mazzota, 2000).

There are some limitations of CEs. First, respondents may find some tradeoffs difficult to evaluate because they are unfamiliar with the topic or concepts being presented. Second, the respondents' behavior underlying the results of a contingent choice study is not well understood. Respondents may resort to simplified decision rules if the choices are too complicated, which can bias results. Third, if the number of attributes or levels of attributes is increased, the sample size and/or number of comparisons each respondent makes must be increased. When presented with a large number of tradeoff questions, respondents may lose interest or become frustrated. Contingent choice may extract preferences in the form of attitudes instead of behavior intentions. By only providing a limited number of options, it may force respondents to make choices that they would not voluntarily make (King & Mazzota, 2000).

As developed by McFadden (1974), a choice experiment is based on a random utility maximization (RUM) model, where the choice of an alternative represents a discrete choice from a set of alternatives. Each alternative is represented with a utility function U_i for profile i that contains a deterministic component (V), which is a function of X_i, a vector of attributes associated with profile i; p_i, which is the cost of profile i; and β, which is a vector of preference parameters; and ε_i, which is a stochastic component. The RUM model can be represented by:

Equation A-1

$$\boldsymbol{U_i = V(X_i, p_i, \beta) + \varepsilon_i}$$

It is assumed that utility is linear in parameters:

Equation A-2

$$\boldsymbol{U_i = \sum_{k=1}^{1} \beta_k X_{ik} + \beta_p p_i + \varepsilon_i}$$

where β_k is the preference parameter associated with attribute k, X_{ik} is attribute k in profile i and β_p is the parameter on profile cost. The above equation represents the main effects. If interaction effects are included, the utility function can be represented by:

Equation A-3

$$\boldsymbol{U_i = \sum_{k=1}^{1} \beta_k X_{ik} + \beta_p p_i + \sum_{m=1}^{1} \sum_{k=1}^{1} \beta_{km} X_{ik} X_{im} + \varepsilon_i}$$

where β_{km} is a vector of preference parameters for interaction between attributes k and m in profile i and X_{ik} and X_{im} are attributes k and m in profile i. The marginal utility of attribute k can be represented by:

Equation A-4

$$\textbf{marginal utility} = \frac{\partial \boldsymbol{U}}{\partial \boldsymbol{X}_{\boldsymbol{k}}} = \boldsymbol{\beta}_{\boldsymbol{k}}$$

The parameter β_p on profile cost, represents the change in utility associated with a marginal increase in income. The negative of the parameter estimate $(-\beta_p)$ is interpreted as the marginal utility of money.

The marginal rate of substitution (MRS) between any two attributes k and m is computed as the ratio of two parameter estimates.

Equation A-5

$$\boldsymbol{MRS}_{\boldsymbol{km}} = \frac{\frac{\partial \boldsymbol{U}}{\partial \boldsymbol{X}_{\boldsymbol{k}}}}{\frac{\partial \boldsymbol{U}}{\partial \boldsymbol{X}_{\boldsymbol{m}}}} = \frac{\boldsymbol{\beta}_{\boldsymbol{k}}}{\boldsymbol{\beta}_{\boldsymbol{m}}}$$

Equation A-6

$$\textbf{Marginal value (implicit price) of attribute } \boldsymbol{k} = \frac{\frac{\partial \boldsymbol{U}}{\partial \boldsymbol{X}_{\boldsymbol{k}}}}{\frac{\partial \boldsymbol{U}}{\partial \boldsymbol{P}_{\boldsymbol{i}}}} = \frac{\boldsymbol{\beta}_{\boldsymbol{k}}}{\boldsymbol{\beta}_{\boldsymbol{p}}}$$

An individual will choose alternative i if $U_i > U_j$ for all $i \neq j$. However, since there is a stochastic component, you can only describe the probability of choosing alternative i, specified as:

Equation A-7

$$\boldsymbol{P}(\boldsymbol{i}|\boldsymbol{C}) = \boldsymbol{P}\left(\boldsymbol{U}_{\boldsymbol{i}} > \boldsymbol{U}_{\boldsymbol{j}}\right) = \boldsymbol{P}(\boldsymbol{V}_{\boldsymbol{i}} + \boldsymbol{\varepsilon}_{\boldsymbol{i}} > \boldsymbol{V}_{\boldsymbol{j}} + \boldsymbol{\varepsilon}_{\boldsymbol{j}});\ \forall\, \boldsymbol{j} \in \boldsymbol{C}$$

where C is the set of all possible alternatives. This can be rearranged to show that choices are made based on utility differences across alternatives:

Equation A-8

$$P(i|C) = P(V_i - V_j > \varepsilon_j - \varepsilon_i);\ \forall\, j \in C$$

Thus, any variable that remains the same across profiles drops out of the model. If errors are assumed to be IIA (have independence of irrelevant alternatives) and are Gumbel-distributed, the multinomial logit (MNL) model applies. A logit model is useful when trying to explain discrete choices. Given three discrete choices with 5 attributes and an additional cost attribute, indirect utility (V_i), can be represented by the following set of equations:

Equation A-9

$$\begin{cases} V_1 = \alpha_1 + \beta_1 X_{11} + \beta_2 X_{12} + \beta_3 X_{13} + \beta_4 X_{14} + \beta_5 X_{15} + \beta_p P_1 \\ V_2 = \alpha_2 + \beta_1 X_{21} + \beta_2 X_{22} + \beta_3 X_{23} + \beta_4 X_{24} + \beta_5 X_{25} + \beta_p P_2 \\ V_3 = \alpha_3 + \beta_1 X_{31} + \beta_2 X_{32} + \beta_3 X_{33} + \beta_4 X_{34} + \beta_5 X_{35} + \beta_p P_3 \end{cases}$$

To evaluate the probability of choosing alternative i, for estimation purposes, the values need to be transformed so they take on a real value that is restricted to the unit interval and can be interpreted as a probability. The multinomial logit model is obtained by applying the transformation to the V_i's:

Equation A-10

$$\begin{cases} P(1) = \dfrac{e^{V_1}}{e^{V_1} + e^{V_2} + e^{V_3}} \\ P(2) = \dfrac{e^{V_2}}{e^{V_1} + e^{V_2} + e^{V_3}} \\ P(3) = \dfrac{e^{V_3}}{e^{V_1} + e^{V_2} + e^{V_3}} \end{cases}$$

More generally, the choice probability can be written as:

Equation A-11

$$P(i|C) = \frac{\exp(V_i)}{\sum_{j \in C} \exp(V_j)}$$

Given an additively separable specification of utility, the probability of choosing alternative i from the set C is written as:

Equation A-12

$$\boldsymbol{P(i|C) = \frac{\exp(\sum_{k=1}^{1} \beta_k x_{ik} + \beta_p p_i)}{\sum_{j \in C} \exp(\beta_k x_{jk} + \beta_p p_j)}}$$

