PERCEPTIONS OF ECOSYSTEM SERVICES IN RAPIDLY URBANIZING AREAS:

A CASE STUDY IN TREASURE VALLEY

by

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DEDICATION

To my family. Drea & dad, for always visiting me, encouraging me, and (most importantly) keeping me in line. Rich, for making bad jokes and bringing Marlena into this world.

In memory of my momma, who never failed to tease me for being a lifelong student and, in the same breath, tell me how proud she was. She was hard working, had a quick wit, loved playing in the dirt, and loved showing her love with a fantastic meal. I'll always make sure to smell the wildflowers and turn up Fleetwood Mac on the radio.

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ABSTRACT

Urbanization poses complex challenges for balancing sustainable environmental management with human well-being. Many areas of the western US are experiencing rapid urbanization as people move to the region for a high quality of life. However, urbanization has major impacts on ecosystem services (ES), and therefore human well-being, making it important for decision-makers to understand the consequences and trade-offs that occur with urbanization. Given recent urbanization, the Boise Metropolitan Area, Idaho is a useful case study to explore a) differences in demand for ES between socio-demographic groups, b) perceptions of urbanization impacts to ES supply, and c) how those ES may change with future urbanization.

In chapter one of this thesis, we quantified the impacts of projected urban growth to highly valued land use-land covers in the region and disseminated results in various forms to reach a broader audience. This was a collaborative effort between researchers from several different departments, including Geoscience, Economics, Public Policy & Administration, and Human-Environment Systems. We built scenarios to characterize plausible urban growth up to 2100. The Economics department built the urban growth model, which was applied by the Geoscience and Human-Environment Systems departments to quantify potential impacts. The Public Policy & Administration, and Human-Environment Systems departments worked together to format results in shareable formats: 1. A white paper for interested stakeholders, 2. A story map for the general public, and 3. Raw data for academic circulation. The story map generated widespread

interest gaining over 1,300 views. The white paper has been utilized by local media, non-profit organizations, and special interest groups. Additionally, members of the Human-Environment Systems department presented results at several meetings, including the Eastern Idaho-Oregon Seed Association (over 100 people), the Ag Forum (over 300 people), and the NW-GIS conference.

In chapter two of this thesis, we explored perceptions of ES by conducting face-to-face surveys with over 400 people. We compared perceived impacts to the supply of ES between urban land and agriculture and found that people perceive higher overall negative impacts to ES by urban land than agriculture. Urban areas are associated with positive impacts to local identity and recreation, while agriculture is positively associated with cultural heritage and food production. Both urban land and agriculture are negatively associated with water quality, air quality, and habitat for species with urban land having greater, negative impacts. We also measured whether perceptions differ between the general public and experts. Experts and the general public generally agreed on ES trends, except for habitat for species and climate regulation – the majority of experts agreed they were decreasing whereas approximately half of the general public perceived them as decreasing. We found significant differences regarding perceived importance of ES. The general public places higher importance on food production and alternative energy while experts place higher importance on water quality and recreation. These observed differences indicate a need to incorporate social demand in order to appropriately address diverse perspectives in planning to ensure policy resilience. Our social survey approach can be applied in other study areas to illuminate potential conflicts in demand for ES across a variety of contexts where urbanization is the dominant land use change dynamic.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BMA	Boise Metropolitan Area
ES	Ecosystem Services
HES	Human-Environment Systems
LULC	Land Use-Land Cover
MILES	Managing Idaho’s Landscapes for Ecosystem Services
NLCD	National Land Cover Database
SES	Social-Ecological Systems

THESIS OVERVIEW

Urbanization is a global phenomenon where in the last decade the world's urban populations exceeded rural populations; by 2050 it's expected that over 60% of the world's population will reside in urban areas (Martine, 2007). This shift in population poses issues for managing for environmental sustainability and human well-being. Urban areas are increasingly considered crucial in addressing environmental issues on a variety of scales (Bai et al., 2017; Elmqvist et al., 2015; Lovell and Taylor, 2013) from the direct loss of natural areas to increased carbon emissions (Bai et al., 2017; Theobald et al., 2016). Key to successful implementation of land use planning and policy is the inclusion of social values or needs (Decker et al., 2015; Ostrom, 2009; Phillipson et al., 2012). To address this, researchers are using place-based approaches that frame or prioritize issues within a social context to balance environmental health and human well-being (Bennett, 2016; Lovell and Taylor, 2013).

My thesis addresses these global issues of urbanization, land use policy, and human well-being by conducting interdisciplinary, team-based research on urban growth and ecosystem services in the Treasure Valley, Idaho, one of the fastest urbanizing areas in the United States. In Chapter 1, we participated in a collaborative working group to build different scenarios of urbanization, and projected urban growth up to 2100. Urban growth projections were then applied to current land use-land cover to capture areas at risk of conversion to urban land. In Chapter 2, we conducted a social survey in the summer of 2016 to gauge current values related to ecosystem services.

Chapter 1: Communicating scientific findings is typically left to news media (Besley and Tanner, 2011; Treise and Weigold, 2002; Weigold, 2001), where, "for scientists, science communication with a lay audience is almost always a secondary issue. Of first importance, from a professional standpoint, is the business of science itself" (Weigold, 2001, p. 180). However, there are several intervening causes for lack of communicating findings including monetary and time costs, understanding audience needs, mistrust of media, and lack of cultural support (Besley and Tanner, 2011; Cortner, 2000; Weigold, 2001). Overcoming these hurdles to communicate with diverse audiences can have significant implications for influencing policy and increasing public awareness and trust (Bubela et al., 2009; Cortner, 2000). Actively engaging with the general public requires training scientists at the graduate level and utilizing different mediums to communicate results (Bubela et al., 2009).

To adequately engage with local audiences in our study area we incorporated "public scholarship" into this thesis. Public scholarship refers to "community-engaged research" disseminated in diverse, creative formats (Bartha, 2017). The objective was to share our results with interested audiences in easily digestible formats. To that end we formatted our results for three separate audiences: 1. A white paper for interested stakeholders, 2. A story map for the general public, and 3. Raw data for academic circulation. This work was collaboratively completed by several departments, including Geoscience, Economics, Public Policy & Administration, and Human-Environment Systems.

Chapter 2: In Chapter 2, we used the Ecosystem Services Framework as the foundation to understand how urbanization affects human well-being. Ecosystem services are the "direct and indirect benefits human obtain from the ecosystems that support human well-being…" (MEA, 2003). Our objectives were to: a) Quantify impacts of urbanization to current land use-land cover using urban growth projections generated by a collaborative group, and b) Measure differences in demand for ecosystem services between socio-demographic groups, and perceptions of urbanization impacts to supply of ecosystem services.

The overarching goal of this thesis is to demonstrate the impacts of urbanization to human well-being. Chapter 1 is a description of the "public scholarship" portion of my thesis. Chapter 2 is the scholarly portion of my thesis, and is formatted as a publication. Appendix A contains the survey instrument used to collect data for Chapter 2. Appendix B is research conducted independently but ultimately not included in Chapter 2. References for both chapters and appendices follow Chapter 2.

CHAPTER ONE: PUBLIC SCHOLARSHIP

A COLLABORATIVE EFFORT TO DEMONSTRATE POLICY EFFECTS ON URBAN GROWTH IN TREASURE VALLEY, IDAHO

Introduction

The Boise-Nampa metropolitan area is often recognized as an area in major transition. Myriad publications recognize its livability due to affordability, its "small town feel" and quality of life, including access to recreation, cultural attractions, and safety (CNN Money, 2011; Comen et al., 2015; Forbes, 2018; Saunders, 2013; Sharf, 2018; U.S. News, 2017). But the region is also poised for major expansion: population in the region continues to grow, with total population increasing by 120% between 1990-2015 (Bureau, 2015). As of 2017 the Boise-Nampa metropolitan area is ranked as the 7th fastest growing in the country (Bureau, 2018). In fact, urban land area has increased by 10% in the last ten years (NLCD, 2011) despite the increase in infill development and decrease in edge expansion and outlying development (Dahal et al., 2017). Through continued engagement with the public, the MILES (Managing Idaho's Landscapes for Ecosystem Services) group found that stakeholders and decision-makers wanted a better understanding of what urban growth in the region would look like. To fill this gap, MILES proposed projecting urban growth in Ada and Canyon counties up to 2100 under different scenarios to demonstrate the effects of policy on urban development.

MILES is funded by the National Science Foundation to conduct applied research on Social-Ecological Systems (SES) in Idaho, resulting in information that is useful to stakeholders and the general public. To accomplish this, MILES engages with stakeholders in an iterative process that gathers information and data needs, and allows stakeholders to give feedback. This method of information sharing is considered the "public engagement" model, an alternative approach to the "deficit model." The deficit model approach assumes that the general public has insufficient knowledge regarding research and science; efforts are directed at sharing scientific results via media outlets to bolster public scientific literacy (Bubela et al., 2009; Wynne, 1992). The public engagement approach acknowledges diverse views, and different modes of understanding based on preferred learning styles, values, and beliefs (Bubela et al., 2009; Cortner, 2000). Engaging regularly with stakeholders can increase acceptance of research, increase understanding, and help to frame research for the general public (Bubela et al., 2009; Cortner, 2000).

The collaborative group formed to project urban growth consisted of four principal investigators, two graduate students, and one undergraduate student. The principal investigators worked out of the Geoscience, Economics, Public Policy & Administration, and Human-Environment Systems (HES) departments. Approaching complex environmental issues from a SES framework allows researchers to not only better understand how these systems function, but also how they interact. Researchers have typically approached SES questions independently, from within their own disciplines (Alberti et al., 2003; Jacobs et al., 2016; Ostrom, 2009). However, interdisciplinary research has increased in popularity as social and biophysical scientists work together to tackle large-scale issues spanning multiple disciplines, including efforts like MILES.

There were two main objectives: (1) to model urban expansion under different scenarios up to 2100, and (2) disseminate the results in various formats to inform diverse audiences. The group worked together to build scenarios, I and the graduate student from the Economics department worked together to compile the data necessary for the analysis, the model was built by researchers from the Economics department, and I and researchers from the Public Policy department led the public scholarship component, to disseminate the results to the public.

Methods

The scenarios and methods for the model are summarized in the attached white paper, and described in full in the online dataset. Here I will describe our efforts to communicate results and additional outreach actions.

Quantifying Impacts to Land Use-Land Cover Under Projected Urbanization

Spatially representing projected urban expansion is a useful exercise in itself, but we wanted to know what kind of impacts urbanization may have on current land use-land cover (LULC). Data used to accomplish this included the modeled urbanization projections (2100), the National Land Cover Database (NLCD) (2011), and county-level GIS data. To quantify impacts the NLCD was overlaid with each projected scenario. By subtracting the current urban area from the projected urban area we captured the total estimated LULC loss (Figure 1.1).

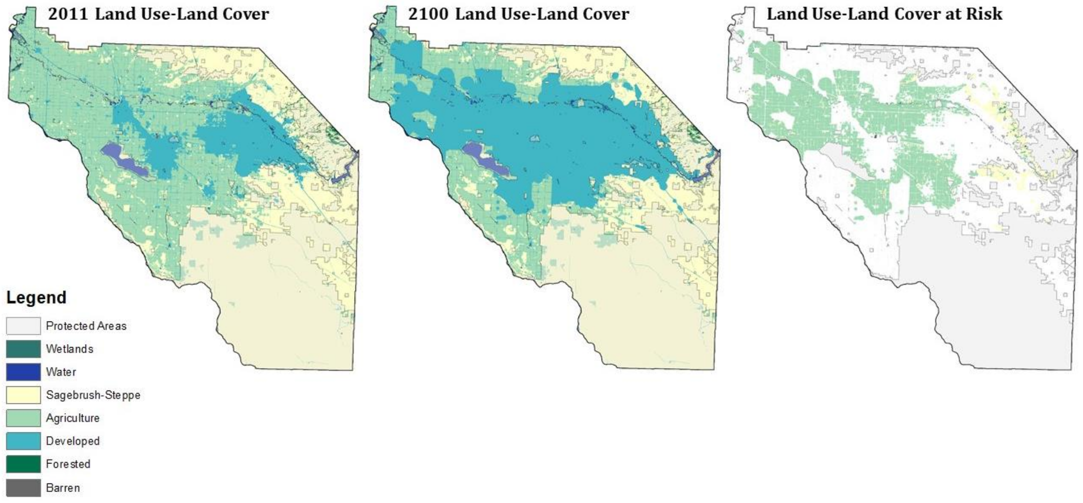

Figure 1.1. The 2011 NLCD urban area (left) was clipped from the 2100 projected urban area (center) to capture total area at risk of conversion to urban area (right).

Communicating Results to Diverse Audiences

Building on the public engagement approach, we shared our results in easily digestible formats, where the results could then be framed according to issues of interest. To that end we formatted our results for three separate audiences: 1. A white paper for interested stakeholders, 2. A story map for the general public, and 3. Raw data for academic circulation.

The white paper was written by HES and Public Policy & Administration collaborators. White papers are a form of grey literature intended to have "direct bearing on public policy and/or the everyday life for people within cities," (Urban Communication Foundation, 2012). In this endeavor, we succinctly described the history of LULC change in the region, and focused on simplified methods and results. General policy recommendations concluded the paper. This format allows stakeholders to quickly gather information, and to frame issues of interest related to urbanization.

The story map was created by the HES and Public Policy & Administration departments. Story maps are intended to apply a compelling, visual narrative alongside raw data. ArcMap 10.5 and ArcGIS Online were used to create the story map. In this endeavor, we went into greater detail about time periods that were significant in shaping the study area as we know it today. Minimal information regarding methods was included. Results were clearly displayed using maps and figures. Similar to the white paper, the story map concluded with general policy recommendations. This format allows the general public to peruse portions of interest in an easily navigable fashion.

Results

The story map has over 1,100 views online (Fig. 1.2), and the data set has been downloaded 47 times. Our project page also has a large number of unique views relative to other HES project pages; for instance, in March our page had twice as many unique views (60) as the second highest viewed page. Two local newspapers have reported on the study: Capital Press and Idaho Statesman, both of which link to Boise State’s HES website containing all aforementioned data or directly to the white paper and story map. The story map won Map of the Month from the Idaho Geospatial Office, resulting in almost 200 additional views.

