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Mapping Ecosystem Service Flows of Estuary Restoration Projects on the Oregon Coast to Identify Impacted Stakeholders

by

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A thesis submitted in partial fulfillment of the
requirements for the degree of

Master of Science
in
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Abstract

The recent impetus for estuarine restoration has largely focused on resolving key ecological problems; however, less is known about how people might benefit or be impacted by restoration. By mapping benefits that flow from functional salt marshes and estuarine systems I examined how different social groups might be impacted by restoration based on race and class. In this study, I considered three ecosystem services (recreation, aesthetics, cultural/historical/spiritual) and where they might impact surrounding communities. In this paper I argue that stakeholder groups can be identified by mapping ecosystem service flow areas. I hypothesized that these three ecosystem services would have different spatial distributions and therefore include different stakeholder groups. I also hypothesized that there would be significant differences in race and income between these groups with less racial diversity in the group impacted by aesthetic changes than in the other groups.

I mapped ecosystem service flows (areas impacted by ecosystem change beyond the restoration site); driving distance as a proxy for access to estuaries for recreation, viewshed as a proxy for aesthetics, and salmon habitat, essential to the Native Nations of the Pacific Northwest, as a proxy for cultural/historical/spiritual services. I then overlayed these spatial layers with US Census data to identify which communities might be impacted by ecosystem service changes from restoration initiatives. I looked for differences in race and class distributions in impacted populations to determine how restoration impacts are distributed. Populations impacted by estuary restoration were found to be majority White non-Hispanic, but with variation in rates of non-White populations for block groups within each ecosystem service area, especially when the Columbia River was included in the analysis. Race differences between ecosystem service areas were not determined to be significant by this study. Differences in household income between ecosystem service area groups were most notable between stakeholders within the driving time area and upstream salmon habitat area with the Columbia River included in the analysis. The comparison highlights the importance of considering changes for stakeholders impacted by one or more ecosystem service category. Mapping ecosystem services to gain a spatially explicit understanding of the benefits these ecosystems provide has valuable applications for stakeholder analysis and outreach for potential restoration projects.

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Chapter 1
Introduction

An estimated 50-70% of estuary area in the US has been developed or converted to other landcover types, resulting in a more than 90% loss of saltmarshes in some areas (Barbier et al., 2011; Brophy, 2019; Casagrande, 1997). Growing recognition of the importance of estuary wetlands in coastal ecosystems, and in social systems through their provision of ecosystem services, has led to increased interest in their conservation and restoration (Burger, 2002; D. K. Loomis & Paterson, 2014b; Shepard et al., 2011). With over half the world’s population living within 100 km of bays and estuaries (Burger, 2002), the management of coastal ecosystems involves a diverse set of stakeholders and rights holders with diverse interests (Ortner et al., 2014; Stephenson et al., 2014). Incorporating this diversity in the project planning process has been shown to improve outcomes for management and restoration projects by increasing public support for projects and reducing litigation (Aggestam, 2014; Culhane, 2013; Eskerod et al., 2015; Larson et al., 2013). While research shows that involving stakeholders is key, the process of identifying stakeholders often relies on stakeholder self-identification, snowball techniques, or outreach to organizations or previously organized groups (EPA, 2008; Freeman et al., 2010; Mathur et al., 2007). In this study I propose a method for identifying stakeholders through mapping ecosystem services that provides land managers with information about stakeholder’s location and which impacts they are most likely to experience. In addition, when combined with census data, this method can provide information about the demographics of stakeholder groups with implications for environmental justice in decision making processes.

As coastal land management planning should ideally include this diversity of stakeholders, it is useful to identify stakeholder groups by identifying groups impacted by ecosystem service changes from restoration. The concept of ecosystem services inherently links ecosystems with humans as the beneficiaries of goods and services originating from ecosystems (Costanza et al., 2017; D. K. Loomis & Paterson, 2014b). Mapping ecosystem services can be useful to inform land management and policy decisions, however maps of ecosystem services generally provide information regarding the areas where services originate (Vorstius & Spray, 2015; Zhang et al., 2017) and don't consider the impacts these services have on surrounding areas and populations. An alternate method employed to visualize the spatial reach of ecosystem services and populations affected involves mapping ecosystem service flows (Bagstad et al., 2014; Palomo et al., 2013). In this study I combine the use of census data to analyze populations based on race and class, a technique common in environmental justice studies, with the technique of ecosystem service flow mapping to identify stakeholders. By using the novel approach of mapping the flows of ecosystem services in combination with census data, we gain a better understanding of the populations impacted by the changes in flows of ecosystem services due to restoration projects.

In this paper I argue that stakeholder groups can be identified by mapping ecosystem service flow areas. Based on past work mapping ecosystem service flows and demand (Bagstad et al., 2014; Burkhard et al., 2014; Goldenberg et al., 2017) I hypothesized that on the Oregon coast the three mapped ecosystem services have different spatial distributions and therefore include different stakeholder groups. I also hypothesized that there was significant differences in race and income between these groups with less racial diversity in the group impacted by aesthetic changes from restoration than in the other defined stakeholder groups on the Oregon coast due to the area's history of settler colonialism and removal of Indigenous populations (Berg, 2007; Wilkinson, 2010).