If we let N represent the sample size and define

Equation A-13

$$\boldsymbol{y_{in} = \begin{cases} 1 \text{ if respondent } n \text{ chose profile } i \\ 0 \qquad\qquad\qquad\qquad otherwise \end{cases}}$$

the likelihood function for the MNL model is:

Equation A-14

$$\boldsymbol{L = \prod_{n=1}^{N} \prod_{i \in C} P_n(i)^{y_{in}}}$$

The MNL model is estimated by finding the values of the β's that maximize the log-likelihood function:

Equation A-15

$$\boldsymbol{\ln L = \sum_{n=1}^{N} \sum_{i \in C} y_{in} \left(\sum_{k=1}^{1} \beta_k x_{ikn} + \beta_p p_{in} - \ln \sum_{j \in C} \left(\sum\nolimits_{k=1}^{1} \beta_k x_{jkn} + \beta_p p_{jn} \right) \right)}$$

Including price as an attribute in the conditional indirect utility function (conditional on the choice of alternatives) allows the assessment of economic welfare measures, or compensating variation (Champ, Boyle, & Brown, 2003; Rosen & Small, 1981). Compensating variation is a measure of utility change introduced by John Hicks (1939). It is the area under the Hicksian demand curve evaluated at the initial utility level and two prices.

A willingness-to-pay (compensating variation) welfare measure can be obtained from:

Equation A-16

$$\boldsymbol{CV = WTP = \beta_p^{-1} \ln \left[\frac{\sum_i \exp\left(V_i^1\right)}{\sum_i \exp\left(V_i^0\right)}\right]}$$

where β_p is the marginal utility of income (Hanley, Wright, & Koop, 2002). WTP for an attribute can be represented as:

Equation A-17

$$\boldsymbol{WTP_k = -\beta_k / \beta_p}$$

The standard MNL generates results in a conditional indirect utility function of the form

Equation A-18

$$\boldsymbol{V_i = ASC_i + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \beta_p P_i}$$

Where ASC_i is the alternate-specific constant which captures the influence of unobserved attributes relative to the specific alternatives (Carlsson et al., 2003; Hensher, Rose, & Greene, 2005). The $\beta's$ represent the coefficients on the vector of attributes, and the $X's$ are the attributes. Surveys that contain an opt-out (prefer neither) option typically require the use of dummy variables known as alternative-specific constants (ASCs). ASCs identify the utility of the opt-out option. Since the opt-out alternative has no attributes, an ASC is necessary to model this alternative's utility. If there are K alternatives in the choice set, the $(K - 1)$ ASCs are included in the econometric specification (Champ et al., 2003). An ASC is a dummy variable that equals one when the status quo option was not chosen. If an examination of the parameters reveals a significant value, then the utility associated with moving away from the current situation is negative and significant (Adamowicz, Boxall, Williams, & Louviere, 1998).

Since the alternatives in this study are unlabeled, an ASC cannot be interpreted and is left out of the model. The conditional logit for this model is represented by:

Equation A-19

$$\boldsymbol{V_i = \beta_1 X_{size} + \beta_2 X_{ecological\ quality} + \beta_3 X_{Palouse\ earthworm} + \beta_4 X_{threatened\ plants} + \beta_5 X_{Public\ Access} + \beta_p P_i}$$

The estimated coefficients can be used to derive the relative importance or preference of the respondents towards each attribute. Policy analysts and decision makers have an interest in knowing which features of conservation are most important to residents in the Palouse Prairie region. This is done by considering how much difference each attribute could make in the total utility of the prairie. The equation for estimating the relative importance (RI) is detailed in Halbrendt et al. (1995), and is:

Equation A-20

$$\boldsymbol{RI_i = 100 \times \frac{UR_i}{\sum_{i=1}^{n} UR_i}}$$

where RI_i is the relative importance of attribute i, and UR_i is the utility range of attribute i.

Since the survey contains qualitative attributes, dummy variables are needed for the analysis. Dummy variables can be defined for $L - 1$ qualitative attribute levels in the usual manner, and the status quo level would be designated as the omitted level. The parameter estimates on included levels represent changes to the status quo. The problem with this approach is that when dummy variables are used to code attribute levels, the attribute level that is associated with the omitted category is perfectly collinear with the intercept in a regression model and no information is recovered about preferences on the omitted level. To overcome this problem, effects codes are used because they are uncorrelated with the intercept and the values of omitted levels for each attribute can be estimated (Louviere, Hensher, & Swait, 2000). Effect codes can be created using the following criteria (Champ et al., 2003):

1) if the profile contains the first level of the attribute, set $EC_1 = 1$,
2) if the profile contains the L^{th} level of the attribute, set $EC_1 = -1$,
3) if neither step 1 nor step 2 apply, set $EC_1 = 0$.

If an attribute has two levels, you only need to create one effects-coded variable using criteria 1 through 3. If an attribute has three levels, the coding process is continued by creating a second effects coded variable, EC_2 , using three additional criteria:

4) if the profile contains the second level of the attribute, set $EC_2 = 1$,
5) if the profile contains the L^{th} level of the attribute, set $EC_2 = -1$,
6) if neither step 4 nor step 5 apply, set $EC_2 = 0$.

If an attribute has more than 3 levels, effect codes continue to be created in this manner until $L - 1$ effects codes are created for each L-level attribute. Using this coding scheme, the parameter value for the omitted attribute level can be computed. The value of the parameter for the L^{th}-level of an attribute is:

Equation A-21

$$\boldsymbol{b_1}(-\mathbf{1}) + \boldsymbol{b_2}(-\mathbf{1}) + \cdots + \boldsymbol{b_{L-1}}(-\mathbf{1})$$

where b_n is the parameter estimate on the n^{th} level $(n \neq L)$ of an effects coded variable.

Champ et al. (2003) provide the steps necessary for conducting a CE:

1) Characterize the decision problem: Clearly identify the economic and environmental problem. This requires the geographic and temporal scope of the change in the environmental quality and the types of values that are associated with changes in environmental quality.

2) Identify and describe the attributes: Identification of relevant attributes of the good to be valued. Use of literature reviews, focus groups, and expert consultations should be used to help identify the relevant attributes. Assign attribute levels that are feasible, realistic, and span the range of respondents' preference maps. Use of focus groups, pilot surveys, literature reviews, and expert consultations should be used to select the appropriate attribute levels.

3) Develop an experimental design: Use statistical design theory to combine the levels of attributes into a number of alternative scenarios or profiles to be presented to respondents.

4) Develop the questionnaire: Use of verbal descriptions and graphics are used to create a survey that respondents will understand. Pre-testing is necessary to assure that respondents clearly understand the information being presented.

5) Collect data: Data are collected using best survey practices.

6) Estimate the model: Preference parameters in the utility model are estimated econometrically.