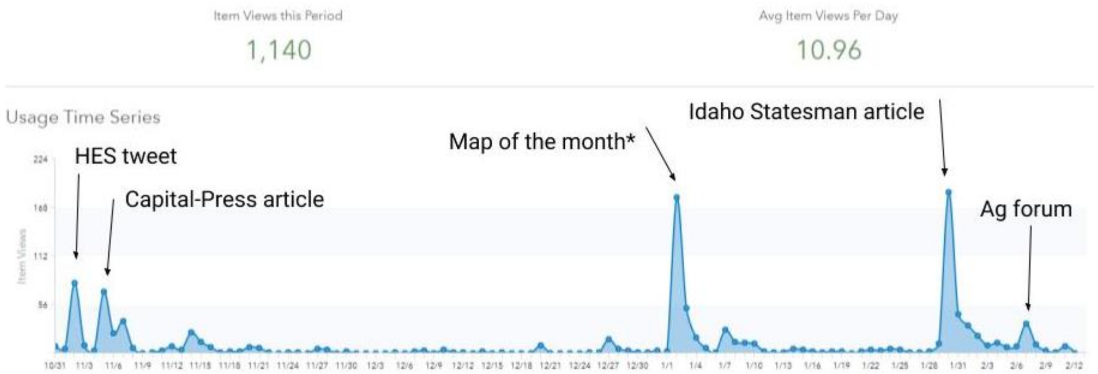

Figure 1.2. Story map views from date of release (November, 2017) to mid-February, 2018

Members of the HES department participated in community outreach events, such as the Idaho-Eastern Oregon Seed Association conference in Boise (presented to over 100 people) and the Ag Forum in Nampa (presented to over 300 people). The story map was presented to and received feedback from professionals and researchers at the Northwest GIS Conference in Boise. Lastly, several interested stakeholders have reached out to us seeking permission to share our results to emphasize their own goals, including: agricultural business owners, The Nature Conservancy, Treasure Valley Food Coalition, and Idaho Conservation League.

Discussion

Formatting our results using three different approaches appears to have successfully reached a wider audience. The white paper and story map were easily shared online and appealed to different reader preferences. Both the white paper and story map were linked to in separate news outlets. Results have been used to explore urbanization impacts to agriculture, transportation, and housing affordability. We received feedback and comments from the general public, business owners, non-profit organizations and other researchers.

As a new researcher deeply invested in my study area, this has been a rewarding endeavor where I gained a lot of new experience including: participating in a collaborative group, writing for different audiences, mentoring undergraduate students, creating a story map, presenting to large audiences, and community engagement via presentations and one-on-one meetings. However, this project ended up taking up a large portion of time – particularly because it was so successful, and we kept receiving inquiries.

For future collaborative projects, I would recommend two things. First, to clearly describe who (if anyone) will engage with the public, for how long, and to what extent. Second, for involved graduate students, to incorporate completed work as an independent study or thesis chapter, depending on complexity and longevity of the project. I was fortunate in having a committee that agreed to incorporate this work into my thesis as a chapter.

CHAPTER TWO: MANUSCRIPT DRAFT

PERCEPTIONS OF ECOSYSTEM SERVICES IN RAPIDLY URBANIZING AREAS: A CASE STUDY IN TREASURE VALLEY

Abstract

Urbanization poses complex challenges for balancing sustainable environmental management with human well-being. Many areas of the western US are experiencing rapid urbanization as people move to the region for a high quality of life. Urbanization has major impacts on ecosystem services (ES), and therefore human well-being, making it important for decision-makers to understand the consequences and trade-offs that occur with urbanization. Given recent urbanization in the greater Boise, Idaho area is a useful case study to explore a) areas at risk of conversion due to urban growth, b) differences in demand for ES between socio-demographic groups, c) perceptions of urban and agricultural impacts to ES supply, and d) awareness of current ES trends. We explored perceptions of ES by conducting face-to-face surveys with over 400 people. We also applied urban growth projections to current land use-land cover and found agriculture to be at high risk of conversion. We measured whether perceptions differ between socio-demographic groups, e.g. between the general public and experts. Experts and the public generally agreed on ES trends, except for habitat for species and climate regulation – the majority of experts agreed they were decreasing whereas approximately one-third to one-half of the general public perceived them as decreasing. We found significant differences regarding perceived importance of ES. The general public places higher importance on food production and alternative energy while experts place higher importance on water quality and recreation. We also compared perceived impacts to ES between urban land and agriculture and found that people perceive higher overall negative impacts to ES by urban land than agriculture. Urban areas are associated with positive impacts to local identity and recreation, while agriculture is positively associated with cultural heritage and food production. Both urban land and agriculture are negatively associated with water quality, air quality, and habitat for species with urban land having greater, negative impacts. These observed differences indicate a need to incorporate social demand in order to appropriately address diverse perspectives in planning to ensure policy resilience. Our social survey approach can be applied in other study areas to illuminate ES-human relationships across a variety of contexts where urbanization is the dominant land use change dynamic.

1. Introduction

While urbanization occurs on a relatively small portion of the Earth, the accompanying ecological footprint extends far beyond city boundaries (Alberti et al., 2003; Nelson, 2005). Urbanization, particularly urban sprawl, decreases ecosystem biodiversity and resilience, and lowers the overall potential to provide ecosystem services (ES) to communities (Marull et al., 2010; Niemelä et al., 2010). Urban expansion often outpaces population growth (Alberti et al., 2003; Seto et al., 2012), a concern elevated by the United Nation's projection that 60% of the world's population will live in urban areas by 2030 (Martine, 2007). In this "age of cities" (Choa, 2012) urban planning is necessary for ensuring human well-being and environmental sustainability in the face of larger issues like shifting population centers and climate change (de Groot et al., 2010; MEA, 2003). Human well-being depends on the supply of ES, and refers to the five primary components required by humans for survival and quality of life: basic material for a good life, health, security, good social relations, and freedom of choice and action (MEA, 2003).

Urbanization is occurring especially rapidly in the western region of the United States, partially driven by amenity-related migration. Historically resource-dependent rural areas in the western region of the United States are experiencing a flood of newcomers as people seek out homes in low-cost areas with high quality of life (Brunson and Huntsinger, 2008; Hansen et al., 2002) provided by natural amenities such as access to recreation, proximity to open space, and scenic terrain (Hansen et al., 2002; Rasker and Hansen, 2000). The influx of people not only diversifies previously homogenous landscapes (Acharya and Bennett, 2001) but also the demographics and corresponding sociocultural goals and values (Decker et al., 2015; Patterson et al., 2003). Understanding how land use-land cover (LULC) change affects highly valued ES is key to successful planning and management of areas with high demand and often conflicting needs (de Groot et al., 2010; López-Martínez, 2017; Patterson et al., 2003). We should also then consider to understand perceptions of values as they relate to ES in areas that are experiencing high levels of growth.

Examining the dynamics between cities and the natural environment from a social-ecological perspective allows for a holistic approach to planning (Elmqvist et al., 2015; Kremer et al., 2016; Reyers et al., 2013). Due to the complicated nature of social-ecological systems, there is still a need to present information in a way that is applicable and useful for decision-makers (Alberti et al., 2003; Kremer et al., 2015; Ruckelshaus et al., 2015; Scholte et al., 2015). The Millennium Ecosystem Assessment (2003) formulated the Ecosystem Services Framework in order to systematically study social-ecological systems. The Ecosystem Services Framework calls for the consideration of ecological, economic, political, and sociocultural values in planning, and how those values may be impacted by alternative management decisions (MEA, 2003). Researchers have since begun the process of operationalizing the Ecosystem Services Framework into a comparison between the biophysical “supply” of ES and the “demand” for ES, determined by economic and sociocultural valuation (de Groot et al., 2010). However, the demand for ES is often expressed using only economic valuation, falling short in capturing sociocultural perspectives (Castro et al., 2014; Chan et al., 2012; Daw et al., 2011; de Groot et al., 2010; Iniesta-Arandia et al., 2014; Menzel and Teng, 2009).

Literature on the demand for ES is growing, with researchers incorporating social preferences for, or perceived importance of, ES as a proxy for demand (Daw et al., 2011; de Groot et al., 2010; Martín-López et al., 2012) where valuation “includes noneconomic methods to analyze human preferences toward ecosystem service demand, use, enjoyment, and value in which moral, ethical, historical, or social aspects play an important role” (Castro Martínez et al., 2013). Traditionally, experts or influential stakeholders determine relevant sociocultural values, but more recently researchers argue that the inclusion of diverse sociocultural perspectives in planning improves policy resilience (Chan et al., 2016; Decker et al., 2015; Ostrom, 2009). Previous research shows significant differences between socio-demographic groups’ demand for ES, based on gender, level of education, and age (Iniesta-Arandia et al., 2014; Martín-López et al., 2012).

Our overall objective is to characterize social demand for ES in the Boise Metropolitan Area (BMA), a small and rapidly-growing city in the western United States. The BMA is an ideal study site due to rapid population growth causing urban sprawl, threatening ES in high demand by residents. We used urban growth projections to quantify changes in land use resulting from urban growth, and then used face-to-face surveys to measure how people perceived those projected changes would affect ES. Our specific objectives were as follows: (1) Quantify change in current land use-land cover due to urban growth in the Boise area from 2011-2050; (2) measure differences in demand for ES between socio-demographic groups; (3) measure perceived change in ES supply over last ten years; (4) measure perceptions regarding impacts to ES supply by urban areas and agriculture; and (5) relate perceived trends with perceived impacts to ES by urban areas and agriculture.

2. Study Area

The BMA is located in southwestern Idaho (Fig. 2.1) and encompasses 430,990 ha. The study area falls within the Snake River Plain, a semi-arid region with temperatures ranging from 3.7 °C to 15.9 °C (WRCC, 2011). Precipitation averages 152-381 mm annually (McGrath et al., 2002). The valley is primarily lowlands bordered by foothills along the northeast, with elevation ranging from 640-850 meters (McGrath et al., 2002).

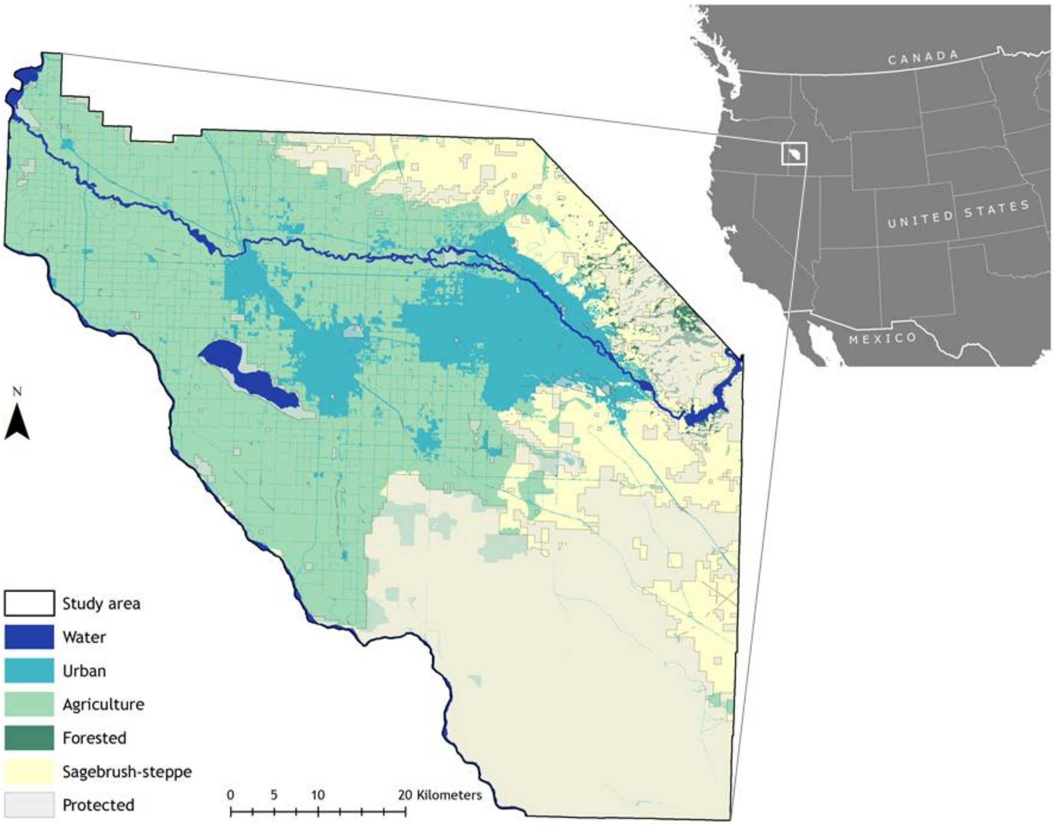

Figure 2.1. The location of the study area in Idaho, USA and major land use-land cover types (NLCD, 2011).

The natural landscape is characterized by sagebrush-steppe, a mixture of big sagebrush (*Artemisia tridentata*), rabbitbrush (*Ericameria nauseosa*), and grasslands comprised mainly of bluegrass (*Poa secunda*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and cheatgrass (*Bromus tectorum*) (McGrath et al., 2002). The area is an agricultural stronghold of the Intermountain West due to the "rich agricultural soils" produced by sediment from the Bonneville Flood (Jones et al., n.d.), and extensive irrigation systems that date back to the late 19th century (McGrath et al., 2002; Society, 1971).

The BMA is currently experiencing urban sprawl due to episodic, rapid population growth and loose regulatory enforcement by local governments (Dahal et al., 2016; Judd and Witt, 2014). The region is characterized by low-density development, with urban land increasing 15 times between 1940 and 2014, relative to population increasing eight times within the same period (Dahal et al., 2016). Development occurs primarily in agricultural areas due to topographic and land ownership constraints (Dahal et al., 2017). The BMA is one of the fastest growing regions in the country, with a 120% population increase between 1990 and 2015 (Bureau, 2015; Sharf, 2018). The area is projected to continue growing due to the low cost of living, high job growth rates, and quality of life (Bureau, 2017; Comen et al., 2015; Frey, 2012; Sharf, 2018).

3. Methods

3.1 Projected Urban Expansion Impacts to Current Land Use-Land Cover

We considered three urban growth scenarios up to 2050 (Sprague et al. 2017): Business as Usual, Low Density, and High Density. The Business as Usual scenario used a population density of 4.14 people/acre, which was based on population density calculated for the study region using the average between 2001-2011. The Low Density (3.78 people/acre) and High Density (5.41 people/acre) scenarios were calculated from trends observed in other western cities starting from the time they were the same current population as the study area. All scenarios used a mid-range population projection of 1.5 million people by 2100, which represents a conservative estimate of future population growth compared to projections completed by regional and state groups (Miller, 2013; Petrich, 2016). Full details of the urban growth projections can be found in Sprague et al. (2017).