In this study I used three ecosystem service 'scorecard' categories pertaining to coastal resource management: recreation, aesthetics, and cultural/historical/spiritual (D. K. Loomis & Paterson, 2014a) each of which can be traced through a distinct 'carrier network' (the transportation network of roads, line of sight, and stream networks) (Bagstad et al., 2014). Using driving distance, viewshed, and upstream salmon habitat respectively as proxies for these categories I mapped areas impacted through ecosystem service change due to estuary restoration projects on the Oregon coast. By mapping ecosystem service flows we can identify areas where people's values regarding restoration are likely to diverge based on the impacts they are subject to via their spatial relationship to restoration sites. In addition, we can gain information about the different stakeholder groups and population demographics that should be included in coastal management decisions by combining these mapped areas with census data.

Chapter 2

Background

Coastal management and estuaries

Wetlands management policy in the United States has come full circle as calls to ‘drain the swamp’ remain in the political lexicon but are contrary to today’s management goals that include ‘no net loss’ of wetland area, and increasing recognition of the many vital ecosystem services these areas provide (Barbier et al., 2011; Fretwell et al., 1996; Mitsch & Gosselink, 2010). Considering this increasing recognition, moves to restore wetland, and in particular estuary systems, are underway in the private and nonprofit sectors as well as at state and federal levels of government.

NOAA defines estuaries as areas where freshwater and salt water mix, often at the mouth of a river flowing into the sea, to create brackish water with salinity levels ranging from 35 parts per thousand common in sea water to 0.5 ppt farther upstream, depending on tidal influence (US Department of Commerce, n.d.). As estuaries harbor some of the most highly productive ecosystems (Mitsch & Gosselink, 2010), and have often afforded humans ease of transportation from the ocean inland, they have become population centers in many parts of the world. While providing people many benefits including food, natural materials, and harbors used for fishing and trade, estuaries have also been the sites of high levels ecosystem change, industrial development, and pollution due to human activities (Elkind, 2006; Fredrickson, 2013; Padawangi, 2012; Thrush, 2006). Estuaries encompass a variety of ecosystem types as well, ranging from submerged areas like eelgrass beds, to mud flats and high marsh areas formed through accumulation of sediment carried down rivers over time. Oregon has about 55,600 acres of estuary wetlands (Fretwell et al., 1996) with three major types of wetlands within estuaries: Tide Flats, Eel-grass bed wetlands, and Salt marshes (Kjelstrom & Williams, n.d.).

Despite interest in restoring estuary ecosystems, the difference between historic tidal estuary area and present estuary extent is significant with changes due to restoration minor compared to historic losses on the West coast of the US (Brophy, 2019; Sherman et al, 2019). Anthropogenic impacts to coastal ecosystems have changed how these systems function in significant ways (Fuss, 1999; Orr & Orr, 2005). As humans are dependent on many of the ecosystem functions and services of these environments, the restoration of these habitats has become a conservation and restoration focus for government agencies, as well as nonprofit and community groups.

Estuary Restoration

Estuary restoration projects broadly fall into two categories. They are either part of state or federally mandated mitigation plans or are voluntary, non-regulatory projects. Mitigation restoration projects seek to offset damages or estuary loss in other areas. Voluntary projects, on the other hand, are not regulated and can result in a gain of estuary ecosystem area. Increasing the number of voluntary estuary restoration projects has the potential for increases in ecosystem services from these highly productive ecosystems (Fuss, 1999).

Several factors contribute to the successful completion of an estuary restoration project. These include interest from those in control of the land (e.g., private landowners, tribes, and state or federal agencies), support in the form of funding, and often the successful acquisition of permits gained through state and federal permitting processes as defined by the National Environmental Protection Act (NEPA) that requires community input and approval. Community support is influenced by public perception of restoration projects and their effects on surrounding ecosystems and human populations (Root-Bernstein & Frascaroli, 2016; Yamashita, 2021).

Estuary restoration comprises a range of activities including reintroduction of tidal flows to diked or drained land, invasive species removal, revegetation with native plants, and modification of infrastructure (tide gates and culverts for example) to increase tidal influence and/or fish and wildlife access (*Oregon Watershed Restoration Tool*, n.d.). Restoration activities in turn affect ecosystem services provided by an area, services that are distributed through numerous systems with various spatial scales.

Ecosystem Services

The concept of ecosystem services has been explored a great deal since it gained widespread popularity after Constanza et al.'s article *The Value of the World's Ecosystem Services and Natural Capital* was published in *Nature* in 1997. Ecosystem services are generally described as the direct and indirect benefits that people gain from the environment (Costanza et al., 1997). The concept was originally intended to highlight the value of intact ecosystems given that economic market valuations of resource extraction places value only on the extracted resource, and any value loss from disturbance or destruction is considered as an externality (Costanza et al., 2017).

The concept of ecosystem services has been criticized for being overly anthropocentric (Gagnon Thompson & Barton, 1994; McCauley, 2006), an argument that

Costanza et al address by noting that the concept was meant to highlight the complexity of the interconnections of the world (Costanza et al., 2017). While a greater variety of connections are highlighted using this concept than when considering only ‘traditional’ economic transactions, these connections center on human use and benefit, a focus that defines the term anthropocentrism.