7) Interpret the results for policy analysis or decision support: Results are interpreted for policy analysis and decision support. CE applications are targeted to generating welfare measures and/or predictions of behavior.

Appendix B: Protocol Approval

University of Idaho

April 7, 2013

Office of Research Assurances
Institutional Review Board
PO Box 443010
Moscow ID 83844-3010

Phone: 208-885-6162
Fax: 208-885-5752
irb@uidaho.edu

To: Watson, Philip
Cc: Decker, Kevin

From: Traci Craig, PhD
Chair, University of Idaho Institutional Review Board
University Research Office
Moscow, ID 83844-3010

Title: 'Choice Experiment to determine willingness to pay for Palouse Prairie conservation'

Project: 13-059
Approved: 04/07/13
Expires: 04/06/14

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the protocol for the above-named research project is approved as offering no significant risk to human subjects.

This approval is valid for one year from the date of this memo. Should there be significant changes in the protocol for this project, it will be necessary for you to resubmit the protocol for review by the Committee.

Traci Craig

Traci Craig

University of Idaho

Office of Research Assurances
Institutional Review Board
PO Box 443010
Moscow ID 83844-3010

Phone: 208-885-6162
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August 29, 2012

To: Prather, Tim
Cc: Davis, Cleve

From: Traci Craig, PhD
Chair, University of Idaho Institutional Review Board
University Research Office
Moscow, ID 83844-3010

Title: 'Palouse Prairie Cultural Landscape'

Project: 12-233
Approved: 08/28/12
Expires: 08/27/13

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the protocol for the above-named research project is approved as offering no significant risk to human subjects.

This approval is valid for one year from the date of this memo. Should there be significant changes in the protocol for this project, it will be necessary for you to resubmit the protocol for review by the Committee.

Traci Craig

Traci Craig

Appendix C: Postcards, Letters, and Survey

Pre-Postcard

Palouse Prairie Conservation Survey **May 2013**

In a few days you will receive by mail a request to fill out a brief web survey to help researchers at the University of Idaho understand how residents of the Palouse region value conservation of native Palouse Prairie sites.
You will need to enter the web address into your computer and you will be directed to the survey. The survey will take about 10-15 minutes of your time.

I am writing in advance because we have found many people appreciate being advised that a research study is in progress. In order for our results to truly represent all the people in this region it is important that we receive your completed survey. This research can only be successful with the generous help of people like you. To say thank you, you will receive a small token of appreciation with the request to participate. If you have questions about this study, you may call the Social Science Research Unit, toll-free at 1-877-542-3019,
or locally at 885-5595.
Sincerely,

Kevin Decker, PhD Graduate Student
University of Idaho

Web Letter

May 21, 2013

Palouse Resident
123 Main Street
Moscow, ID 83843

Dear Palouse Resident,

Researchers at the University of Idaho and the Social Science Research Unit are writing to ask for your help in understanding how residents of the Palouse region value conservation of native Palouse Prairie sites. In order to learn about this issue we are asking people who live in the region to share their values, thoughts, and opinions. You have been randomly selected among households in the region to participate in this study.

The questionnaire should only take about 10 – 15 minutes to complete. Your responses are voluntary and will be kept confidential. Your name will not be used with the data. We are asking you to take the survey online, the survey can be found at http://www.prairiesurvey.com Please enter the code #### to take the survey. If you have questions about this survey you may call the Social Science Research Unit toll-free at 1-877-542-3019 or locally at 208-885-5595. This study has been reviewed and approved by the University of Idaho Institutional Review Board.

By taking a few minutes to share your thoughts and opinions about the value of the conservation of native Palouse Prairie sites you will be helping us out a great deal. We have included a small token of appreciation enclosed as a way of saying thank you for your participation.

Sincerely,

Kevin Decker, PhD Graduate Student
University of Idaho

Web Follow-Up Letter

May 30, 2013

Palouse Resident
123 Main Street
Moscow, ID 83843

Dear Palouse Resident,

Last week a letter was sent to you to asking you to complete an online survey in order to understand how residents of the Palouse region value conservation efforts of native Palouse Prairie sites.

If you have already completed the web questionnaire please accept our sincere thanks. If not, please do so today. The on line survey can be found at http://www.prairiesurvey.com please enter the code ####. The questionnaire should only take about 10 – 15 minutes to complete. Your responses are voluntary and will be kept confidential. It is extremely important that your responses be included in order for our results to truly represent people in this region.

If you have any questions please call the Social Science Research Unit, toll-free, at (1-877-542-3019) or locally at 885-5595.

Sincerely,

Kevin Decker, PhD Graduate Student
University of Idaho

Letter with Survey

June 13, 2013

Palouse Resident
123 Main Street
Moscow, ID

Dear Palouse Resident,

About three weeks ago you were asked to take a survey online seeking your thoughts and opinions about conservation of native Palouse Prairie sites. We are sending the survey in the mail in case you were not able to complete the survey on line.

The Social Science Research Unit at the University of Idaho is conducting the study which has been approved by the Institutional Review Board at the University of Idaho.

The questionnaire has an identification number for mailing purposes only. The information you provide will be completely confidential. Your name will not be used with the data. Please return the survey in the postage paid, self-addresses envelope provided.

If you have questions about this survey you may call the Social Science Research Unit toll-free at 1-877-542-3019 or locally at 885-5595.

Sincerely,

Kevin Decker, PhD Graduate Student
University of Idaho

Letter with Survey Follow-Up

July 9, 2013

Mary Sample
100 Main Street
Anytown, ID 99999

Dear Mary Sample,

A month ago we sent a mail survey seeking your thoughts and opinions about conservation of native Palouse Prairie sites. We have not yet heard from you and are sending a second survey. For the results to accurately represent the beliefs of Palouse residents, it is very important that each questionnaire in the sample be completed and returned.

The Social Science Research Unit at the University of Idaho is conducting the study which has been approved by the Institutional Review Board at the University of Idaho.

The questionnaire has an identification number for mailing purposes only. The information you provide will be completely confidential. Your name will not be used with the data. Please return the survey in the postage paid, self-addressed envelope provided.

Thank-you very much for your participation in this study we appreciate your time. If you have questions about this survey you may call the Social Science Research Unit toll-free at 1-877-542-3019 or locally at 885-5595.

Sincerely,

Kevin Decker, PhD Graduate Student
University of Idaho

Complete Survey: Design 1

Palouse Prairie

Native Flowers on Paradise Ridge: AlisonMeyerPhotography.com

Survey conducted by

University of Idaho

Environmental Science Program

National Science Foundation, IGERT

Introduction: In this survey, you will be asked to compare two hypothetical Palouse Prairie sites that represent the range of ecological states or conditions that prairie sites are currently found in within the region. The two prairie sites will vary in their characteristics and cost of conservation. Please read the section below before taking the survey so that you are familiar with each of the characteristics that will be presented to you.