Using ArcMap 10.5, the urban growth scenarios (Sprague et al., 2017) were overlaid upon the 2011 National Land Cover Dataset (NLCD) to measure what LULC would be lost due to urban growth. LULC categories were simplified to capture major existing types present in the study area. Our final categories of LULC loss included:

urban (NLCD classes 21-24), forested (NLCD classes 41-42), rangeland (NLCD classes 52 and 71), and agriculture (NLCD classes 81-82).

3.2 Ecosystem Services and Human Well-Being

In the American West, recent urbanization is the biggest threat to loss of natural areas, impacting the supply of ES (Nelson, 2005; Theobald et al., 2016). Urbanization itself is often driven by indirect factors including economic markets and sociocultural values (Nelson, 2005). Our survey is intended to better understand social demand for ES, and how those ES may be impacted under projected urbanization.

3.2.1 Survey Design and Implementation

We conducted a face-to-face survey with 416 people in the BMA. Following Castro et al.'s (2016) design, the survey gathered information about (1) perceived importance and vulnerability of ES, (2) perceived impact from land uses on ES, and (3) socio-demographic data including age, level of education, occupation, annual household income, political ideology, ethnic background, length of residency, and place of residency. We prefaced our survey with an introduction to our study using plain language. For instance, rather than introducing and defining the term "ecosystem services" we referred to "contributions provided by the environment." To better facilitate understanding by respondents we used photograph panels to illustrate the location of the study area, define ES, and introduce land use scenarios (Appendix A).

We collected our surveys from mid-June to August 2016 using nonrandom convenience sampling across the BMA. Over 30 sampling locations were visited including high traffic locations (e.g. Department of Motor Vehicles and public libraries), public events (e.g. farmer's markets and free concerts), and recreation areas. Only respondents who identified as residents were considered for this data analysis, amounting to 392 observations. Table 2.1 shows demographic information for survey respondents compared to the study area's population (U.S. Census Bureau 2015). The sample is underrepresented in age group 75+, Asian Americans, and Hispanic/Latino people. The sample is overrepresented in age group 55 to 64, and black or African American people.

3.2.2 Perceived Ecosystem Service Importance and Vulnerability

To gauge perceived importance and vulnerability of ES we showed respondents a panel of 11 ES, each represented by a picture and short definition (see Appendix A). From the 11 ES we asked them to rank the four ES most important for regional human well-being, followed by an explanation for why each ES is important. For each of the chosen ES we asked respondents whether they perceived the supply of the ES as decreasing, increasing, stable, or they don't know ("I don't know" responses were excluded from analysis).

Table 2.1: Survey participant demographics compared to BMA population

	Survey Participants	Boise Metro Area*
Gender (n=371)		
Female	49.6%	50.2%
Male	50.4%	49.8%
Age (n=390)		
18 to 24	10.3%	12.4%
25 to 34	21.3%	19.3%
35 to 44	15.1%	18.8%
45 to 54	16.7%	17.6%
55 to 64	22.6%	15.4%
65 to 74	12.1%	9.9%
75+	2.1%	6.6%
Median age	47	34.3
Race and Ethnicity (n=379)		
White (non-Hispanic)	85.8%	81.0%
Black, African American	2.9%	0.9%
Native American	0.8%	0.7%
Asian American	0.8%	2.1%
Native Hawaiian or other Pacific Islander	0.3%	0.2%
Latino or Hispanic	6.6%	13.1%
Other	2.9%	2.0%
Income (n=286)		
Under $20,000	18.5%	17.6%
$20,000 to $39,999	17.1%	22.9%
$40,000 to $59,999	20.6%	19.7%
$60,000 to $99,999	23.4%	23.3%
$100,000 and above	20.3%	16.6%

*2015 American Community Survey 5-year estimates

All data analysis was conducted using Stata 15.0 and a combination of statistical methods. The two-sample Wilcoxon rank-sum test was used to compare perceived importance and perceived supply trend between socio-demographic groups. Perceived importance is coded as 0 = not chosen, 1 = least important, and 4 = most important. Perceived supply trend is coded as -1 = decrease, 0 = stable, 1 = increase (see Appendix A).

All socio-demographic groups are coded as dummy variables to test between groups. Expert is coded as 1 = employees from state/federal land management agencies and 0 = general public. Gender is 1 = female and 0 = male. Level of education is 0 = up to bachelor's and 1 = bachelor's or above. Political ideology is 1 = conservative and 0 = liberal (Hamilton et al., 2014). Place of residency is 1 = urban (over 50% of zip code is urban) and 0 = agriculture (over 50% of zip code is agriculture) (Johnson et al., 2004; Marquart-Pyatt, 2008). Age is split into quartiles to test for differences between the youngest and oldest age groups using two separate group tests. To test for differences between the youngest quartile of the sample, 1 = 18-33, 0 = 34-86; for the oldest quartile, 1 = 59-86 and 0 = 18-58 (Martín-López et al., 2012). Length of residency is 1 = long-term residents and 0 = shorter-term residents. Smith and Krannich (2009) suggest using the last wave of population growth as the determinant for differentiating between long-term and shorter-term residents. In our case, a long-term resident is a respondent living in the area for 15 years or more.

3.2.3 Perceived Impacts to Ecosystem Services by Urban Expansion

Following Quintas-Soriano et al.'s design (2016) we asked respondents whether or not different LULC types in the BMA impact the contributions we derive from the landscape. We showed them a panel of LULC types (urban and agriculture) and asked them to identify up to two, if any, ES that are positively impacted, and up to two, if any, ES that negatively impacted. We then asked respondents to assign an intensity score of each LULC ranging from [1] being the minimum impact and [10] being the maximum impact. ES not chosen as positively or negatively impacted are not included in the analysis.

Welch's t-tests were used to compare perceived impacts between urban land and agriculture using the summed estimated impacts to individual ES (range -10 – 10).

4. Results

4.1 Projected Changes in Land Use from Urban Growth

Our urban growth scenarios indicate that urban land will increase between 59-106% from 2011 to 2050, which corresponds to an 87,700-113,800 ha increase (Fig. 2.2). Urban land will replace agriculture, forested areas, and sagebrush-steppe, with the largest losses in agricultural areas. Agriculture loss ranges from 22-37% by 2050, amounting to 30,600-52,000 ha. Forested areas will also be impacted by urban development, losing between 18-25% of current forests (198-275 ha). Sagebrush-steppe remains relatively unchanged with losses between 7-12%, (5,290-8,870 ha), largely due to much of it being protected under different levels of public ownership.

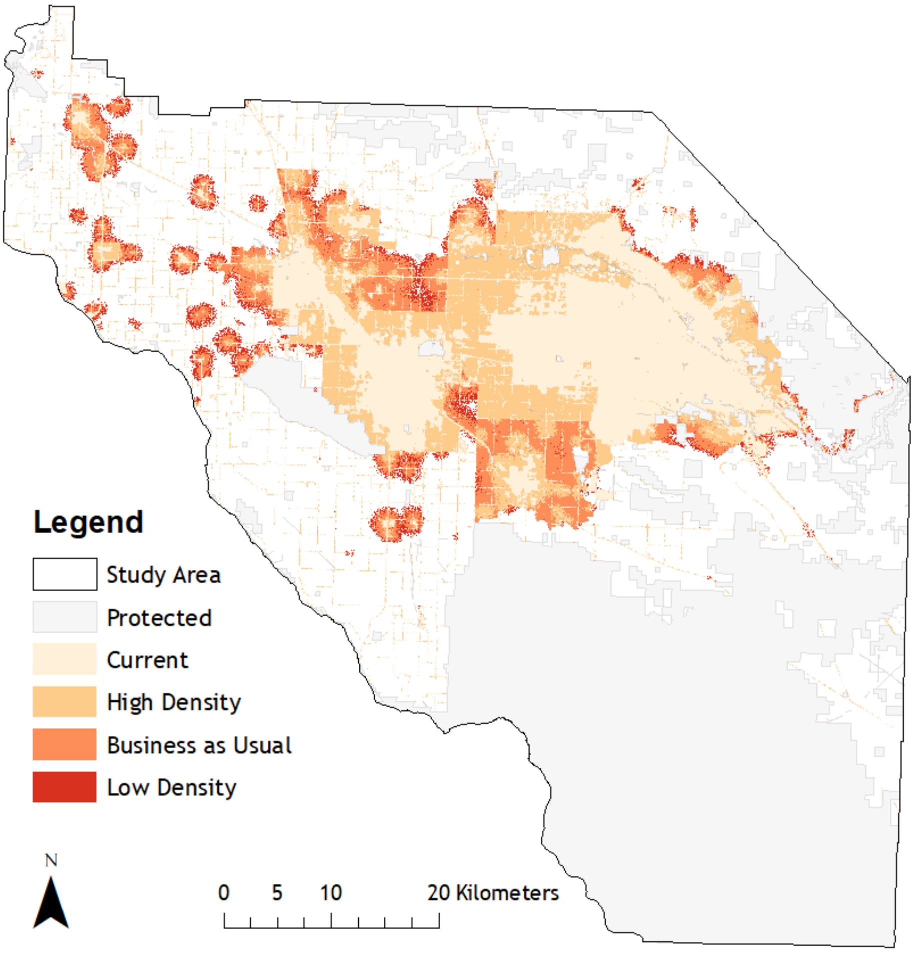

Figure 2.2. Projections for urban expansion under three different scenarios (High Density, Business as Usual, and Low Density) up to 2050.

4.2 Perceived Impacts of Urban Growth On Ecosystem Services and Human Well-Being

4.2.1 Perceived Importance of Ecosystem Services

Results of our survey demonstrated that our sample of survey respondents value some ES more than others (Fig. 2.3). Overall, provisioning, or direct, ES received higher average rankings while cultural ES averaged lower rankings. Food production was the most frequently chosen ES (over 50% respondents chose it as important), followed by water quality (45% of respondents), and freshwater provision (41% of respondents). The three lowest ranked ES were cultural heritage (17% of respondents), climate regulation (17% of respondents), and local identity (20% of respondents). Recreation and habitat for species were frequently chosen (51% and 47% of respondents, respectively) but ranked lower.

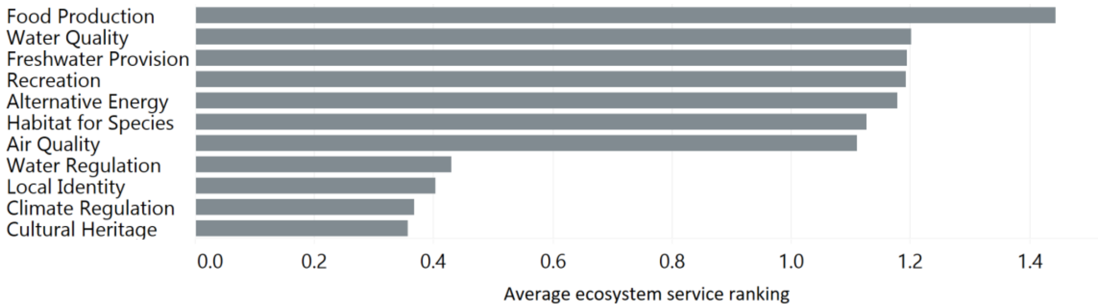

Figure 2.3. Overall average ES rankings (on a scale of 0-4, where 4 is most important and 0 is not chosen).

We tested if different socio-demographic groups in our sample valued ES differently. We found significant differences between groups based on place of residency, length of residency, level of education, political ideology, and gender (Table SI-1). University-educated respondents placed lower importance on alternative energy (mean = 0.93 compared to 1.48 mean for non-university-educated respondents). Liberals placed higher importance on climate regulation (mean = 0.56) than conservatives (mean = 0.17). Urban residents placed higher importance on water quality (mean = 1.43) than agricultural residents (mean = 0.90). Women placed higher importance on air quality (mean = 1.32) than men (mean = 0.89). Both shorter-term and university-educated respondents placed higher importance on recreation (mean = 1.39 and 1.36, respectively) than long-term residents and non-university-educated respondents (mean = 1.02 and 0.97, respectively).

The general public ranked food production and alternative energy higher than experts, while experts ranked water quality, recreation, and freshwater provision higher than the general public (Fig. 2.4).

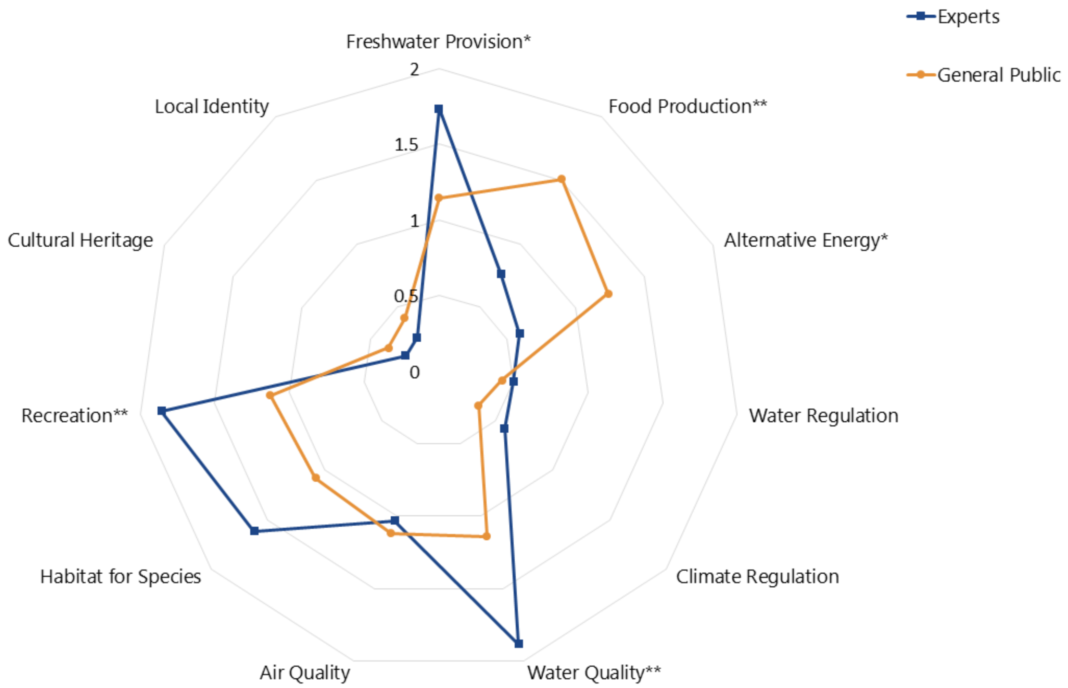

Figure 2.4. Wilcoxon rank-sum test comparing average ES rankings (on a scale of 0-4, where 4 is the most important) between experts and the general public. Significant differences indicated by asterisks (*<.05; **<.01).