While Costanza et al. note that ecosystem services benefit people in non-market contexts that go unrecognized too often, Loomis takes a somewhat different view and discusses the ways that ecosystem services reflect society’s values (D. Loomis, 2005). Ecosystem goods and services inherently reflect values of society as the definitions of what constitutes a good or service arise from the ways that people interact with the ecosystem a good or service is derived from (D. Loomis, 2005). Loomis and Patterson note, in their discussion of coastal resource management plans, that ecosystem services are the desired benefits that can be derived from an ecosystem (D. K. Loomis & Paterson, 2014b).

A concept that compliments this thinking is that of mapping the demand (Burkhard et al., 2014; Wolff et al., 2015) or ‘flow’ of ecosystem services following carrier networks such as line of sight, hydrology, or transportation infrastructure (Bagstad et al., 2013, 2014). Mapping demand and flow are similar concepts as there must be demand for a service to flow to an area. Mapping ecosystem service flow is useful for making connections between services and the people that benefit from them. Ecosystem service flows have been mapped in a number of contexts that include outdoor recreation services in Europe (Palomo et al., 2013); cultural and provisioning services from protected natural areas in Spain (Palomo et al., 2013); carbon sequestration, sediment filtering, scenic viewsheds, open space proximity, and flood regulation in the Puget sound (Bagstad et al., 2014), and user defined benefits of local coastal environments in the UK (Burdon et al., 2019). Maps are produced either through participatory mapping exercises or modeling using available data as in this study. Wolff et al. note that the majority of studies on demand or flow of ecosystem services have taken place in Europe (Wolff et al., 2015), but despite Europe's lengthy coastlines, focus on coastal ecosystems has been sparce in this area of study.

A growing body of work has expanded the understanding of the ecosystem services provided by wetlands and estuaries (Barbier et al., 2011; Gilby et al., 2020; D. K. Loomis & Paterson, 2014b; Shepard et al., 2011). Functional estuarine systems provide many benefits to surrounding populations including water quality improvement from sediment filtering, wave action attenuation and coastal protection from flooding, habitat for numerous animals including aquatic and avian species, such as salmon in the Northwestern U.S., and aesthetic and recreational opportunities (Barbier et al., 2011; Shepard et al., 2011). There are many ecosystems service types and, as Loomis points out, management that optimizes all ecosystem services is not always possible. For example, managing coastal resources to increase access for recreationalists contradicts management for undisturbed wildlife habitat (D. Loomis, 2005). Sikor et al. discuss this concept in the context of the distributive justice issues as this tradeoff "highlights the significance of decisions about what kinds of services should be provided at what level and to whom" (Sikor, 2013, p. 188).

Projects that restore estuary wetland areas change the ecosystem services of the area and have numerous impacts on populations near the projects. Resorting tidal hydrology to a diked field decreases the value of the area for agriculture but increases other ecosystem services such as sediment filtering capacity and habitat for fish, wildlife, and native vegetation. These changes have a range of effects that can include the aesthetic, recreational, cultural, historical, and spiritual ecosystem services provided by an area. These impacts are not equally distributed spatially, and therefore affect human populations differently depending on spatial proximity. Mapping the ‘flow’ of these ecosystem service changes, therefore, can assist in identifying the interests of stakeholders based on the ways they are impacted, and can provide information about where stakeholders effected by restoration are located.

For this project I mapped the flow of three types of ecosystem service affected by estuary restoration on the Oregon coast: aesthetic services, recreation access, and cultural/historical/spiritual services represented by salmon presence. The three variables, used to define ecosystem service flows, were chosen due to their relevance to coastal management decisions. Ecosystem services have been grouped into categories using numerous organizing principles. Loomis & Paterson discuss a process of grouping ecosystem services into five overarching ‘scorecard’ categories for use in coastal land use management, policy, and planning (D. K. Loomis & Paterson, 2014a). These categories were the result of a process meant to produce “indicators that would capture changes in the delivery of overall ecosystem services impacted by, or that will impact, changes in particular sets of environmental characteristics” (D. K. Loomis & Paterson, 2014a, p. 65) in coastal restoration in the Everglades in Florida, and were meant to be broadly applicable to coastal restoration work. Referencing that framework, the three categories used for this project are recreation, cultural/historical/spiritual, and aesthetics as they are relevant to stakeholders and associated with ‘flow paths’ as seen in Bagstad et al.’s work (Bagstad et al., 2013). The three mapped variables used as proxies for these categories are viewshed, access to recreation via driving time, and salmon habitat upstream of restoration projects (Figure 1). These variables flow through three of the networks Bagstad et al. use in their Service Path Attribution Networks (SPANs) modeling of ecosystem service flows. As Bagstad et al. note, ecosystem services can flow through lines-of-sight, transportation networks, and stream networks (Bagstad et al., 2013).