What is Palouse Prairie? The region of southeastern Washington and northern Idaho characterized by rolling hills and deep soils is known as the Palouse. The Palouse Prairie is the original ecosystem that consists of bunchgrasses, forbs, and shrubs. While it once covered large portions of southeastern Washington, northern Idaho, and northeastern Oregon, conversion to agricultural production was almost complete by the late 19th century. The remaining prairie sites are scattered across the landscape, usually on rocky ridges, steep slopes, along streams and on field margins. Less than 1% of Palouse Prairie remains today and almost all sites are located on private property.

Conservation: Conservation is the act of conserving, protecting, and preserving the natural environment, natural ecosystem, vegetation, and wildlife through measures that prevent loss, degradation, and destruction of existing Palouse Prairie sites.

View from Kamiak Butte: AlisonMeyerPhotography.com

Size: Patches can vary in size but most are quite small with about 50% less than 2.5 acres and 70% less than 5 acres.

Giant Palouse Earthworm: The Giant Palouse earthworm is the only native earthworm in the Palouse Prairie and is considered rare.

Rare Plants: Rare plants are native plants that are very uncommon or scarce locally.

Cost: Cost is the conservation cost that you would be willing to pay in your household (hh) per year toward Palouse Prairie conservation for that specific prairie site. Any money paid toward conservation must be considered spent money that cannot be used on other things.

Public Access: Access to prairie sites is typically restricted due to their presence on private land. Some sites are located on public property and some private land owners will allow access to their site with permission.

Ecological Quality: Ecological quality is determined from biological, non-biological, and physical characteristics of the prairie. It is a measure of the condition of each prairie site.

> **Low**: A site where soils have been heavily degraded or disturbed. It is isolated from other prairie sites. It is heavily invaded by non-native species. It has very few total species. Of all the species present, some species occur frequently and others occur infrequently.
>
> **Medium**: A site where soils have some degradation or disturbance. It is moderately isolated from other prairie sites. It has been invaded by non-native species but still supports native species. Of all the species present, some species occur more frequently than others.
>
> **High**: A site where soils have limited or no degradation or disturbance. It is near other prairie sites. It has very few invasive species. It has many native species. All the species present occur with about the same frequency.

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 1:	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Present	Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$25	$50	
	❑	❑	❑

Question 2:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Not Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$150	$5	
	❑	❑	❑

Question 3:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	Yes	
Cost/hh/year	$150	$100	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 4:	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	No	No	
Cost/hh/year	$100	$50	
	❑	❑	❑

Question 5:	Prairie A	Prairie B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$100	$5	
	❑	❑	❑

Question 6:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Present	
Public Access	No	Yes	
Cost/hh/year	$25	$150	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 7:	Prairie A	Prairie B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Present	Present	
Rare Plants	Not Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$5	$50	
	❑	❑	❑

Question 8:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	High	
Giant Palouse Earthworm	Not Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$50	$25	
	❑	❑	❑

Question 9:	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$100	$100	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would choose?

Question 10:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Low	
Giant Palouse Earthworm	Not Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$25	$150	
	❑	❑	❑

Question 11:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$150	$5	
	❑	❑	❑

Question 12:	Prairie Type A	Prairie Type B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Present	Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$50	$5	
	❑	❑	❑

13. What is the maximum out of pocket expense that you would be willing to pay in your household per year for Palouse Prairie conservation?

$_______________

14. Prior to taking this survey, what was your level of knowledge about the Palouse Prairie?

- ❑ No knowledge
- ❑ A little knowledge
- ❑ A moderate amount of knowledge
- ❑ A great deal of knowledge

15. Please rank the attributes in order of importance to you, with 1 being most important and 6 being least important.

_____ Size
_____ Ecological Quality
_____ Giant Palouse Earthworm
_____ Rare Plants
_____ Public Access
_____ Conservation Cost

16. What year were you born *(YYYY)*?

____

17. What is your gender?

- ❑ Male
- ❑ Female

18. On a scale of 1 to 7 where 1 is very liberal, 4 is moderate and 7 is very conservative, how would you describe your political views?

Very Liberal			Moderate			Very Conservative
❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

19. What is your race/ethnicity? (You may check more than one box)

- ❑ African American/Black
- ❑ Asian/Pacific Islander
- ❑ Hispanic/Latino
- ❑ Native American/American Indian
- ❑ White/Non-Hispanic
- ❑ Other or mixed race (please specify):

____

20. How many people live in your household in each of the following age categories?

_____ Adults (18 years and older)
_____ Children age 13 – 17
_____ Children age 0 – 12

21. What is your employment status?

- ❑ Employed full time
- ❑ Employed part-time
- ❑ Full-time Student
- ❑ Serving on Active Duty in the Armed Forces
- ❑ Full-time Homemaker
- ❑ Holding a job, but on temporary layoff
- ❑ Looking for work
- ❑ Retired
- ❑ Disabled

22. What is the highest grade or year of school you completed?

- ❑ 12th grade or less, no diploma
- ❑ High school graduate or GED
- ❑ Some college, no degree
- ❑ Associate's degree
- ❑ Bachelor's degree
- ❑ Graduate or professional degree

23. What is your total household income (before taxes)?

- ❑ Less than $15,000
- ❑ $15,000 - $24,999
- ❑ $25,000 - $34,999
- ❑ $35,000 - $49,999
- ❑ $50,000 - $74,999
- ❑ $75,000 - $99,999
- ❑ Greater than $100,000

24. How many years have you lived in the Palouse region?

_______ years

25. Do you currently own land in the Palouse region?

- ❑ Yes
- ❑ No

26. If you answered "Yes" to question 25, does your land contain any native Palouse Prairie patches?

- ❑ Yes, undisturbed prairie
- ❑ Yes, disturbed prairie
- ❑ Yes, restored prairie
- ❑ No
- ❑ Unsure

27. On a scale of 1 to 5, with 1 being not valuable at all and 5 being extremely valuable, please rate how valuable the remaining patches of native Palouse Prairie are to you and your family.

1	2	3	4	5
❑	❑	❑	❑	❑
Not Valuable at All				Extremely Valuable

28. Culturally significant plants are defined as any native plant, lichen, moss, or fungus that can be used for food, teas, medicine, in ceremonies, or materials in artisan craft. On a scale of 1 to 5, with 1 being not valuable at all and 5 being extremely valuable, please rate how valuable culturally significant plants, lichens, mosses, and fungus of the Palouse Prairie are to you and your family.

1	2	3	4	5
❑	❑	❑	❑	❑
Not Valuable at All				Extremely Valuable

29. How appropriate or inappropriate is it to use a monetary amount to inform conservation decisions about Palouse Prairie?