4.2.2 Perceived Vulnerability of Ecosystem Services

Survey respondents were asked whether they perceived their four most important ES as increasing, decreasing, or stable over the last ten years. Habitat for species, air quality, and food production are perceived as the top three most vulnerable ES (Fig. 2.5). Water quality and climate regulation are also perceived as decreasing, while recreation, alternative energy, and local identity are all perceived as increasing. Water regulation and freshwater provision are perceived as stable.

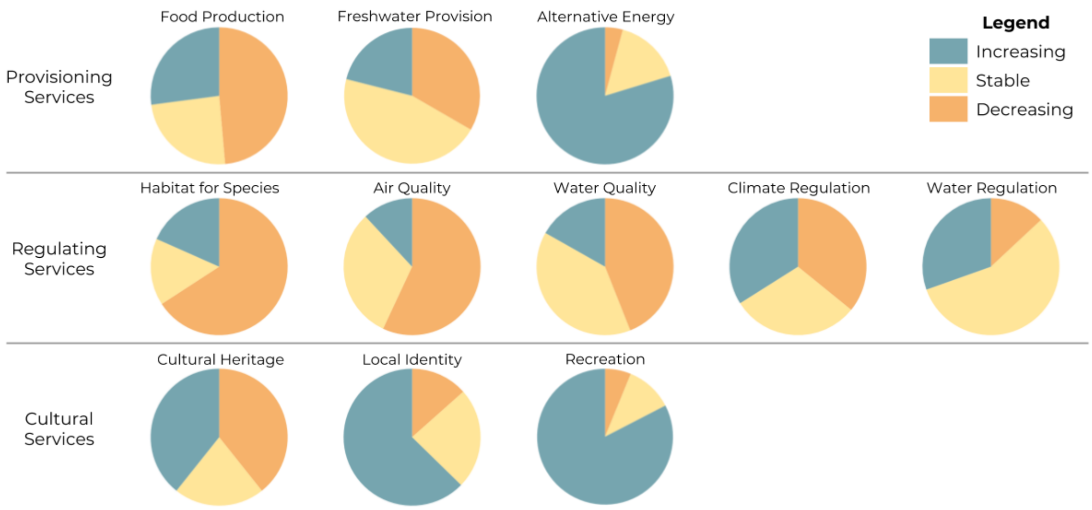

Figure 2.5. Perceived vulnerability of ES where respondents chose whether they perceived the ES as decreasing, increasing, or stable over the last ten years.

We tested for differences between socio-demographic groups with regards to perceived vulnerability, and found significant differences between experts and the general public regarding regulating ES (Table SI-2). Experts perceived climate regulation as decreasing or stable (mean = -0.67) while the majority of the general public perceived it as increasing or stable (mean = 0.06). All experts perceived habitat for species as decreasing (mean = -1.00) whereas a little over half of the public perceived it as decreasing (mean = -0.42). We also found a significant difference between university-educated respondents and others for food production. University-educated respondents perceived food production as stable (mean = 0.00) while the majority of non-university-educated respondents perceived it as decreasing (mean = -0.46).

4.2.3 Perceived Impacts of Urban and Agricultural Land To Ecosystem Services

Survey respondents were asked to rank on a scale of [1] to [10] how each LULC impacts ES, with the option to say no impact to any ES. Urban land was perceived as having higher overall negative impacts to ES (mean = -1.97) compared to agriculture (mean = -0.36). For individual ES (Fig. 2.6), agriculture is perceived as having a negative impact to local identity and a positive impact on food production, while impacts by urban land on those same ES are the opposite. Both urban and agriculture were perceived as positively impacting cultural heritage, with agriculture having higher positive impacts. Both urban and agriculture were perceived as negatively impacting habitat for species, air quality, and water quality, with urban land having higher negative impacts to all three.

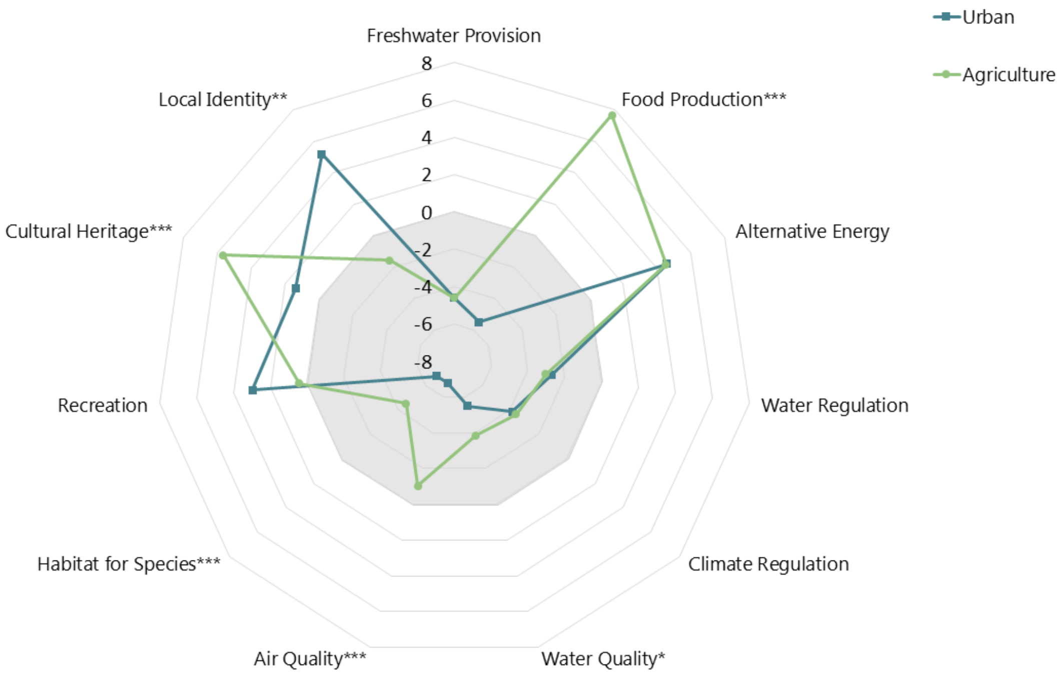

Figure 2.6. Welch's t-test to compare overall perceived impacts to ES by urban and agriculture. Significant differences between land uses indicated by asterisks (*<.05; **<.01; *<.001).**

Perceptions of urban land aligns with perceptions of ES vulnerability (Fig. 2.7). Habitat for species, air quality, water quality, food production, freshwater provision, and climate regulation were all perceived as decreasing and negatively impacted by urban land. Alternative energy and local identity were perceived as increasing and positively impacted by urban land.

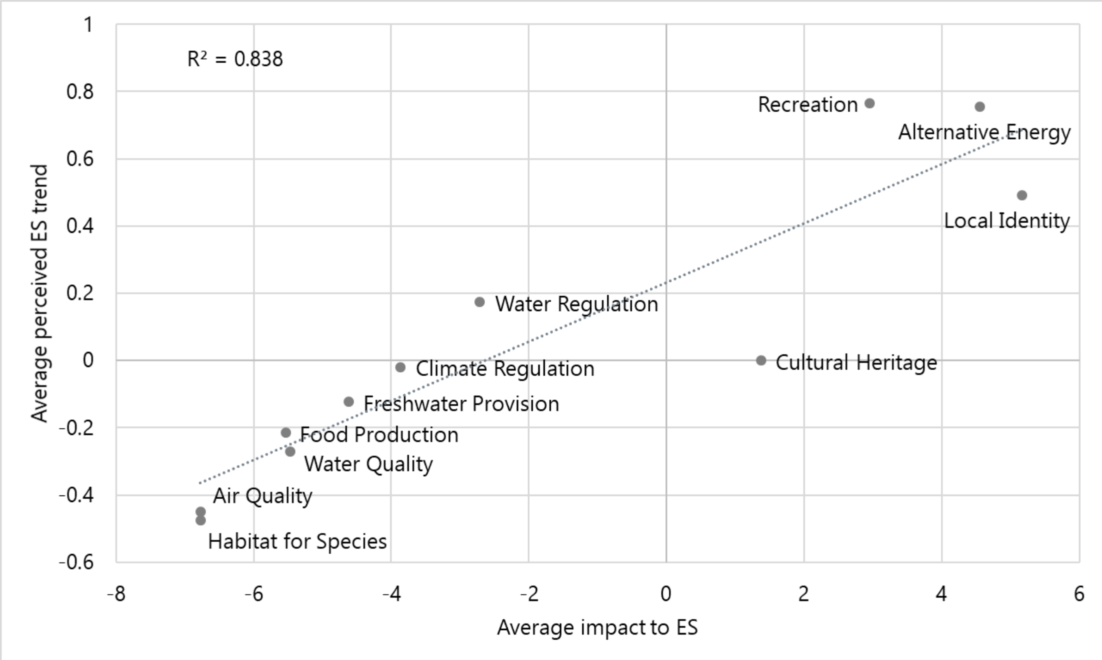

Figure 2.7. Scatterplot displaying relationship between perceived ES trends (range from -1 to 1 where -1 is decreasing, 0 is stable, and 1 is increasing) and perceived impacts to ES by urban land (range from -10 to 10).

5. Discussion

We did a rigorous evaluation of (1) likely future scenarios of urban growth and agricultural land loss, and (2) the demand for ES and perceptions regarding urban growth impacts to ES supply. The urban growth scenarios indicated there will be a continued transition from an agricultural-dominated landscape to an urban-dominated area by 2050. In areas experiencing rapid urbanization, there are two key issues with regards to ES supply and demand: the change in supply of ES that people either highly value or depend upon, and the change in most valued ES due to changing demographics (Bagstad et al., 2014; Nelson, 2005).

Biophysical-based studies of ES in urbanizing landscapes indicate that the high quality of life drawing people to our study area, and the western U.S., is likely to degrade as urbanization continues, impacting the supply of ES like air and water quality. Air quality is often negatively impacted by urbanization, particularly by increased transportation emissions (Bai et al., 2017; Xu et al., 2016) and decreased ability of the environment to purify the air (Xu et al., 2016). The likelihood of increasing frequency of human-caused wildfires coupled with anticipated changes in the climate also threaten air quality, alongside other ES like recreation, habitat for species, and water quality (Hawbaker et al., 2013; Nelson et al., 2013; Westerling et al., 2006). Decreasing agricultural operations may improve water quality, but the increase of household runoff, impermeable surfaces, and loss of natural vegetation may exacerbate existing water quality issues in the region (Bai et al., 2017; Pataki et al., 2011). Urban development can increase stream temperatures via increased air temperature, decreased water quantity, and heated discharge/runoff (Coles et al., 2012; O'Driscoll et al., 2010; Spanjer et al., 2018), leading to lower species richness and decreased productivity for fish species (Spanjer et al., 2018). Other impacts to wildlife include decreased species richness and productivity for bird species (Gagné et al., 2016; Meyrier et al., 2017).

Newer, expanding cities are less predictable and less compact than development occurring in older cities (Bai et al., 2017), likely due to a lack of comprehensive planning for a diverse suite of ES coupled with periodic, rapid development. Respondents in our study area showed high awareness of current urbanization and associated impacts to ES. However, while comprehensive planning is in place for some cities, development typically falls in favor of business owners and developers (Witt et al., 2010). Successfully managing for expected urbanization requires balancing between ES supply and demand via enforceable planning and regulatory measures. Urban development can positively supply ES in high demand at the city level via (1) increasing public transit to decrease traffic and resulting degradation of air quality (Barton, 2009), (2) preserving open space to maintain recreational opportunities, aesthetic preferences, air and water quality, and habitat for species (Lovell and Taylor, 2013), and (3) utilizing mixed use zoning to encourage heterogeneous landscapes supplying a wide range of ES (Bolund and Hunhammar, 1999; Lovell and Taylor, 2013).

Sociocultural values are an important indirect driver of urbanization as people's preferences can significantly shape how development occurs (Liu et al., 2007; Nelson, 2005). Survey responses indicated that people place high importance on direct ES like food production, cultural ES like recreation, and water-related ES like freshwater provision and water quality. Other studies show similar patterns where water-related ES and recreation are often chose as important (Castro et al., 2016, 2011; Martín-López et al., 2012; Quintas-Soriano et al., 2016). Overall, ES like cultural heritage and climate regulation were rarely chosen as important. Cultural ES like cultural heritage and local identity are often ranked lower or not chosen as important (Castro et al., 2016, 2011; Martín-López et al., 2012; Quintas-Soriano et al., 2016).

Similar to other studies, respondents negatively associated ES such as habitat for species, air quality, and water quality with urban land, and positively associated recreation and local identity with urban land (Brown and Brabyn, 2012; Quintas-Soriano et al., 2016). Agriculture is positively associated with cultural heritage (Brown and Brabyn, 2012) and negatively associated with regulating ES (Quintas-Soriano et al., 2016).

Relative to males, females attributed higher overall importance to air and water quality, a finding supported by other studies evaluating environmental concern (Brehm et al., 2013; C. Johnson et al., 2004; Shen and Saijo, 2008; Vaske et al., 2001). Literature regarding differences in preferences based on age are conflicting (C. Johnson et al., 2004; Liu et al., 2014; Shen and Saijo, 2008). Our results show significant differences for provisioning ES where older respondents rank freshwater provision higher and younger respondents rank food production higher. A higher level of education generally relates with greater environmental concern (Dunlap et al., 2000; Gifford and Nilsson, 2014; Kollmuss and Agyeman, 2002); our results supported this with university-educated respondents generally ranking indirect and cultural ES higher than direct ES. Our results also supported literature demonstrating greater environmental concern by liberals relative to conservatives (Dunlap et al., 2000; Hamilton et al., 2014; Liu et al., 2014); overall, liberals placed higher importance on indirect ES, with conservatives placing significantly lower importance on climate regulation.

Our results show that the general public placed higher importance on directly beneficial ES like food production and alternative energy, while experts highly valued indirect benefits like water quality and recreation. The experts surveyed were primarily from land management agencies and may have a preference for ES derived from more natural landscapes (i.e. forested and sagebrush-steppe) than those derived from anthropocentric landscapes (i.e. agricultural land and urban areas) (Strumse, 1996). For instance, the more highly valued regulating ES such as water quality and habitat for species are generally associated with forested or sagebrush steppe areas. Experts also have a tendency to value ES related to their expertise (García-Llorente et al., 2012; Scholte et al., 2015). We surveyed professionals working directly with air and water quality issues (Department of Environmental Quality) and habitat for species (Idaho Fish and Game).