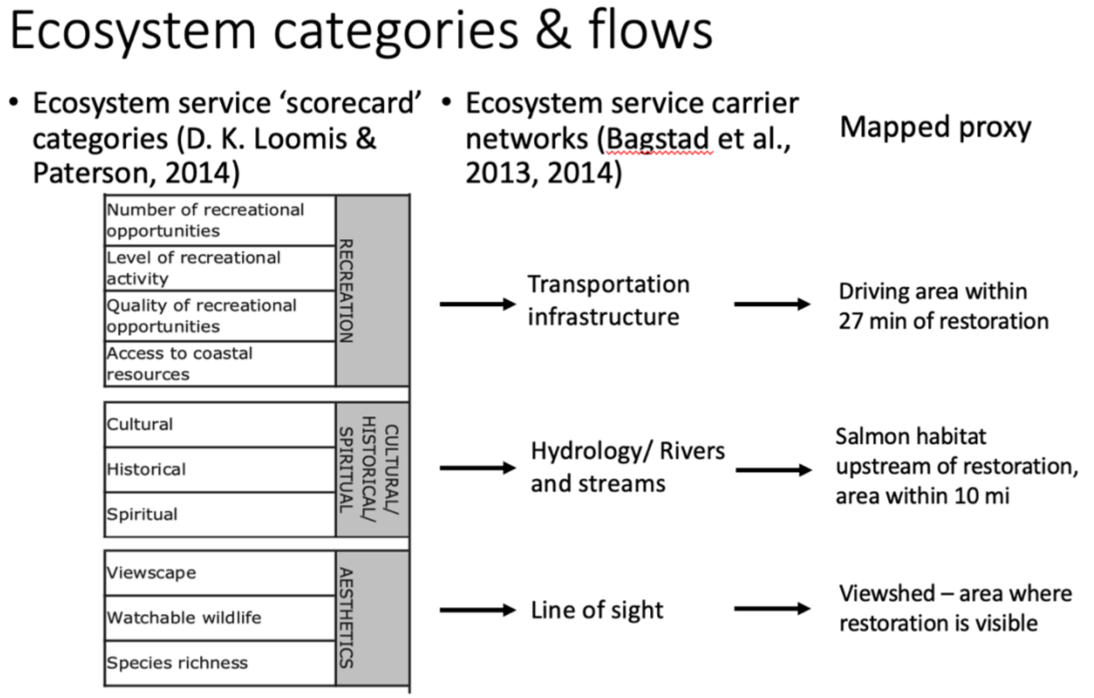


Figure 1. Conceptual model linking ecosystem service categories, ecosystem service flow through carrier networks, and mapped proxies for each ecosystem service category.

Aesthetics – Viewsheds

A viewshed is the area visible from a given point via an unobstructed line of site. In this study viewsheds for estuary restoration projects were mapped to create a multipart polygon representing the area where one or more restoration site is visible. Weinstein comments on the aesthetic value of estuaries, noting that there is often tension between satisfying the ecological and society-based goals of restoration (Weinstein, 2007).

While people have used raw materials from estuaries like grass for cattle fodder, that practice is less common on the west coast than in the past on the east coast (Casagrande, 1997). Rather than using saltmarsh grasses, the more common practice in the Northwest has been to dike and drain wetland area to create fields for agriculture and cattle grazing (Fuss, 1999; Orr & Orr, 2005). This trend has had significant consequences for vegetative cover, hydrology, and presence of fish and wildlife in these areas. These changes have impacted the visual and recreational ecosystem services provided by estuaries on the Oregon coast as well as energy and matter flows and other impacts to ecosystem function in the land and sea. Estuary restoration often includes reintroduction of tidal flows to diked or drained land. This restoration can occur along a spectrum from breaching or removing dikes to changing tide gate mechanics to enable more regular flows that promote historical hydrology as well as fish passage. Vegetation changes resulting from changes in hydrology (Figure 2) or from invasive species removal impacts the aesthetic quality of an estuary. Reintroduction of tidal flows also influences visible wildlife presence (birds, elk, and beavers for example). These aesthetic and wildlife changes impact surrounding human populations within the viewshed of a site. Hindsley et al. find that, for a given property, each degree of view of the Gulf of Mexico increased home prices in Pinellas County, Florida by an estimated $1300 (Hindsley et al., 2013). Similarly, home sale prices are positively related to area of forest visible with a 1% increase per acre of forest visible for homes near forest compared to those farther away, with both proximity and viewshed affecting both housing prices and a willingness to pay for forest restoration (Mueller et al., 2018; Poudyal et al., 2010). These studies indicate that homeowners value viewsheds of natural areas.

Literature on communities' opinions of the aesthetic changes from estuary restoration is sparce. It has been found that "people who have positive images of coastal wetlands" are more likely to support restoration projects (Yamashita, 2021, p. 138). However, Orr and Orr note that the creation of the first National Estuarine Research Reserve in Coos Bay, Oregon in 1974 was not embraced by all community members as Stella Whittick is quoted commenting that "My dad cleared all this land and now it's really a shame to watch it grow back over like it is" (Orr & Orr, 2005, p. 106).

Figure 2. Lower Drift Creek in Alsea Bay, Oregon. Meandering channels and brown vegetation are visible indications of the reintroduction of tidal influence. Photo courtesy of Paul Engelmeyer.