Not Appropriate		Neutral		Very Appropriate
❑	❑	❑	❑	❑

30. What is your reasoning for the answer to question 29?

____

____

____

____

How strongly do you agree or disagree with each of the following statements:

31. I don't want the landscape of the Palouse Prairie to change.

- ❑ Strongly agree
- ❑ Somewhat agree
- ❑ Neither agree nor disagree
- ❑ Somewhat disagree
- ❑ Strongly disagree

32. The Palouse Prairie is part of my identity and heritage.

- ❑ Strongly agree
- ❑ Somewhat agree
- ❑ Neither agree nor disagree
- ❑ Somewhat disagree
- ❑ Strongly disagree

33. Nature is unspoiled on the Palouse Prairie.

- ❑ Strongly agree
- ❑ Somewhat agree
- ❑ Neither agree nor disagree
- ❑ Somewhat disagree
- ❑ Strongly disagree

34. Please use the space below to provide any additional concerns or comments regarding your opinions about Palouse Prairie conservation or comments related to any part of this survey. Feel free to attach a separate sheet with more comments.

Thank you for taking the time to complete this survey!

If you have questions, feel free to contact us at:

Social Science Research Unit
Toll-free: 1-877-542-3019
Local telephone: 885-5595
Email: ssru@uidaho.edu

University of Idaho

Survey Design 2

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 1:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$25	$50	
	❑	❑	❑

Question 2:	Prairie A	Prairie B	
Size	1 to 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$100	$25	
	❑	❑	❑

Question 3:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Not Present	Not Present	
Rare Plants	Present	Present	
Public Access	Yes	No	
Cost/hh/year	$50	$150	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 4:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$25	$100	
	❑	❑	❑

Question 5:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$50	$150	
	❑	❑	❑

Question 6:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Medium	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$5	$5	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 7:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$100	$100	
	❑	❑	❑

Question 8:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	No	
Cost/hh/year	$150	$5	
	❑	❑	❑

Question 9:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	Yes	
Cost/hh/year	$25	$150	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 10:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$100	$25	
	❑	❑	❑

Question 11:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Not Present	Not Present	
Rare Plants	Not Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$5	$50	
	❑	❑	❑

Question 12:	Prairie Type A	Prairie Type B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Present	
Public Access	No	Yes	
Cost/hh/year	$150	$5	
	❑	❑	❑

Survey Design 3

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 1:

	Prairie A	Prairie B	
Size	Greater than 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$150	$5	
	❑	❑	❑

Question 2:

	Prairie A	Prairie B	
Size	Less than 1 acre	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Present	Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$50	$100	
	❑	❑	❑

Question 3:

	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$50	$25	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 4:	Prairie A	Prairie B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$25	$150	
	❑	❑	❑

Question 5:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Present	
Public Access	No	Yes	
Cost/hh/year	$50	$100	
	❑	❑	❑

Question 6:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$25	$5	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 7:	Prairie A	Prairie B	
Size	1 to 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$100	$50	
	❑	❑	❑

Question 8:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$5	$50	
	❑	❑	❑

Question 9:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Not Present	
Public Access	Yes	Yes	
Cost/hh/year	$25	$150	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 10:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Present	
Public Access	Yes	No	
Cost/hh/year	$50	$25	
	❑	❑	❑

Question 11:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	No	No	
Cost/hh/year	$150	$100	
	❑	❑	❑

Question 12:	Prairie Type A	Prairie Type B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$50	$5	
	❑	❑	❑

Survey Design 4

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 1:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$25	$150	
	❑	❑	❑

Question 2:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$25	$100	
	❑	❑	❑

Question 3:	Prairie A	Prairie B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	High	
Giant Palouse Earthworm	Present	Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$5	$100	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 4:	Prairie A	Prairie B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	High	
Giant Palouse Earthworm	Not Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	Yes	Yes	
Cost/hh/year	$5	$150	
	❑	❑	❑

Question 5:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	No	No	
Cost/hh/year	$100	$5	
	❑	❑	❑

Question 6:	Prairie A	Prairie B	
Size	Greater than 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$50	$150	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 7:	Prairie A	Prairie B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$25	$25	
	❑	❑	❑

Question 8:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$50	$5	
	❑	❑	❑

Question 9:	Prairie A	Prairie B	
Size	Greater than 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Present	
Public Access	Yes	No	
Cost/hh/year	$150	$150	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 10:	Prairie A	Prairie B	
Size	Less than 1 acre	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Medium	
Giant Palouse Earthworm	Not Present	Not Present	
Rare Plants	Not Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$5	$100	
	❑	❑	❑

Question 11:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	High	
Giant Palouse Earthworm	Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	Yes	
Cost/hh/year	$5	$25	
	❑	❑	❑

Question 12:	Prairie Type A	Prairie Type B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	No	No	
Cost/hh/year	$5	$100	
	❑	❑	❑

Survey Design 5

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 1:	Prairie A	Prairie B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$50	$100	
	❑	❑	❑

Question 2:	Prairie A	Prairie B	
Size	Greater than 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$50	$25	
	❑	❑	❑

Question 3:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$50	$150	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 4:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Medium	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$150	$25	
	❑	❑	❑

Question 5:	Prairie A	Prairie B	
Size	Less than 1 acre	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$25	$5	
	❑	❑	❑

Question 6:	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$100	$100	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 7:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	Yes	Yes	
Cost/hh/year	$150	$50	
	❑	❑	❑

Question 8:	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$150	$50	
	❑	❑	❑

Question 9:	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	No	No	
Cost/hh/year	$25	$100	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 10:	Prairie A	Prairie B	
Size	Less than 1 acre	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$25	$5	
	❑	❑	❑

Question 11:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	No	No	
Cost/hh/year	$5	$5	
	❑	❑	❑

Question 12:	Prairie Type A	Prairie Type B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Not Present	
Public Access	Yes	Yes	
Cost/hh/year	$50	$100	
	❑	❑	❑

Survey Design 6

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 1:

	Prairie A	Prairie B	
Size	1 to 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Not Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$150	$25	
	❑	❑	❑

Question 2:

	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$25	$100	
	❑	❑	❑

Question 3:

	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Present	Present	
Rare Plants	Present	Present	
Public Access	No	Yes	
Cost/hh/year	$5	$50	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 4:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$150	$50	
	❑	❑	❑

Question 5:	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Not Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$50	$100	
	❑	❑	❑

Question 6:	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Present	Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$50	$150	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 7:	Prairie A	Prairie B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$100	$150	
	❑	❑	❑

Question 8:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Present	
Public Access	No	Yes	
Cost/hh/year	$5	$100	
	❑	❑	❑

Question 9:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$5	$25	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 10:	Prairie A	Prairie B	
Size	1 to 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$150	$100	
	❑	❑	❑

Question 11:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$25	$25	
	❑	❑	❑

Question 12:	Prairie Type A	Prairie Type B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$50	$150	
	❑	❑	❑

Survey Design 7

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 1:	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Low	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$150	$5	
	❑	❑	❑

Question 2:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Medium	High	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$25	$100	
	❑	❑	❑