These results in particular may be of interest to urban planners in showing the disconnect between experts and the general public. For instance, the difference in rank of alternative energy between the general public versus experts indicates it may not be a priority for experts, but there's a supportive public. Additionally, experts might not be effectively communicating with the general public. There might be specific environmental concerns related to ES like water quality and habitat for species that the general public is unaware of, and consequently does not prioritize. Increasing communication between experts and the general public and further incorporating broad sociocultural values into urban planning and land management adopts the holistic approach advocated by place-based, context-specific frameworks (Ostrom, 2009; Potschin and Haines-Young, 2013; Reed, 2008), making implemented policies more resilient over time (Chan et al., 2016; Decker et al., 2015).

Applying the Ecosystem Services Framework to measure sociocultural values has its limitations. We asked respondents to form on-the-spot opinions regarding their attitudes towards sometimes abstract concepts (Scholte et al., 2015). We see more importance placed on provisioning and regulating ES which are easier to grasp. For instance, people are often aware that freshwater provision and food production are essential parts of their lives. Some regulating ES are more recognizable as well, such as water quality (as compared to water regulation) and habitat for species. Cultural ES are not often discussed in everyday life and may have been confusing topics to develop opinions about. Results may also be skewed due to asking respondents to rank only four of the 11 ES rather than all of them. In reviewing overall responses, it appears people often resorted to choosing direct ES, citing necessity. While this method was intended to simplify and shorten response times it may have ultimately reduced the ability to accurately explore trade-offs between individual ES. Lastly, we defined the population of interest as "people residing in the BMA." However, we conducted convenience sampling rather than representative sampling. This poses issues in generalizing our sample to represent the population of interest (Groves, 2004).

6. Conclusion

Urbanization is a global phenomenon that forces urban planners, land managers, decision-makers, and scientists to consider balancing the demands of the world's population with environmental sustainability. The demand for ES is likely to change as populations shift, consequently impacting ES supply, both in terms of its source and delivery. Our study demonstrated the conversion of lands associated with valued ES to urban land, particularly agriculture, wetlands, and forested areas. There are many ways for cities to successfully manage for a wide variety of ES in the face of rapid urbanization by implementing and enforcing city-regional level regulatory measures. Accounting for this change in demand and supply of ES will better prepare the world's population when faced with large-scale problems likely to occur with climate change, such as flooding, food insecurity, and water scarcity.

Table SI-1: Differences in average ES importance rankings between socio-demographic groups

Factors	Mean relative value (S.D.)										
	Freshwater Provision	Food Production	Alternative Energy	Water Regulation	Climate Regulation	Water Quality	Air Quality	Habitat for Species	Recreation	Cultural Heritage	Local Identity
Expert Knowledge											
Experts	1.74*	0.76**	0.59*	0.50	0.58	1.88**	1.03	1.62	1.86**	0.24	0.26
	(1.75)	(1.37)	(1.13)	(1.13)	(1.25)	(1.54)	(1.51)	(1.65)	(1.57)	(0.87)	(0.67)
General Public	1.14*	1.51**	1.23*	0.42	0.35	1.14**	1.12	1.08	1.13**	0.37	0.42
	(1.57)	(1.60)	(1.54)	(1.04)	(0.92)	(1.50)	(1.42)	(1.35)	(1.39)	(0.91)	(0.96)
Place of Residency											
Urban	1.08	1.36	1.20	0.42	0.40	1.43**	1.15	1.11	1.15	0.27*	0.45
	(1.54)	(1.58)	(1.52)	(1.06)	(1.01)	(1.57)	(1.46)	(1.35)	(1.44)	(0.77)	(0.97)
Agriculture	1.17	1.66	1.28	0.26	0.35	0.90**	1.08	1.17	1.12	0.50*	0.40
	(1.59)	(1.62)	(1.56)	(0.81)	(0.95)	(1.37)	(1.38)	(1.44)	(1.38)	(1.05)	(0.99)
Length of Residency											
Short-term residents (<15 years)	1.22	1.50	1.19	0.43	0.35	1.01*	1.01	1.13	1.39**	0.37	0.44
	(1.59)	(1.58)	(1.56)	(1.07)	(0.96)	(1.41)	(1.36)	(1.39)	(1.46)	(0.97)	(0.98)
Long-term residents (≥15 years)	1.17	1.38	1.15	0.42	0.39	1.37*	1.21	1.10	1.02**	0.35	0.36
	(1.59)	(1.60)	(1.48)	(1.01)	(0.94)	(1.58)	(1.48)	(1.38)	(1.37)	(0.85)	(0.91)
Level of Education											
Up to Bachelor's	1.21	1.51	1.48***	0.36	0.34	1.07	1.01	1.19	0.97**	0.40	0.38
	(1.63)	(1.60)	(1.55)	(0.99)	(0.96)	(1.49)	(1.33)	(1.44)	(1.30)	(0.91)	(0.89)
Bachelor's or above	1.18	1.38	0.93***	0.49	0.40	1.33	1.18	1.08	1.36**	0.33	0.41
	(1.57)	(1.58)	(1.43)	(1.09)	(0.95)	(1.53)	(1.49)	(1.36)	(1.48)	(0.92)	(0.99)
Political Ideology											
Conservative	1.38	1.68*	1.27	0.31	0.17**	0.99	1.21	0.96	0.99	0.55*	0.41
	(1.64)	(1.62)	(1.60)	(0.90)	(0.63)	(1.46)	(1.51)	(1.38)	(1.24)	(1.11)	(0.90)
Liberal	1.16	1.13*	1.20	0.47	0.56**	1.21	1.08	1.30	1.30	0.28*	0.31
	(1.59)	(1.52)	(1.54)	(1.05)	(1.14)	(1.52)	(1.39)	(1.47)	(1.47)	(0.84)	(0.73)
Gender											
Female	1.10	1.46	1.18	0.36	0.34	1.23	1.32**	1.07	1.14	0.35	0.42
	(1.56)	(1.56)	(1.52)	(0.95)	(0.92)	(1.55)	(1.47)	(1.37)	(1.41)	(0.92)	(0.99)
Male	1.28	1.48	1.28	0.52	0.42	1.05	0.89**	1.16	1.16	0.39	0.37
	(1.60)	(1.64)	(1.55)	(1.14)	(1.01)	(1.42)	(1.35)	(1.38)	(1.39)	(0.93)	(0.91)
Age											
<35 years	1.08	1.67*	1.19	0.41	0.39	1.20	0.96	1.16	1.26	0.32	0.36
	(1.59)	(1.60)	(1.52)	(1.00)	(1.03)	(1.56)	(1.33)	(1.43)	(1.40)	(0.84)	(0.82)
≥35 years	1.25	1.35*	1.17	0.44	0.36	1.19	1.19	1.12	1.15	0.38	0.41
	(1.60)	(1.58)	(1.52)	(1.07)	(0.92)	(1.50)	(1.46)	(1.37)	(1.42)	(0.94)	(0.97)
<59 years	1.12*	1.48	1.17	0.41	0.38	1.23	1.08	1.20	1.21	0.38	0.39
	(1.59)	(1.59)	(1.50)	(1.00)	(0.99)	(1.54)	(1.41)	(1.42)	(1.42)	(0.93)	(0.91)
≥59 years	1.44*	1.35	1.20	0.51	0.34	1.11	1.22	0.93	1.10	0.31	0.41
	(1.59)	(1.60)	(1.58)	(1.16)	(0.84)	(1.46)	(1.47)	(1.28)	(1.39)	(0.85)	(0.98)

*<.05
**<.01

***<.001

Table SI-2: Differences in average ES trends between socio-demographic groups

Factors	Mean relative value (S.D.)										
	Freshwater Provision	Food Production	Alternative Energy	Water Regulation	Climate Regulation	Water Quality	Air Quality	Habitat for Species	Recreation	Cultural Heritage	Local Identity
Expert Knowledge											
Experts	-0.36	0.25	0.78	0.20	**-0.67***	-0.32	-0.75	**-1.00****	0.86	-0.50	0.20
	(0.84)	(0.96)	(0.67)	(0.45)	(0.52)	(0.82)	(0.62)	(0.00)	(0.48)	(0.71)	(0.84)
General Public	-0.09	-0.23	0.75	0.17	**0.06***	-0.26	-0.42	**-0.42****	0.75	0.02	0.52
	(0.71)	(0.84)	(0.51)	(0.67)	(0.84)	(0.72)	(0.70)	(0.81)	(0.56)	(0.90)	(0.72)
Place of Residency											
Urban	0.06	-0.29	0.71	0.06	0.19	-0.21	-0.40	-0.52	0.84	-0.11	0.54
	(0.67)	(0.80)	(0.59)	(0.68)	(0.87)	(0.76)	(0.72)	(0.78)	(0.45)	(0.90)	(0.74)
Agriculture	-0.24	-0.29	0.78	0.42	0.00	-0.32	-0.46	-0.25	0.68	-0.08	0.33
	(0.78)	(0.83)	(0.47)	(0.51)	(0.88)	(0.60)	(0.67)	(0.90)	(0.64)	(0.88)	(0.80)
Length of Residency											
Short-term residents (<15 years)	-0.17	-0.15	0.84	0.11	0.00	-0.31	-0.37	-0.54	0.78	0.00	0.56
	(0.69)	(0.86)	(0.42)	(0.58)	(0.69)	(0.73)	(0.68)	(0.78)	(0.51)	(0.92)	(0.67)
Long-term residents (≥15 years)	-0.09	-0.25	0.69	0.22	-0.03	-0.25	-0.51	-0.42	0.74	0.00	0.44
	(0.76)	(0.84)	(0.58)	(0.70)	(0.95)	(0.75)	(0.71)	(0.79)	(0.59)	(0.89)	(0.79)
Level of Education											
Up to Bachelor's	-0.15	**-0.46****	0.74	0.13	0.10	-0.31	-0.41	**-0.32***	0.68	-0.07	0.57
	(0.73)	(0.75)	(0.50)	(0.74)	(0.85)	(0.74)	(0.70)	(0.83)	(0.63)	(0.91)	(0.73)
Bachelor's or above	-0.12	**0.00****	0.76	0.19	-0.09	-0.25	-0.48	**-0.61***	0.82	0.08	0.42
	(0.73)	(0.87)	(0.55)	(0.60)	(0.84)	(0.73)	(0.70)	(0.73)	(0.49)	(0.89)	(0.73)
Political Ideology											
Conservative	-0.06	-0.26	0.85	-0.17	-0.25	-0.36	-0.53	-0.28	0.67	0.00	0.53
	(0.68)	(0.82)	(0.37)	(0.98)	(0.96)	(0.58)	(0.67)	(0.94)	(0.69)	(0.94)	(0.83)
Liberal	0.00	0.00	0.80	0.24	0.04	-0.13	-0.35	-0.54	0.81	0.15	0.44
	(0.76)	(0.89)	(0.46)	(0.66)	(0.87)	(0.70)	(0.79)	(0.77)	(0.47)	(0.90)	(0.70)
Gender											
Female	-0.20	-0.35	0.79	0.24	-0.05	-0.25	-0.49	-0.46	0.82	0.00	0.45
	(0.69)	(0.83)	(0.48)	(0.66)	(0.90)	(0.73)	(0.69)	(0.82)	(0.47)	(0.94)	(0.75)
Male	-0.05	-0.10	0.71	0.11	0.03	-0.30	-0.33	-0.48	0.69	0.00	0.48
	(0.74)	(0.84)	(0.57)	(0.63)	(0.82)	(0.73)	(0.73)	(0.77)	(0.63)	(0.89)	(0.74)
Age											
<35 years	-0.08	-0.13	0.83	0.15	-0.07	-0.38	-0.51	-0.49	0.68	0.07	0.55
	(0.76)	(0.81)	(0.38)	(0.38)	(0.83)	(0.74)	(0.67)	(0.78)	(0.60)	(0.88)	(0.60)
≥35 years	-0.15	-0.26	0.72	0.18	0.00	-0.24	-0.43	-0.47	0.80	-0.02	0.45
	(0.72)	(0.87)	(0.57)	(0.73)	(0.86)	(0.72)	(0.71)	(0.80)	(0.53)	(0.91)	(0.79)
<59 years	-0.16	-0.19	0.75	0.22	0.00	-0.29	-0.48	-0.46	0.76	-0.07	0.44
	(0.75)	(0.84)	(0.51)	(0.55)	(0.81)	(0.71)	(0.68)	(0.80)	(0.56)	(0.88)	(0.73)
≥59 years	-0.08	-0.30	0.76	0.07	-0.07	-0.24	-0.37	-0.50	0.77	0.23	0.63
	(0.68)	(0.88)	(0.55)	(0.83)	(0.96)	(0.78)	(0.75)	(0.76)	(0.56)	(0.93)	(0.72)

*<.05
**<.01

THESIS CONCLUSIONS

In chapter one of this thesis I participated in a collaborative, interdisciplinary effort to a) produce scenarios of urban growth to 2100 in the Treasure Valley, Idaho, and b) disseminate those results in several formats to reach the general public and decision-makers. The land use projections demonstrated (1) the extent of urbanization under different population growth and population density scenarios and (2) the conversion of major land use-land cover types under projected urban growth. In our study area, agriculture is most at risk of conversion due to topographic constraints, ease of development, and land ownership (Dahal et al., 2017). By 2050, we expect a minimum loss of 22% of agriculture under the High Density scenario, ranging up to a 37% loss under the Low Density scenario. It's worth pointing out our study area's Business as Usual scenario is much closer to the Low Density scenario than the High Density scenario. That is, when other major metropolitan areas experience a decrease in density, or sprawl, the rate of expansion is similar to the BMA's current rate of expansion.

Our efforts to share these results with the general public and interested stakeholders has been successful. Our results have been incorporated into multiple news stories by Idaho Statesman, Capital Press, and Edible Idaho. Based on contact received regarding our products, we've reached diverse audiences including non-profit organizations (The Nature Conservancy, Treasure Valley Food Coalition, and Idaho Conservation League), city-regional-state government employees (Canyon County, City of Boise, COMPASS, and state legislators), special interest groups (various business owners), and interested members of the public.