Recreation – Access via Driving distance

Recreational activities in Oregon’s estuaries include birdwatching, kayaking, fishing, hunting, and gathering activities such as oyster and clam digging. Estuary restoration has been shown to increase availability of these activities through increases in fish and avian populations (Yamashita, 2021), and changes in the social perception of the value and safety of an estuary (Coleman et al., 2009). While tourism plays a role on Oregon’s coast, local recreational access is the focus in this study as residents are more consistently impacted by changes to ecosystem services than visitors. Access to outdoor water or ‘blue space’ for recreation have been examined in terms of cultural and economic impacts and benefits (Haeffner et al., 2017; Kim & Nicholls, 2016; Laatikainen et al., 2017; Ruiz-Frau et al., 2013). In their study of “accessibility of popular recreation environments by the water,” Laatikainen et al. (2017) use public participation GIS to investigate service area thresholds and modes of transport in the Metropolitan Area of Helsinki, Finland. Their findings, that walking and driving were the most common modes of access with a median driving time of 27 minutes for accessing natural areas, were used in this study to inform the service area threshold used.

Cultural/historical/spiritual – salmon in stream networks

As anadromous fish, salmonids travel from inland stream reaches to the ocean before returning upstream to spawn, therefore stream networks equate to salmon habitat for significant portions of their lifecycle. Salmon are an especially important factor in restoration work in the Northwest as the fish are an important part of the economics of the Northwest as well as being a cultural keystone species for numerous Northeast Tribes

(Garibaldi & Turner, 2004; Moss, 2016). Garibaldi & Turner comment that cultural keystone species are “plants and animals that form the contextual underpinnings of a culture” as they have fundamental roles in the material and spiritual life of a group (Garibaldi & Turner, 2004). They further note that “obvious examples [of cultural keystone species] include western red-cedar and salmon for Pacific Northwest Coast peoples” (Garibaldi & Turner, 2004).

As Dan Bottom notes in his discussion of salmon lifecycle habits, estuaries were not understood to be an integral part of salmonid’s lifecycle until the 1990s, and were in fact considered a bottleneck that fish were barged past (Evan Hayduk, 2018). Closer study of salmon lifecycle revealed the key part that estuary habitats play in both the acclimatization of juvenile fish to salt water, and the adaptation of some juveniles to stay in these estuary environments for longer than others, a variation in habit that serves to diversify the lifecycle pattern of the species which protects fish from environmental threats (Fresh et al., 2005; Lundrigan et al., 2004). Juvenile salmon benefit from estuary habitat on their way out to sea as they need food, places to hide from predators, and places to rest and acclimatize to saline water as they travel out to sea (Brophy, 1999; Evan Hayduk, 2018; Fresh et al., 2005). Increased survival rates of young fish have impacts on fish stocks in rivers and streams upstream from estuaries as adult fish return to spawn in subsequent years. Restoration of estuarine systems has been shown to produce an increase in juvenile salmon populations utilizing the estuary within the first 2 to 3 years of restoration (Gray et al., 2002), and as early as the first year after additional estuary habitat became available (Ellings et al., 2016). Increases in estuary area and available marsh channels from restoration have direct implications for salmon populations upstream. Salmon habitat upstream of restoration projects is used as a proxy for the category of cultural/historical/spiritual ecosystem services in this project.

Northwest Indigenous History

Native people, designated by the U.S. census as ‘American Indian and Alaskan Natives,’ have seen drastic change in their populations’ spatial distribution with varying levels of force and violence since the arrival of European settlers. Thrush discusses Native populations’ struggles to maintain traditional territory and food gathering practices as settler populations drastically changed the landscape to build the city of Seattle (Thrush, 2006). Thrush (2006) tells the story of Native people in the Puget Sound area between the 1880s and 1930s as urbanization deprived them of land and livelihoods. He challenges the common historical perspective (and settler myth making) that urban Seattle and Indigenous narratives are separate and incompatible, and instead pieces together a picture of this period of history that highlights Native people’s continued presence despite often violent removal from land they traditionally occupied. Thrush writes that "along the lakes, rivers, and shores of Seattle, environmental inequality was literally built into the city's new watersheds, and its legacies resonate down to the present day" (Thrush, 2006, p. 96). He points out that this recognition of Native People's history in the Puget Sound area is often missing from narratives of its urban development and notes that the ecological destruction from landscape engineering by settlers should be linked to loss of traditional culture and food gathering for Indigenous people. While Thrush does not use the term environmental justice, the history lesson provided by his paper identifies the roots of the current calls for environmental justice by Puget Sound's Indigenous groups.

Wilkinson traces a similar narrative regarding the history of Native peoples of the Oregon coast as Native groups were forced to move off traditional lands to reservations defined by the U.S. federal government (Wilkinson, 2010). The Oregon historical society notes that "the Coast Indian Reservation (later called the Siletz Reservation), created in 1855, encompassed the entire west side of the central Coast Range, covering more than a million acres from Cape Lookout to the mouth of the Siltcoos River" (*Acquiring Reservation Land*, n.d.) (Figure 3). These reservations were subsequently whittled down through a combination of the U.S. federal government's failure to honor or defend treaty obligations, court rulings, and state political machinations (*Acquiring Reservation Land*, n.d.; Wilkinson, 2010) (Figure 4). The federal process of termination in the 1950s moved Indigenous populations to urban centers and attempted to disband the reservation system in the U.S (Gilio-Whitaker, 2019; Wilkinson, 2010). In conjunction with earlier failures to honor treaties this left Native populations with little control over land management decisions on Oregon's coast. Subsequent land management has led to the current situation, where restoration of estuary ecosystems is recognized as key to preserving or enhancing these ecosystems and the availability of the ecosystem services they provide. This history provides context for the hypothesis in this study that racial diversity would differ between areas defined by different ecosystem service flows, with less racial diversity expected in the group impacted by aesthetic changes from restoration than in the other defined stakeholder groups.