Question 3:	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$5	$150	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 4:

	Prairie A	Prairie B	
Size	1 to 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	Yes	No	
Cost/hh/year	$50	$5	
	❑	❑	❑

Question 5:

	Prairie A	Prairie B	
Size	Greater than 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Present	
Public Access	No	Yes	
Cost/hh/year	$25	$50	
	❑	❑	❑

Question 6:

	Prairie A	Prairie B	
Size	Greater than 5 acres	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$5	$100	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 7:	Prairie A	Prairie B	
Size	1 to 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Present	Not Present	
Public Access	No	No	
Cost/hh/year	$150	$100	
	❑	❑	❑

Question 8:	Prairie A	Prairie B	
Size	Less than 1 acre	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Present	Not Present	
Public Access	No	Yes	
Cost/hh/year	$50	$25	
	❑	❑	❑

Question 9:	Prairie A	Prairie B	
Size	Less than 1 acre	Less than 1 acre	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Low	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$5	$50	
	❑	❑	❑

Indicate which prairie site you prefer to conserve by checking the appropriate box. If you do not like either prairie site option, you have the ability to choose "Neither". If you like both prairie site options equally, please only choose one of them. Each choice is independent and should be considered separately. Cost indicates the amount of money you would be willing to pay in your household (hh) per year for that specific prairie site. If you were considering spending money on Palouse Prairie conservation, and these were your only alternatives, which would you choose?

Question 10:	Prairie A	Prairie B	
Size	Less than 1 acre	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	High	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	No	Yes	
Cost/hh/year	$100	$25	
	❑	❑	❑

Question 11:	Prairie A	Prairie B	
Size	Greater than 5 acres	Greater than 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	Low	Medium	
Giant Palouse Earthworm	Present	Not Present	
Rare Plants	Not Present	Not Present	
Public Access	Yes	Yes	
Cost/hh/year	$150	$5	
	❑	❑	❑

Question 12:	Prairie Type A	Prairie Type B	
Size	1 to 5 acres	1 to 5 acres	NEITHER: I wouldn't choose either of these.
Ecological Quality	High	Medium	
Giant Palouse Earthworm	Not Present	Present	
Rare Plants	Not Present	Present	
Public Access	Yes	No	
Cost/hh/year	$25	$100	
	❑	❑	❑

Appendix D: Survey Demographics

Data collection was conducted by the University of Idaho Social Science Research Unit using a modified Dillman method (Dillman et al., 2009). The mixed-mode study included web and mail components. An address-based sample of 1600 residents in the Palouse area was purchased from Survey Sampling Intl. (Shelton, Connecticut, U.S.A.). A sample of 1300 households was drawn proportionate to population in Latah County, Idaho, and Whitman County, WA. Samples of 100 households were drawn from the Idaho cities of Plummer, Worley, and Lapwai (300 total) in an attempt to increase the response from 'hard to reach' populations on the Palouse, such as ethnic minorities and those in lower socio-economic statuses.

To increase the survey response rate, 1600 pre-postcards were mailed 16 May 2013 notifying respondents that they would be receiving a link to the web survey in a letter. A letter with the link to the survey and unique password was mailed to the same 1600 addresses on 21 May. By 29 May, 59 surveys had been completed on the web; 208 of these first letters were returned as non-deliverable. A second letter was sent 30 May to the remaining 1333 residents with the link to the survey and contained a $1.00 bill as an incentive and as a token of appreciation. By 6 June, there were a total of 234 completed web surveys. Four respondents had refused, 280 letters total were non-deliverable, 2 respondents were deceased, and 5 were physically or mentally unable to do the survey. Paper surveys were sent on 13 June, using 7 different versions assigned randomly to each respondent. A simple random sample of 300 was selected from the remaining non-respondents and these were sent a second paper survey by mail on 18 July 2013.

At the end of the data collection period, there was a total of 421 completed surveys (241 completed online, 180 completed paper copy), 17 respondents refused the survey, 338 were non-deliverables, and 821 were non-respondents. Two respondents were deceased and 5 were physically or mentally unable to complete the survey. The final response rate was 26.34%; cooperation rate, defined as he number of eligible respondents who completed the survey, divided by the total number of households reached, was 96.1%; refusal rate was .01%, and contact rate, defined as the number of households reached divided by the number of surveys sent, was 27.6%. These rates were calculated using the American Association for Public Opinion Research (AAPOR) standard definitions and formulas (AAPOR, 2006). Copies of all the letters and survey with design are located in the appendix.

Population demographic information was collected from the U.S Census Bureau's American Community Survey (ACS) 2007 – 2011 (U.S. Census Bureau, 2012) and compared to the collected sample for age, education, and income. Additional demographic information on gender, political affiliation, ethnicity, children, employment, and residency, was also collected in the survey.

There are some important differences between the population and the sample. There was a total of 371 responses from the survey on age. From that sample, the mean age is 54.03 years, and the median age is 54. Based on comparisons between the survey sample and the ACS data, the sampled population differs from the general population. The age category of 18 – 19 comprises 27.5% of the population, but only 0.3% of the sample. Similarly, the age category of 20 – 24 comprises 21.1% of the population, but only 5.1% of the sample (Figure

D-1). There was a total of 386 responses from the survey on education. The education categories of 12th grade or less, high school graduate or GED, and some college with no degree were under sampled and the education categories of associates degree, bachelor's degree, and graduate or professional degree were over sampled. This means that the sample disproportionately represents those with a higher education (Figure D-2). There was a total of 355 responses from the survey on income. The income categories of less than $15,000, $15,000 – $24,999, and $25,000 – $34,999 were under sampled, and the income categories of $35,000 – $49,999, $50,000 – $74,999, $75,000 – $99,999, and greater than $100,000 were over sampled (Figure D-3). This means that the sample disproportionately represents those with higher incomes. These results are because the survey was conducted in May – July when most of the large university student populations from the University of Idaho and Washington State University were absent. This caused proportionate oversampling in most of the other age categories relative to the ACS data. As a consequence, the sample represents permanent residents of the region instead of the more transient student population.