In chapter two of this thesis we explored how urbanization may influence human well-being by measuring perceptions of ES including (1) perceived personal importance, (2) perceived ES trends, and (3) perceptions regarding impacts to ES by urban land and agriculture. We found that the general public places higher importance on direct ES, while experts place higher importance on indirect ES. This indicated a lack of discourse between experts and the general public as there are either topics of concern potentially being overlooked by influential stakeholders, or environmental issues that might not be clearly communicated with the general public. Other differences between socio-demographic groups demonstrate the need to continue gauging public interest to effectively plan land use policy. For instance, differences between short-term and long-term residents indicate there may be an overall shift in ES preferences. Respondents in our study area seem aware of which ES are decreasing, and may be further threatened by urbanization. However, there appears to be a lack of effort on part of city-regional planners to address these issues via enforceable regulatory measures. Lastly, relative to agriculture, urban land appears to be perceived as having greater, negative impacts to ES. Our social survey approach can be applied in other study areas to illuminate ES-human relationships across a variety of contexts where urbanization is the dominant land use change dynamic.

These chapters together ask researchers, urban planners, and residents to consider what landscape characteristics they consider vital to maintaining human well-being and a high quality of life, and how these characteristics can be preserved in the face of rapid urbanization. There is ample opportunity to plan urban development to preserve direct, indirect, and cultural ES important for both environmental sustainability and human well-being.

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APPENDIX A

Survey Instrument

[Continues on following page]

DATE .... Nº SURVEY .... INTERVIEWER NAME........................

Idaho State University and Boise State University are cooperatively working on a study examining the links between humans and nature. We are studying the contributions provided by the Treasure Valley and their relationship with different land use and climate scenarios. To do this we are surveying locals and tourists in the area. It would be helpful to know your opinion/perception through this survey. Would you like to answer? Thank you! Remember that all responses are anonymous and it only takes 15 min. There are no "right answers", just tell us what you think.

Study area*: The study area is located in southwestern Idaho and includes the Treasure Valley landscapes.*

SHOW A STUDY AREA MAP WITH THE LOCATION OF THE TREASURE VALLEY

Section A: Ecosystem Benefits Perception in the Treasure Valley

Nature is providing, directly or indirectly, contributions to human, which are essential for our wellbeing. For instance, humans get food from oceans, coastal protection from storms or pleasure by visiting beaches

(Do not show ES panel until question 2)

1. Do you think the Treasure Valley provides contributions that contribute to human wellbeing of the region? (Here it's important to explain what we mean by Treasure Valley)

- ☐ Very many
- ☐ Many
- ☐ Few
- ☐ Very little to none

Can you give me examples of some potential benefits? (All they consider)

………

………

…………………………

2. From **CONTRIBUTIONS PANEL**, could you choose what you think are the most important contributions for maintaining wellbeing or quality of life of people living or visiting in the Treasure Valley? (Choose only 4) and how do think they have changed? (The same, worse, better, or don´t know)

(SHOW/EXPLAIN CONTRIBUTIONS PANEL)

Ecosystem Services	***Choose 4*** *of 11 ES and rank:* *(1) Least important* *(2) Somewhat important* *(3) Very important* *(4) Most important*	*Why are they important? (describe with 1 or 2 words)*	*Using the 4 ESB you chose: In the last 10 years, would you say each has:* *(1) Decreased* *(2) Remained the same* *(3) Increased* *(4) Don´t know*	***Choose*** *the location on the TV map where this benefit is coming from (write down cell number(s))*
Freshwater provision				
Food from agriculture and livestock				
Alternative energy (hydropower, wind mills, etc.)				
Climate regulation				

Air quality				
Habitat for Species				
Recreation/ ecotourism				
Cultural Heritage				
Water quality				
Local identity				
Water regulation				

3. Which of these factors do you think affect water quality? (select as many as necessary)

☐ Water use for agriculture (+ or -) ☐ Fertilizers (+ or -) ☐ Urban pollution (+ or -)
☐ Reservoirs management (+ or -) ☐ Runoff (+ or -) ☐ Wastewater discharge (+ or -)

Section B: Land Use Perception on Ecosystem Benefits

1. Does land use around the Treasure Valley affect the contributions people get from the landscapes?

☐ NO- Why?...☐ YES –

Why?...

2. Now with more detail, how do you think these land uses affect the contributions that the Treasure Valley provides? (**SHOW CONTRIBUTIONS AND LAND USE PANEL**)

Land Uses	*Contributions negatively affected. Choose up to 2, if any, from the services panel and give them a 1 (min) to 10 (max)*	*Contributions positively affected. Choose up to 2, if any, from the services panel and give them a 1 (min) to 10 (max)*
Urban Development		
Agricultural Land		
Rangeland		
Urban and Natural Forest		

Section C: Climate Scenarios Perception on Ecosystem Benefits

1. How do you think climate is affecting the contributions that the Treasure Valley is providing to humans (**SHOW CONTRIBUTIONS AND CLIMATE SCENARIOS PANELS**)

Climate Scenarios	*Contributions negatively affected. Choose up to 2, if any, contributions and give them a 1 (min) to 10 (max)*	*Contributions positively affected. Choose up to 2, if any, contributions and give them a 1 (min) to 10 (max)*
Warmer/ shorter Winters		
Droughts		
Flooding		

Natural Wildfires		

2. In general, would you say that average winter temperatures are getting warmer around here?

☐ NO ☐ YES

3. How worried are you about drought in this area in the future?

☐ Very worried ☐ A little worried ☐ Not very worried ☐ Not worried at all

4. Thinking specifically about changes to the climate, how concerned are you about climate change?

☐ Very concerned ☐ A little concerned ☐ Not very concerned ☐ Not concerned at all

5. Do you think that climate is somehow affecting the contributions that people obtain in the Treasure Valley?

☐ NO ☐ YES;

example?...

If YES, how do you think these impacts will affect the contributions that people obtain in the Treasure Valley?

(Negatively) 1……2……3……4……5……6……7……8……9……10 (Positively)

Section D: Variables related to environmental behavior

1. Where do you live? ………………………………………………………………………………………

(zip code)

2. What brings you to the Treasure Valley?

☐ TREASURE VALLEY RESIDENT (if they live in any of the Treasure Valley counties)

☐ IDAHO TOURIST (Idaho citizen visiting the Treasure Valley)

☐ NATIONAL TOURIST (Non Idaho citizens visiting the Treasure Valley)

□ BUSINESS (nonresident in the Treasure Valley but working in the area)

3. Have you visited the Boise River?

□ Yes □ No – Are you planning to visit? …………………………………… **(ALL)**

4. Do your parents/grandparents come from this area? **(TREASRUE VALLEY RESIDENTS)**

□ No □ Yes – How many generations has your family lived in the Treasure Valley?…………………………

5. What are your top 3 outdoor recreation activities?…………………………………………………………………….**(ALL)**

- □ Mountain biking
- □ Bait Fishing
- □ Boating
- □ Hiking/running
- □ Off-roading (ATV, snowmobile)
- □ Fly fishing
- □ Hunting
- □ Camping/backpacking
- □ Climbing
- □ Skiing (cross-country-down hill)
- □ Other, which one? ....

6. Do you belong to any community groups? **(ALL)**

□ Yes, what type? (□ Environmental; □ Social; □ Leisure; □ Work; □ Other)
Specifically?..

□ No

7. Are you active in community affairs?

□ No □ Yes (for example, attend city meetings, neighborhood association, or church group)

Specifically?…………………………………………………………………………………………..

7a- If yes: Do you think your opinion is considered in decision making?

□ Yes; How?......……………………………………………………………………………

8. Do you think that government decisions are affecting the health of the Treasure Valley?

□ NO □ YES - In what sense/way?...

9. How long have you lived here? ……………………………………..years **(TV RESIDENTS)**

10. How close to the Boise River do you live?...................... **(TREASURE VALLEY RESIDENTS)**

- ☐ Less than one mile
- ☐ 1-5 miles
- ☐ More than five miles
- ☐ More than 10 miles

10a. What do you like most about living near the Boise River?... **(IF 0 TO 5 MILES)**

10b. What do you like least about living near the Boise River?... **(IF 0 TO 5 MILES)**

11. Does the Boise River hold any particular meaning for you? **(ALL)**

☐ No ☐ Yes – What does the Boise River mean to you?...

13. Have you been here before? ☐ YES ☐ NO **(IDAHO AND NATIONAL TOURIST)**

14. When did you come here the first time? ……………………….. (year) **(IDAHO AND NATIONAL TOURIST)**

15. How often do you come to this area? **(IDAHO AND NATIONAL TOURIST)**

- ☐ Very often (every week)
- ☐ Sometimes (every month)
- ☐ Periodically (every few months)
- ☐ Rarely (once/year or les

16. What geographic location do you identify with most? <u>(Chose just 1):</u>

- ☐ USA
- ☐ Western USA
- ☐ Idaho
- ☐ SW Idaho
- ☐ City/county of residence
- ☐ Other:……………........

17. What year were you born? ....

18. What is the highest level of school you have completed or the highest degree you have received?

- ☐ Less than high school degree
- ☐ High school degree or equivalent (e.g. GED)

☐ Some college but no degree
☐ Associate degree
☐ Bachelor degree
☐ Graduate degree
☐ Other……………………………………
☐ Prefer not to say

19. What is your profession? (If retired, what did you do?)..**(ALL)**
20. Do you own or lease land in the Treasure Valley as part of your occupation? **(TV RESIDENTS)**

☐ Yes, I lease land
☐ Yes, I own land
☐ No

21. **IF YES**: Do you own or lease land for any of the following uses:

☐ Irrigated agriculture
☐ Cattle
☐ Other livestock (sheep, goats, etc.)
☐ Dairy
☐ Mining
☐ Forestry
☐ Other, please specify:

22. What is your annual household income?

☐ < $19,999
☐ $20,000 – $39,999
☐ $ 40,000 – $59,999
☐ $ 60,000 – $79,999
☐ $80,000 - $99,999
☐ > $100,000
☐ Prefer not to say

23. Would you describe yourself politically as conservative, moderate, or liberal?

☐ Moderate
☐ Conservative
☐ Liberal
☐ Prefer not to say
☐ Other………………………………………

24. How would you describe your ethnic background?

☐ White, Caucasian (Non-Hispanic)
☐ Black, African-American
☐ Native American
☐ Latino or Hispanic

□ Asian American

□ Native Hawaiian or other Pacific Islander……………………..

□ Tribe or Tribe Affiliation ………………………….

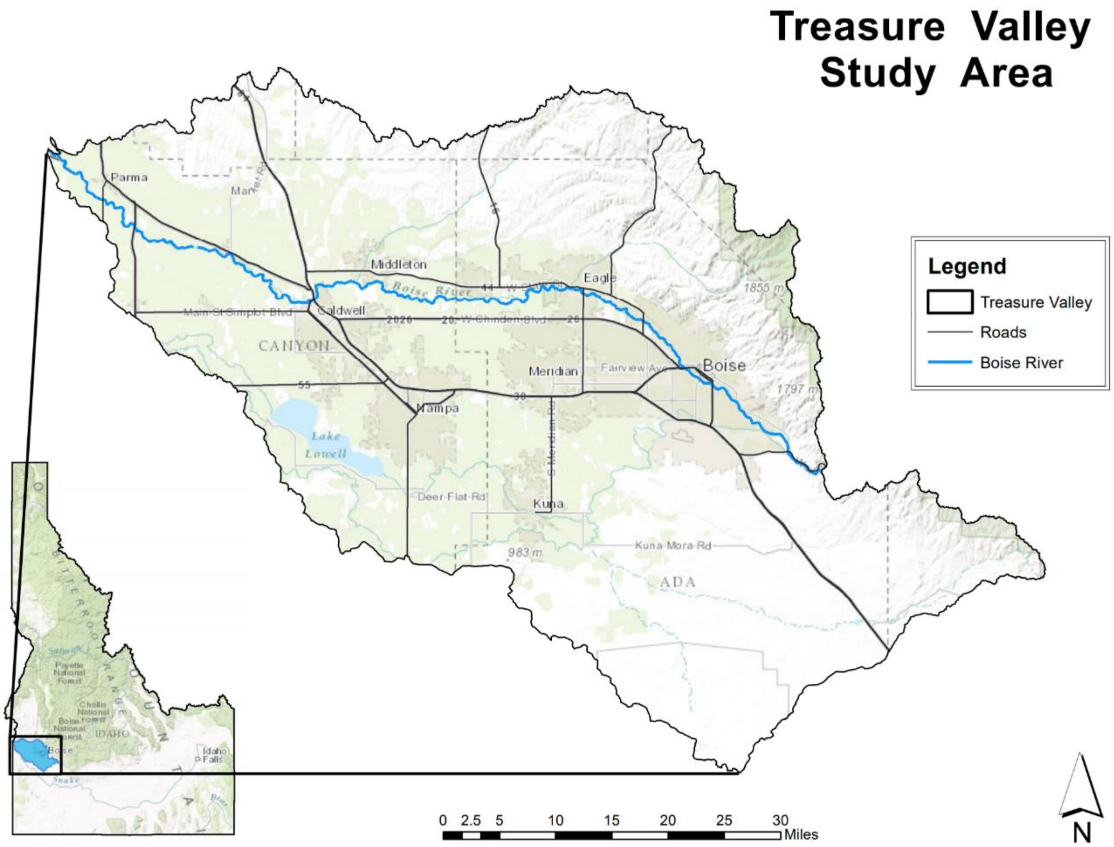
□ Other: ………………..