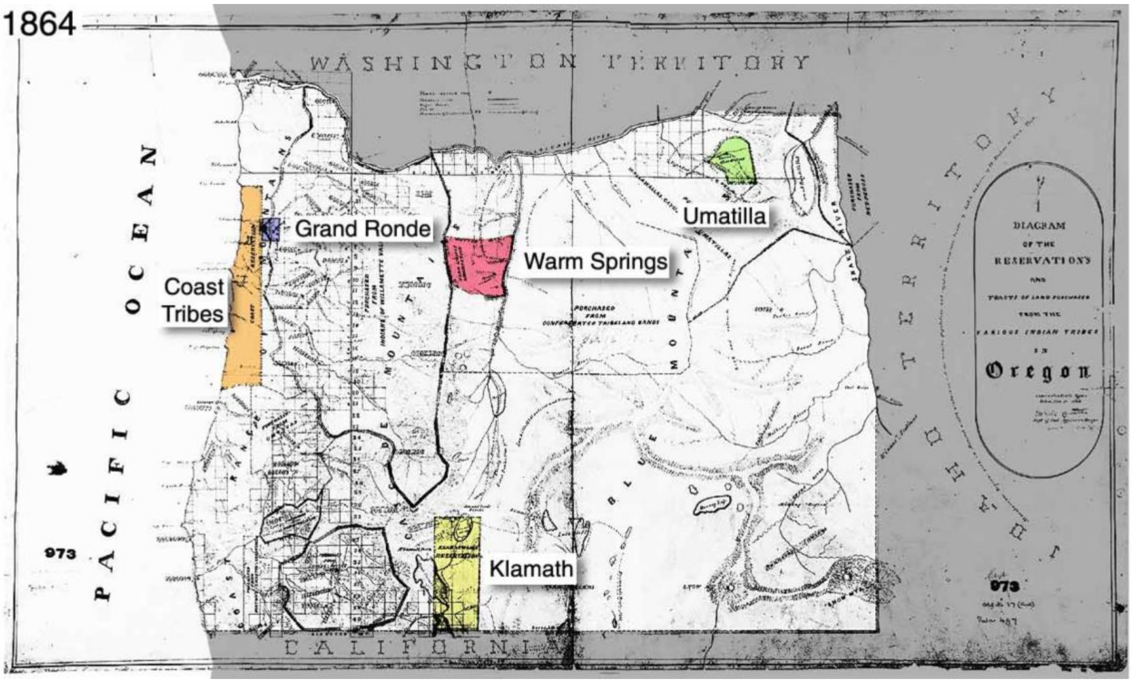


Figure 3. Map of Native reservations in Oregon in 1864 as defined by federal treaties. (*Native Lands and Reservations, Maps*, n.d.)