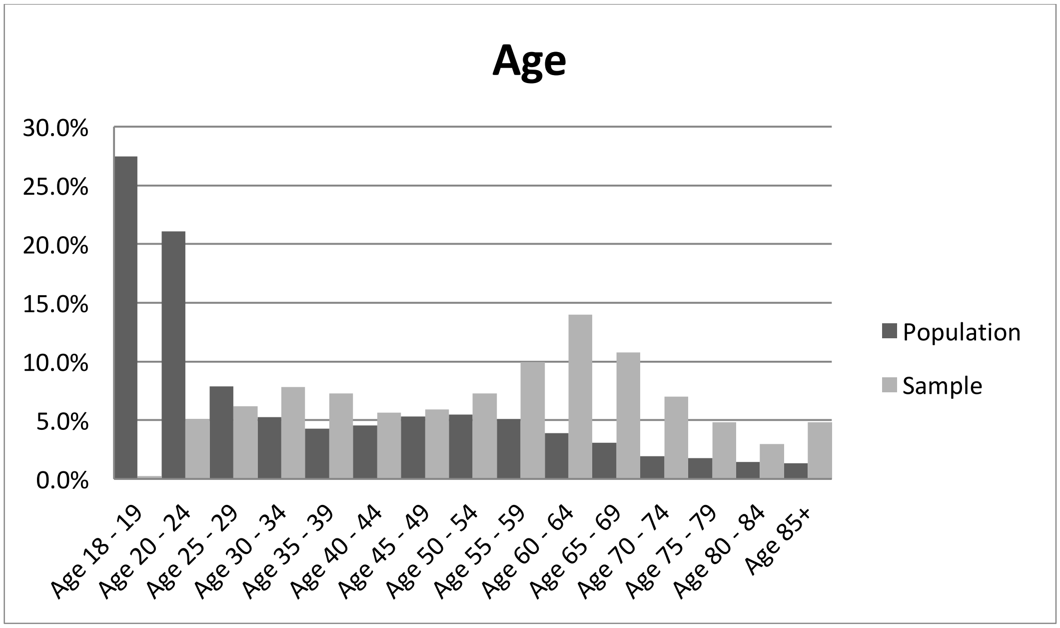

Figure D-1: Comparison of U.S. Census, American Community Survey (population) and survey sample age distributions from survey on Palouse Prairie conservation.

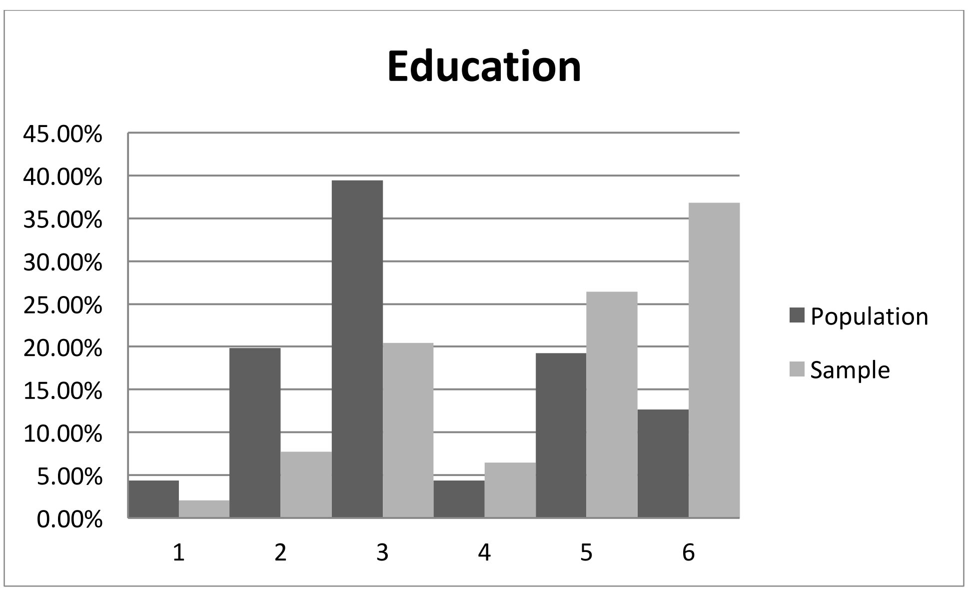

Figure D-2: Comparison of U.S. Census, American Community Survey (population) and survey sample education distributions from survey on Palouse Prairie conservation.

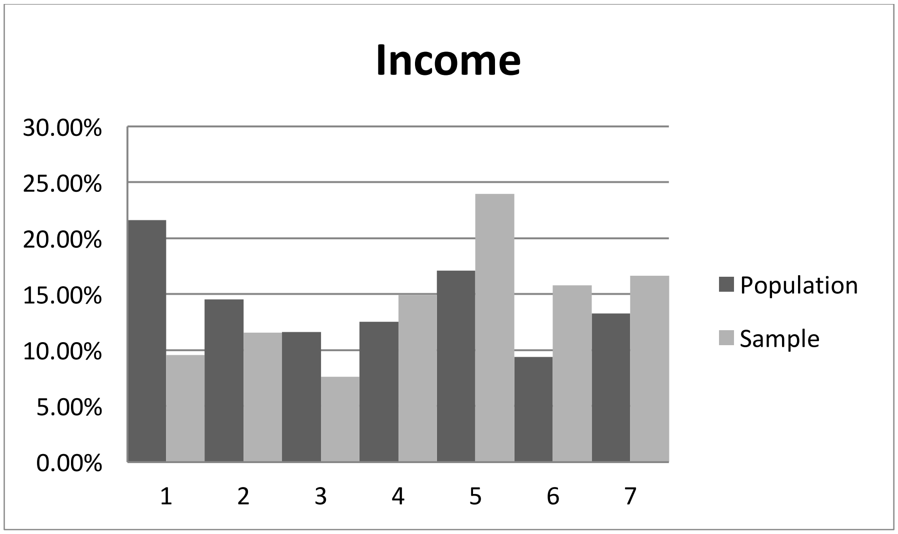

Figure D-3: Comparison of U.S. Census, American Community Survey (population) and survey sample income distributions from survey on Palouse Prairie conservation.

Additional demographic information is provided in the following tables and distributions:

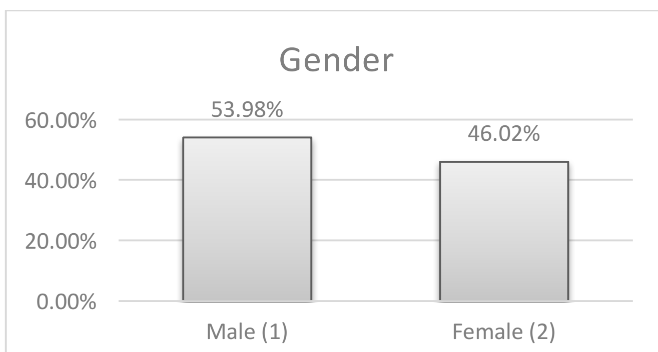

Figure D-4: Gender distribution

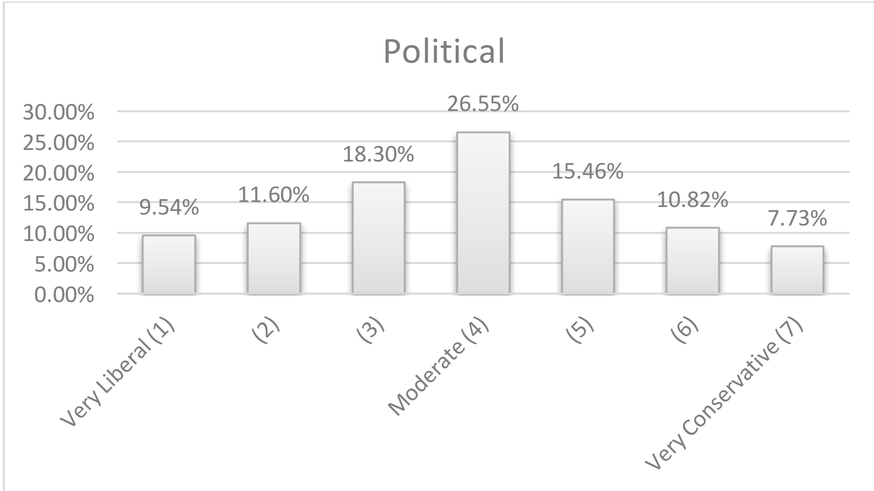

Figure D-5: Political affiliation distribution

Table D-1: Ethnicity distribution

Ethnicity	Count	Percent
African American/Black	3	0.75%
Asian/Pacific Islander	16	3.99%
Hispanic/Latino	10	2.49%
Native American/American Indian	17	4.24%
White/Non-Hispanic	353	88.03%
Other	2	0.50%
	401	100.00%

Table D-2: Adults and children in household

Quantity	Adults (18 years and older)	Children age 0 – 12	Children age 13 – 17
1	104	30	17
2	237	19	9
3+	34	17	1
Total	375	66	27

Table D-3: Employment distribution

Employment type	Count	Percent
Employed Full Time (1)	187	48.32%
Employed Part Time (2)	34	8.79%
Full-Time Student (3)	21	5.43%
Serving on Active Duty in the Armed Forces (4)	0	0.00%
Full-Time Homemaker (5)	12	3.10%
Holding a job, but on temporary layoff (6)	0	0.00%
Looking for Work (7)	10	2.58%
Retired (8)	118	30.49%
Disabled (9)	5	1.29%
	387	100.00%

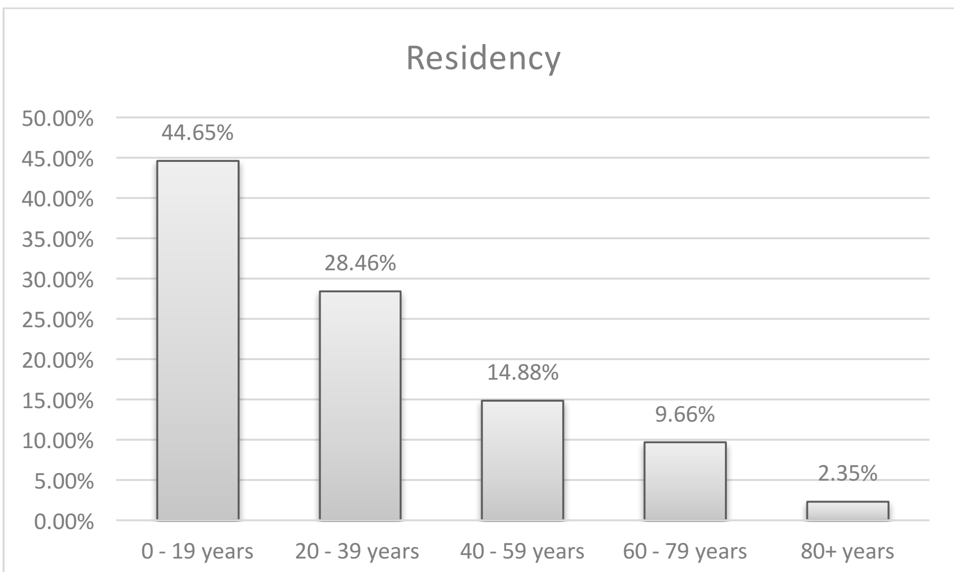

Figure D-6: Residency distribution

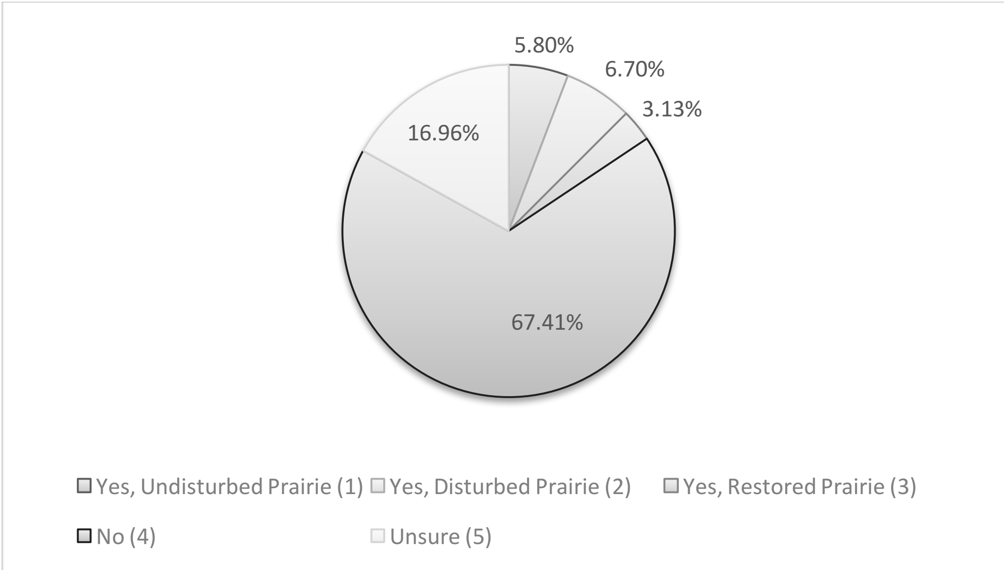

Figure D-7: Own Palouse Prairie

Appendix E: Semi-Structured Interview Questions

1. What is your tribal affiliation?
2. Tell me a little about yourself?
3. What is your age?
4. What native plants and animals are important to you and your family?
5. Why are these native plants and animals important to you or your family?
6. What is the Indian language name of these plants and animals?
7. What language are you speaking?
8. Have you ever tried to access natural places, such as native grasslands or forests, on the Palouse Prairie?
9. Would you be interested in accessing natural places, such as native grasslands or forests, on the Palouse Prairie?
10. What can you tell be about the traditional use of the Palouse Prairie?
11. Do you farm or pasture livestock on the Palouse Prairie?
12. Most of the natural Palouse Prairie is in agriculture and only small patches of native grassland remain. What is your opinion on conserving what remains of the native grassland?
13. Over your lifetime have you noticed any unusual changes to the weather or regional climate? If so, do you foresee these changes affecting your life or traditions?
14. Do you know of anyone else who would be knowledgeable about Palouse Prairie and traditional customs of the Tribe?
15. Do you have anything else you want to say about the Palouse Prairie?