□ Prefer not to say

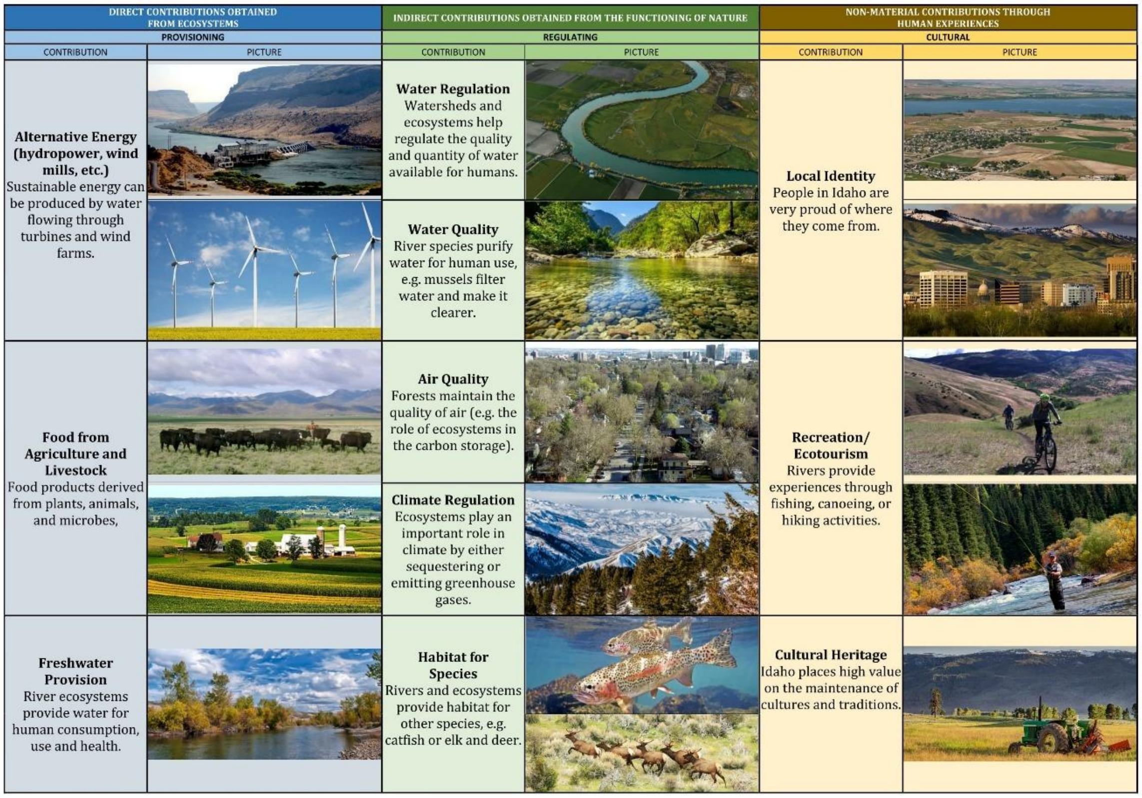
To be completed by the interviewer

- Place of the interview (city, town, village):
…………………………………………………………………

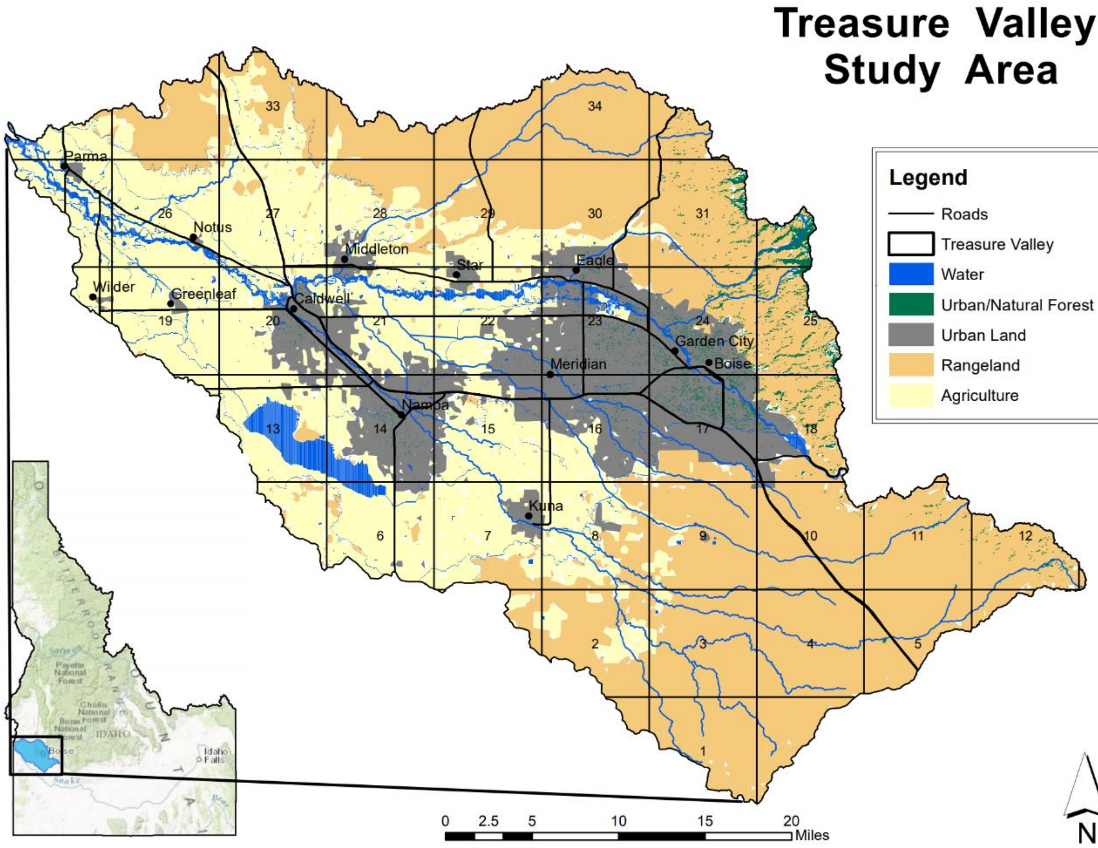
- Respondent’s attitude: good/not very interested/not interested
- Understanding of the questionnaire: high/medium/low
- Gender: male/female


Treasure Valley
Study Area
Legend
Treasure Valley
Roads
Boise River
Parma
Middleton
Eagle
Caldwell
CANYON
Meridian
Boise
Nampa
Lake
Lowell
Deer Flat Rd
Kuna
Kuna Mora Rd
ADA
983 m
1855 m
1797 m
0 2.5 5 10 15 20 25 30 Miles
N

Panel: Study Area



Panel: ES explanatory panel



Treasure Valley Study Area
Legend
Roads
Treasure Valley
Water
Urban/Natural Forest
Urban Land
Rangeland
Agriculture
Parma
Notus
Middleton
Star
Eagle
Wilder
Greenleaf
Caldwell
Garden City
Boise
Meridian
Nampa
Kuna
0 2.5 5 10 15 20 Miles
N

Panel: Land use-land cover to indicate ES supply

Land use and land cover in the Treasure Valley	Pictures
Urban Development	
Agricultural Land	
Rangeland	
Urban and Natural Forests	

Panel: Land use-land cover scenarios

Climate in the Treasure Valley	Pictures
Warmer/Shorter Winters	
Droughts	
Floods	
Natural Wildfires	

Panel: Climate scenarios

APPENDIX B

Independent Research: Relating social science to the ecosystem services framework

1. Introduction

1.1 Relating Social Science to The Perceived Importance of Ecosystem Services (ES)

Brehm et al. (2013) discuss "environmental concern" as a catchall phrase for measuring environmental beliefs, although it is also referenced as a measure for attitudes and underlying values. While environmental concern encompasses a wide variety of environmental issues, it can be generally applied to the Ecosystem Services Framework under the following assumptions:

- Regulating ES (e.g. climate regulation) can be related to higher levels of environmental concern in that they are not directly related to human well-being.
- Provisioning ES (e.g. food production) can be related to lower levels of environmental concern in that they are directly related to human well-being.
- Cultural ES (e.g. cultural heritage) can be related to concern for intrinsic, or immeasurable, qualities of the environment.

Preference for ES is measured using the concept of assigned values. Assigned values refer to the relative value that people give to objects, issues, or places (Ives and Kendal, 2014). Assigned values fall within the same spectrum as attitudes in the cognitive hierarchy model, where stated preferences often change (Gregory et al., 1993; Scholte et al., 2015). Application of assigned values relies on the assumption that the relative importance assigned is based on underlying values, the individual's beliefs, and context (e.g. individual's expectations, social setting, information given, etc.) (Brown, 1984; Scholte et al., 2015). While some researchers have argued that assigned values are often developed spontaneously, particularly in the case of ES where individuals are unlikely to have predefined values (Chan et al., 2012; Gregory et al., 1993; Scholte et al., 2015), for the purpose of this literature review we assume underlying values, beliefs, and attitudes have an influential role in shaping assigned values.

The ability of socio-demographic variables (e.g. gender, age, education, race, and income) to predict environmental concern is well researched. For instance, gender has been examined as a predictor of environmental concern. This research finds mixed results but the overall trend supports women as being more environmentally concerned, relative to men (Johnson et al., 2004; Liu et al., 2014; Vaske et al., 2001). Similar to gender, age is a well-studied determinant of environmental concern, where younger people tend to show more environmental concern (C. Y. Johnson et al., 2004; Jones et al., 2003; Marquart-Pyatt, 2008) potentially due to a generational shift towards biocentric views over anthropocentric views (Jones et al., 2003) or increased education regarding environmental issues (Howell and Laska, 1992). The effect of income on environmental concern is largely inconclusive (Liu et al., 2014; Marquart-Pyatt, 2008; Shen and Saijo, 2008; Vaske et al., 2001); a commonly held assumption is that individuals with higher incomes have satisfied basic needs and hold post-materialist views, including greater concern for the environment (Gifford and Nilsson, 2014; Liu et al., 2014). Higher levels of education are generally associated with greater environmental concern (Dunlap et al., 2000; Gifford and Nilsson, 2014; Kollmuss and Agyeman, 2002; Liu et al., 2014; Marquart-Pyatt, 2008; Shen and Saijo, 2008). There are several underlying theories for this, primarily that increased knowledge or awareness leads to increased environmental concern (Dunlap et al., 2000; Kollmuss and Agyeman, 2002; Liu et al., 2014; Marquart-Pyatt, 2008). Lastly, there are mixed results with regards to race and ethnicity and environmental concern in existing literature. Recent studies have demonstrated that racial and ethnic minorities may show similar or greater concern for the environment, relative to people who are white (Brehm et al., 2013; Gifford and Nilsson, 2014; C. Y. Johnson et al., 2004; Liu et al., 2014).

Place of residence can be linked to environmental concern, where rural residents are more anthropocentric than urban residents (Gifford and Nilsson, 2014) while urban residents are more environmentally concerned (Jones and Dunlap, 1992). This may be due to rural residents relying more on natural resources, or urban residents being exposed to more pollution (Tremblay and Dunlap, 1978).

Greater concern for environmental issues is often linked to liberal political ideology (Dunlap et al., 2000; Liu et al., 2014; Shen and Saijo, 2008) or Democratic party affiliation (Hamilton et al., 2014), and shows more consistency in predicting level of environmental concern than other variables (e.g. income level) (Hamilton et al., 2014; Liu et al., 2014). The basis for this link may be explained by (1) conservative ties to business and industry, which generally oppose environmental regulations (Liu et al., 2014; Shen and Saijo, 2008) or (2) greater acceptance of change by liberals (Dunlap et al., 2000; Shen and Saijo, 2008). Recent studies support this overall trend with liberals showing greater general environmental concern (Dunlap et al., 2000; Hamilton et al., 2014; Liu et al., 2014).

Length of residence is often considered an important variable in rapidly changing areas such as the Treasure Valley, where conflicts are expected between newcomers and longer-term residents (Smith and Krannich, 2009). Previous research indicates longer-term residents are more anthropocentric (Vaske et al., 2001) and place higher importance on traditional land uses (Brehm et al., 2006), while newcomers are more likely to support preservation efforts (Vaske et al., 2001), favor alternative energy sources, and prioritize national interests over local interests (Hamilton et al., 2014).

1.2 Relating Social Science to Perceptions of Lulc Impacts

The second dependent variable in this research is the perceived impact of LULC types on ES. Of particular interest is social perceptions regarding urban areas, as development is often dictated by economic interests (Sullivan, 1994) or by experts (Decker et al., 2015). Due to experts and decision-makers attributing preference to landscapes based on their own interests, there is a potential lack of comprehensive consideration of the landscape as a whole (García-Llorente et al., 2012; Scholte et al., 2015). Framing perceptions of ES by LULC types allows for decision-makers to incorporate socio-cultural values on a scale aligned with management and conservation (López-Martínez, 2017; Turkelboom et al., 2017).

Landscape preference research has shown a strong trend in preference for open spaces, including farmland and forested areas (Acharya and Bennett, 2001; Burchfield et al., 2006; Geoghegan, 2002; Sullivan, 1994). Acharya and Bennett (2001) found that the percent of open space surrounding a home significantly, positively impacts its market value while Geoghegan (2002) found higher property value related to permanent open space over developable open space.

Perceptions of agriculture vary with type (e.g. smaller traditional farms versus greenhouses) with less developed agricultural land being given higher preference ratings (Brown and Brabyn, 2012; García-Llorente et al., 2012). Quintas-Soriano et al. (2016) found that respondents generally viewed greenhouse horticulture negatively, with significant, negative impacts to climate regulation and water regulation. Similarly, Brown and Brabyn (2012) found perceived negative impacts to aesthetic/scenic values, recreation, and historical/cultural values by developed agriculture – however, they did find positive historical/cultural values associated with semi-developed agriculture.

Perceptions of urban areas vary from neutral (López-Martínez, 2017) to positive. Perceived positive impacts from urban areas are generally to cultural ES and include recreation/tourism, aesthetic/scenic values, and historical/cultural values (Brown and Brabyn, 2012; Quintas-Soriano et al., 2016). Perceived negative impacts are generally to regulating ES and include water regulation and erosion control (Quintas-Soriano et al., 2016).

Previous research uses socio-demographic data to better elicit public perceptions of LULC types. For instance, age, education, gender, social class, place of residence, expert knowledge, and residency length all influence landscape preferences (Eija et al., 2014; García-Llorente et al., 2012; Howley et al., 2012; López-Martínez, 2017). Studies regarding the preferences of women, older age groups, and those with a higher education are conflicting where some studies show higher overall perceived values of landscapes (Eija et al., 2014; Filova et al., 2015) and other studies demonstrate the opposite (López-Martínez, 2017; Strumse, 1996). Howley et al. (2012) found that older respondents place higher value on traditional agricultural landscapes than younger age groups. Rural residents prefer traditional agricultural landscapes (Howley et al., 2012), while urban residents tend to place lower value on all landscapes (Filova et al., 2015). Experts are more likely to attribute lower value to non-natural areas (Strumse, 1996).

2. Methods

2.1 Data Analysis

All data analysis was conducted using Stata 15.0 and a combination of statistical methods. Post-estimation tests conducted for the OLS regression models include heteroscedasticity using White's test, normality using the Shapiro-Wilk W test, multicollinearity by checking the variance inflation factor, and model specification using the Ramsey RESET test (Chen et al., 2003).

Binomial logit regression was used to predict the probability that a respondent chose an ES as important (1=ES chosen as important). Ordinary Least Squares (OLS) regression was used to predict the likelihood a respondent chose an ES category using aggregated rankings of individual ES (range 0 – 12).

OLS regression was used to predict the perceived impact of land use on ES categories using the summed estimated impacts to individual ES (range -20 – 20).

2.2 Operationalizing Independent Variables

Gender is a dummy variable with 1 being female and 0 male. Age is a continuous variable using respondents' age. Income is a categorical variable ranging from 1 being <$20,000 estimated household income to 6 being ≥$100,000. Level of education is a categorical variable where 1 = up to high school, 2 = up to bachelor's, 3 = graduate level (Brehm et al., 2006; Jones et al., 2003). Race is a dummy variable with 1 being non-Hispanic white and 0 other (Jones et al., 2003). Political ideology is a categorical variable where 1 = conservative, 2 = moderate, 3 = liberal (Hamilton et al., 2014). Place of residency is a dummy variable with 1 being urban (over 50% of zip code is urban) and 0 other (C. Y. Johnson et al., 2004; Marquart-Pyatt, 2008). Expert knowledge is a dummy variable with 1 being employees from state/federal land management agencies and 0 general public. Length of residency is a dummy variable with 1 being long-term residents and 0 shorter-term residents. Smith and Krannich (2009) suggest using the last wave of population growth as the determinant for differentiating between long-term and shorter-term residents. In our case, a long-term resident is a respondent living in the area for 15 years or more.

3. Results

3.1 Perceived Importance of ES

The importance of individual ES varied among socio-demographic groups (Tables A-1A-1C). Regarding provisioning ES, liberals are 60% as likely to choose food production as an important ES relative to conservatives. Experts are 15% as likely to choose alternative energy relative to the general public. Increasing age increases the likelihood of respondents choosing freshwater provision as an important ES.

Table A-1A: Perceived importance of provisioning ecosystem services

Independent Variables	**Provisioning Services**		
	Food Production (n=207)	Alternative Energy (n=207)	Freshwater Provision (n=207)
Political Affiliation (S.E.)	**0.639*** (0.127)	1.202 (0.232)	0.769 (0.149)
Age (S.E.)	0.985 (0.010)	0.995 (0.010)	**1.021*** (0.010)
Gender (S.E.)	1.344 (0.409)	0.686 (0.209)	0.595 (0.180)
Income (S.E.)	0.877 (0.076)	1.102 (0.096)	1.018 (0.088)
Race (S.E.)	1.256 (0.640)	1.876 (0.929)	0.674 (0.357)
Long-term Resident (S.E.)	0.860 (0.269)	0.739 (0.230)	0.887 (0.275)
Education (S.E.)	1.271 (0.299)	0.835 (0.195)	1.250 (0.292)
Expert (S.E.)	0.418 (0.236)	**0.149**** (0.104)	0.721 (0.400)
Urban Resident (S.E.)	0.683 (0.207)	1.392 (0.421)	0.772 (0.232)
Constant (S.E.)	**7.390*** (6.502)	0.810 (0.697)	0.502 (0.429)
Adjusted R-squared	.0741	.0528	.0525

*p<.05

**p<.01

Table A-1B: Perceived importance of regulating ecosystem services

Independent Variables	Regulating Services				
	Climate Regulation (n=207)	Water Regulation (n=207)	Air Quality (n=207)	Water Quality (n=207)	Habitat for Species (n=207)
Political Affiliation (S.E.)	1.594 (0.447)	1.574 (0.415)	1.023 (0.202)	0.967 (0.187)	1.278 (0.250)
Age (S.E.)	1.005 (0.013)	0.998 (0.013)	0.994 (0.010)	1.005 (0.010)	1.005 (0.010)
Gender (S.E.)	0.683 (0.269)	0.793 (0.310)	**4.032******* (1.273)	1.051 (0.315)	**0.474*** (0.145)
Income (S.E.)	0.959 (0.111)	1.206 (0.138)	0.945 (0.084)	0.939 (0.081)	1.033 (0.090)
Race (S.E.)	0.445 (0.358)	0.599 (0.475)	0.930 (0.465)	0.978 (0.480)	**3.240*** (1.757)
Long-term Resident (S.E.)	1.617 (0.683)	1.065 (0.429)	1.213 (0.383)	1.370 (0.424)	1.485 (0.460)
Education (S.E.)	1.119 (0.349)	1.659 (0.505)	1.122 (0.269)	0.922 (0.213)	**0.618*** (0.147)
Expert (S.E.)	2.921 (1.712)	0.359 (0.261)	0.921 (0.514)	**3.872*** (2.119)	2.328 (1.298)
Urban Resident (S.E.)	1.314 (0.517)	1.046 (0.408)	0.971 (0.298)	1.445 (0.429)	1.089 (0.330)
Constant (S.E.)	**0.037**** (0.044)	**0.017**** (0.020)	0.363 (0.322)	0.510 (0.438)	1.083 (0.935)
Adjusted R-squared	.0697	.0514	.0791	0.0362	.0753

*p<.05
**p<.01
***p<.001

Table A-1C: Perceived importance of cultural ecosystem services

Independent Variables	Cultural Services		
	Recreation (n=207)	Local Identity (n=207)	Cultural Heritage (n=207)
Political Affiliation (S.E.)	1.104 (0.210)	0.980 (0.243)	0.737 (0.172)
Age (S.E.)	0.994 (0.010)	1.002 (0.013)	1.006 (0.012)
Gender (S.E.)	1.375 (0.410)	0.859 (0.327)	0.811 (0.304)
Income (S.E.)	1.059 (0.090)	0.928 (0.102)	1.019 (0.109)
Race (S.E.)	**0.358*** (0.182)	0.438 (0.343)	2.786 (1.509)
Long-term Resident (S.E.)	0.602 (0.184)	0.953 (0.372)	0.609 (0.231)
Education (S.E.)	0.813 (0.188)	0.875 (0.262)	0.872 (0.251)
Expert (S.E.)	2.115 (1.208)	1.298 (0.858)	0.536 (0.446)
Urban Resident (S.E.)	0.929 (0.277)	1.178 (0.447)	0.652 (0.250)
Constant (S.E.)	1.925 (1.637)	0.357 (0.391)	0.706 (0.739)
Adjusted R-squared	.0464	0.0123	.0492

*p<.05

Regarding regulating ES, air quality, water quality, and habitat for species are all significantly tied to socio-economic variables. Women are four times more likely to choose air quality, but 47% as likely to choose habitat for species relative to men. Non-white respondents are three times more likely to choose habitat for species relative to white respondents. Increasing education decreases the probability of respondents choosing habitat for species as an important ES. Experts are almost four times more likely to choose water quality relative to the general public.

There was only one association for cultural ES where non-white respondents are 36% as likely to choose recreation as an important ES relative to white respondents.

We identified significant differences among socio-demographic groups when aggregating ES rankings by categories: provisioning, regulating, and cultural (Table A-2). For example, experts and liberals perceive provisioning ES as less important than the general public and non-liberals, respectively. Liberals, long-term residents, and urban residents perceive regulating ES as more important than non-liberals, shorter-term residents, and non-urban residents, respectively. Expert knowledge has the largest coefficient related to regulating ES. Long-term residents are less likely to choose cultural ES relative to shorter-term residents.

Table A-2: Perceived importance of ecosystem services by categories

Independent Variables	**Provisioning Services (n=207)**	**Regulating Services (n=207)**	**Cultural Services (n=207)**
Political Affiliation (S.E.)	**-0.457*** (0.224)	**0.448*** (0.220)	-0.034 (0.175)
Age (S.E.)	0.002 (0.012)	-0.001 (0.011)	0.004 (0.009)
Gender (S.E.)	-0.641 (0.348)	0.515 (0.340)	0.080 (0.271)
Income (S.E.)	0.007 (0.100)	-0.029 (0.098)	0.029 (0.078)
Race (S.E.)	0.195 (0.574)	0.012 (0.562)	-0.290 (0.448)
Long-term Resident (S.E.)	-0.393 (0.356)	**0.831*** (0.349)	**-0.635*** (0.278)
Education (S.E.)	0.254 (0.269)	-0.194 (0.264)	-0.142 (0.210)
Expert (S.E.)	**-1.552*** (0.620)	**1.877**** (0.607)	0.487 (0.484)
Urban Resident (S.E.)	-0.522 (0.347)	**0.746*** (0.340)	-0.201 (0.271)
Constant (S.E.)	**5.194***** (0.996)	**2.354*** (0.975)	**2.481**** (0.777)
Adjusted R-squared	.0651	0.1070	-0.0026

*p<.05
**p<.01
***p<.001

Relative to conservatives, liberals place a higher importance on regulating services over provisioning services. In comparing individual ES we see, in particular, that liberals attribute more importance to climate regulation and habitat for species than conservatives. Conservatives attribute more importance to food production and both almost equally value alternative energy. Liberals and conservatives ranked recreation and local identity services similarly; however, conservatives attributed higher importance to cultural heritage.

Women placed lower overall value to provisioning ES than men. The largest difference is apparent in the ranking of freshwater provision, while food production and alternative energy are similarly ranked. Regulating and cultural ES were also ranked similarly with the exception of air quality which women ranked slightly higher.

Long-term residents place higher importance on regulating ES and lower importance on cultural ES. Long-term and shorter-term residents similarly ranked cultural heritage and local identity, but long-term residents attributed less importance to recreation. Long-term residents consistently ranked regulating ES higher than shorter-term residents.

Overall, experts attributed less importance to provisioning ES and placed higher value on regulating ES. In particular, experts placed lower value on food production and alternative energy and higher value on climate regulation, habitat for species, and water quality. Both experts and the general public attributed similar importance values to cultural ES excluding cultural heritage, which was often ranked lower by experts.

3.2 Perceived impacts of LULC to ES

Breaking down LULC impacts to ES by categories helps further elicit perceptions (Table A-3). Respondents with a higher education perceive urban land as having a more negative impact on provisioning ES (mean=-1.58) when compared to those with a high school education or less (mean=-0.42). Both women (mean=-8.11) and experts (mean=-11.51) perceive urban land as having a significant, negative impact to regulating ES.

Finally, the oldest age group does not attribute high positive impacts (mean=2.14) to cultural ES when compared to the youngest age group (mean=3.40).

Table A-3: Perceived impacts of urban land on ecosystem services

Independent Variables	Provisioning Services (n=207)	Regulating Services (n=207)	Cultural Services (n=207)
Political Affiliation (S.E.)	0.653 (0.454)	-0.777 (0.514)	-0.297 (0.590)
Age (S.E.)	-0.040 (0.023)	0.031 (0.026)	**-0.081**** (0.030)
Gender (S.E.)	-0.511 (0.703)	**-2.322**** (0.796)	1.786 (0.914)
Income (S.E.)	0.125 (0.203)	-0.325 (0.230)	0.210 (0.264)
Race (S.E.)	-0.756 (1.161)	0.630 (1.315)	-0.938 (1.509)
Long-term Resident (S.E.)	0.748 (0.721)	-0.285 (0.817)	-0.283 (0.938)
Education (S.E.)	**-1.150*** (0.545)	0.915 (0.617)	0.928 (0.708)
Expert (S.E.)	1.590 (1.255)	**-5.058***** (1.421)	1.624 (1.631)
Urban Resident (S.E.)	0.390 (0.703)	0.363 (0.796)	0.515 (0.914)
Constant (S.E.)	0.172 (2.015)	**-5.701*** (2.282)	4.433 (2.620)
Adjusted R-squared	0.0274	0.1098	0.037

*p<.05
**p<.01
***p<.001

There are significant differences between age groups in perceived impacts to provisioning ES from agriculture (Table A-4). Younger respondents perceived higher overall positive impacts (mean=5.52) while older respondents perceived lower positive impacts (mean=3.90). Both liberals (mean=-5.45) and experts (mean=-10.66) perceived higher, negative impacts than conservatives (mean=-0.69) and the general public (mean=-2.93). Lastly, urban residents (mean=1.00) perceived lower, positive impacts to cultural ES than non-urban residents (mean=1.72).

Table A-4: Perceived impacts of agricultural land on ecosystem services

Independent Variables	Provisioning Services (n=207)	Regulating Services (n=207)	Cultural Services (n=207)
Political Affiliation (S.E.)	-0.787 (0.482)	**-1.549*** (0.607)	0.301 (0.341)
Age (S.E.)	**-0.049*** (0.025)	-0.004 (0.031)	0.011 (0.017)
Gender (S.E.)	-1.041 (0.747)	0.783 (0.941)	0.163 (0.528)
Income (S.E.)	0.005 (0.215)	-0.297 (0.271)	0.153 (0.152)
Race (S.E.)	-2.089 (1.233)	-0.504 (1.553)	-0.374 (0.872)
Long-term Resident (S.E.)	1.283 (0.766)	0.297 (0.965)	-0.974 (0.542)
Education (S.E.)	-0.624 (0.579)	0.749 (0.729)	0.748 (0.409)
Expert (S.E.)	0.344 (1.332)	**-5.115**** (1.679)	-0.044 (0.943)
Urban Resident (S.E.)	0.892 (0.746)	-1.221 (0.941)	**-1.161*** (0.528)
Constant (S.E.)	9.790 (2.140)	-0.215 (2.696)	-0.410 (1.514)
Adjusted R-squared	0.038	0.0918	0.0386

***p<.05**

****p<.01**

4. Discussion

4.1 Relating the ESF to Social Science Literature

In relating the ESF to social science literature there have been some confirmed trends, but also some difficulty in establishing linkages between the two. Results were inconclusive regarding age, income, race, and level of education. However, income and education as independent variables tend to have inconclusive results or conflicting results between case studies.

Overall, results for women were similar to reviewed literature where they place higher values on locally-perceived ES such as air and water quality, and lower overall value on provisioning ES.

The length of residency results seem to support the growing argument that there is less of a divide between “newcomers” and longer-term residents. This may be due to longer-term residents having an increased awareness of the region and its environmental quality. There may also be a spatial component connected to residency length, where newcomers may be living in urban-suburban areas where there is a lower perception of issues related to regulating ES (e.g. water quality).

Political affiliation had the most consistent results when compared to reviewed social science literature. As a predictor of environmental concern, political affiliation is useful in that it's measuring an attitude or belief that is often linked with the environment. Interestingly, conservatives attributed greater importance to cultural ES (specifically, local identity and cultural heritage).

4.2 Applying Social Science Methods to the ESF

One explanation for inconclusive results is the nature of the ESF. We asked respondents to form on-the-spot opinions regarding their attitudes towards sometimes abstract concepts. For instance, we see more significant results in the provisioning and regulating categories which are largely easier to grasp. For instance, people are generally aware that freshwater and food are important parts of their lives. Some regulating ES are more recognizable as well, such as water quality (as opposed to water regulation) and habitat for species. Cultural ES are not often discussed in everyday life and may have been confusing topics to develop opinions about.

Another barrier to reaching conclusive results may stem from forcing respondents to rank only four of the 11 ES rather than all of them. In reviewing overall responses, it appears people often resorted to choosing direct or provisioning services out of necessity. While this method was intended to simplify and shorten response times it may have ultimately reduced the ability to accurately explore trade-offs between individual ES.