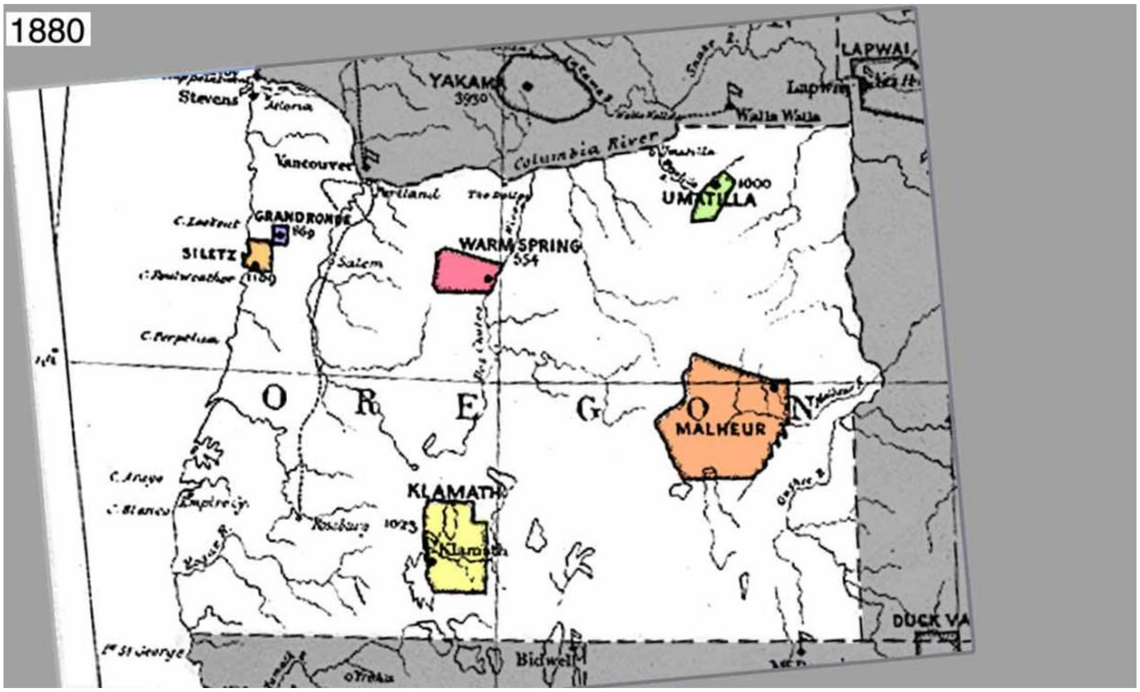


Figure 4. Map of Native reservations in Oregon in 1880 as redefined by federal treaties. (*Native Lands and Reservations, Maps*, n.d.)

Chapter 3

Environmental Justice - Race and Income Demographics

Defining areas where ecosystem services flow, by definition, indicates that there is a population experiencing these services. By combining flow of three types of ecosystem service affected by estuary restoration with census data, we can gain an understanding of the demographics of the population impacted by ecosystem service changes. As this is a study of distributive justice, race and income were analyzed in relation to ecosystem service flow areas for estuary restoration projects to answer the question, are restoration impacts disproportionately distributed by race or income? Race and income are commonly studied when investigating issues of social and environmental justice (Bullard, 2000; Douglas et al., 2012; Hardy et al., 2017; Mohai, 1995). While the environmental justice movement gained momentum in the 1970s and 80s in the US as a response unequal distribution of human caused environmental hazards (Bullard, 2000; Chaudhary et al., 2018), the roots of the injustices that leave people of color and low income citizens disproportionality impacted by negative effects of their surrounding environment are intertwined with the social and economic formation of the U.S (Isenberg, 2017; Wilkerson, 2010).

Redlining, segregation, and other forms of race and class discrimination have shaped the spatial distribution of population in the US. Environmental factors have often played a role in these forms of discrimination as in the case of many of the broken treaties with Native groups in the US that were disregarded due to settler perceptions of land value and desirable natural resources (Gilio-Whitaker, 2019; Wilkinson, 2010). In addition, based on the resulting spatial demographic patterns, the siting of environmental hazards and benefits have been distributed in ways that disproportionally impact populations based on race and income (Bullard, 2000; Graham et al., 1999).

Environmental justice is often discussed in terms of three related dimensions of justice: distribution justice, procedural justice, and recognition justice. Distribution justice is an issue in cases where negative impacts fall more heavily on people of color and low income populations, and where positive impacts are disproportionately unavailable to those same populations. Sikor notes that "distributive justice is about the distribution of environmental goods and bads between different people, such as access to clean water or exposure to air pollution" (Sikor, 2013, p. 7). Toxic dump sites (Bullard, 2000) and coke plants and oil refineries (Graham et al., 1999) have been found to disproportionally impact communities of people of color, while environmental amenities such safe parks for youth in Denver, CO (Rigolon, 2017) and large parks in Baltimore, MA (Boone et al., 2009) are more accessible to higher income, white residents.

Procedural justice refers to the fairness of the process of decision making and policy creation (Bell & Carrick, 2017). Also referred to as participation justice, this term considers how decisions are made and who is included in the process (Sikor, 2013). The 'who' and 'how' of environmental policy and land management decision making have direct consequences the distribution of environmental 'goods and bads' as seem the process of siting a landfill in Switzerland (Hunold & Young, 1998) and permitting for strip mining in Appalachia (Leciejewski & Perkins, 2015).

Environmental justice is discussed with several variations in definition as some authors narrowly define the distributive aspects of the term (Stallworthy, 2006) while others expand to include procedural and recognition justice. The move to extend the term to include procedural justice is prevalent in several studies that conclude that early inclusion of communities effected by environmental issues would create more just solutions and pave the way for greater acceptance during future implementation processes (Douglas et al., 2012; Eskerod et al., 2015; Fredrickson, 2013; Hardy et al., 2017). Padawangi (2012) takes this a step further to investigate spatial justice as she explores the implications of the ways that communities construct space for themselves. Her discussion voices a key component of several other studies clearly when she notes that that top-down solutions often force people to trade environmental problems for socio-economic problems. This dynamic can be seen in case studies of situations where 'solutions' are offered from above including those by Hardy et al. (2017), Douglas et al. (2012), Fredrickson (2013), and Elkind (2006).

Another facet of environmental justice is recognition justice which involves recognition of the histories and distinct cultural identities of groups and individuals and criticism of the power imbalances between groups that have led to cultural domination some groups over others (Sikor, 2013). Recognition justice is an important part of the environmental justice conversation in the US and internationally as "calls for recognition have been at the core of indigenous peoples' mobilizations" (Sikor, 2013, p. 7). The history of Indigenous people's conflicts with European settlers and subsequent removal from ancestral lands in the U.S. coupled with the lack of acknowledgement of this history by many American institutions directly relates to the concept of recognition justice (Gilio-Whitaker, 2019).

The EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* includes a chapter on outreach and stakeholder engagement that notes the importance of including stakeholders in the process of planning restoration and other watershed management projects (EPA, 2008). This document concurs with work in the field of stake holder theory that defines all individuals impacted as potential stakeholders (EPA, 2008; Freeman et al., 2010). Determining where people are impacted and who they are via demographics therefore has valuable applications for stakeholder analysis and outreach for potential restoration projects both from an equity perspective, and for improved chances of public acceptance of projects.

Chapter 4
Methods

The three ecosystem service flows examined in this study are expected to differ spatially. Therefore, the question of who is impacted is expected to differ depending on which type of impact is considered. This lands to the question, who is impacted by estuary restoration activities on the Oregon coast? To answer this question, I mapped three types of ecosystem services affected by estuary restoration projects on the Oregon coast to assess the differences in distribution and identify areas where stakeholder perceptions of restoration are influenced by one or more types of ecosystem service change. Using this information, I overlay these spatial layers with US Census data to identify which communities might be impacted by ecosystem service changes from restoration initiatives to answer the question, for each impact what is the race and income distribution of stakeholder block groups? I then look for differences in race and class distributions in affected populations to determine how restoration impacts are distributed with the intent of answering the question, do the distributions of race and income of the block groups of stakeholders vary among the three different types of restoration-related services examined? I hypothesize that there will be more racial diversity in areas impacted by upstream salmon habitat than in viewshed or driving distance for recreational access due to the history of the removal of Native populations from the coast.

Data

Using data from the Oregon Watershed Restoration Inventory (OWRI) database that includes projects from 1995-2020, I located projects designated as estuary restoration in Oregon (*Oregon Explorer Topics | Oregonexplorer | Oregon State University*, n.d.). This resulted in 50 mapped locations representing 43 projects with the treatment activity type listed as 'Estuarine' in the OWRI database. Several projects are represented using more than one map feature (point, line, or polygon) as spatial differences between restoration activities for a single project were mapped accordingly. These 50 sites were represented using a combination of point, line, and polygon features. Additional data sets used included a digital elevation model for the state of Oregon, the Oregon fish habitat distribution database from Oregon Department of Fish and Wildlife, and U.S. Census data from 2010, 2019, and 2020 (Table 1).

Table 1. Data sets used for spatial and demographic analysis of ecosystem service flows of estuary restoration projects on the Oregon coast and population demographics of impacted census block groups.

Data Source	**Dataset collected**	**Time period**	**Raw data**
Oregon Watershed Restoration Inventory (OWRI) (*Oregon Watershed Restoration Tool*, n.d.)	Geospatial and database records of Oregon watershed restoration projects	1995-2020	21,028 point features, 17,908 line features, 3,571 polygon features
Oregon Department of Forestry (*Oregon Spatial Data Library*, n.d.)	10 m Digital elevation model	2008	Raster file
ODFW (*ODFW - ODFW Data Clearinghouse*, n.d.)	Oregon Fish Habitat Distribution database	1996-2020	Geodatabase with 14 species specific datasets
US Census ACS 5 year	Race and household income by census block group	2015-2019	2,634 Block groups
US Census	TIGER/line shapefiles for census blocks	2010	196,621 blocks
US Census	TIGER/line shapefiles for census blocks	2020	130,807 blocks

Ecosystem Service flow areas defined

For this study all 43 estuary restoration projects were assumed to change aesthetics, recreation, and historical/spiritual/cultural (salmon populations upstream) ecosystem services provided by the project sites. An assessment of the treatment descriptions for each project show that 97% of the projects (42 projects) had an impact on site aesthetics, 97% of the projects (42 projects) impacted recreation opportunities at the site, and 79% of the projects (34 projects) impacted salmon habitat (Appendix A). This last category may be an underestimate as 8 projects listed estuarine vegetation planting or estuarine invasive plant control as treatments and were assumed not to have impacts on salmon populations due to lack of specific information about vegetation types planted, and the fact that impacts on juvenile salmon from invasive species in estuary settings are tentative and inconclusive (Klopfenstein, R., 2016).

The area where estuary restoration projects were assumed to have changed visible aesthetics was mapped by defining the viewshed for the set of projects. I converted projects mapped with polygon and line features to centroid points and combined the 50 sites into one dataset represented using point features. I used this dataset to perform a viewshed analysis using the viewshed tool in ArcGIS Pro version 2.9.0 combined with a 10-meter resolution digital elevation model (DEM) clipped to cover the Oregon coast and Cascade mountain range from the Oregon Geospatial Enterprise Office (*Oregon Spatial Data Library*, n.d.).

Access to estuaries via road networks was used as a proxy for recreational availability to surrounding populations in this study. It was assumed in this analysis that restoration work at all sites impacted recreational opportunities for populations within a driving time area. 27 minutes was used based on Laatikainen et al.'s findings regarding median travel time to recreation areas by the water (Laatikainen et al., 2017). To define areas where recreation access was impacted by estuary restoration projects, I created an isochrone map of areas within a 27-minute drive from the restoration sites. This analysis used the ArcGIS pro 'generate service areas' tool with road travel towards the sites which were represented using points.

Areas impacted by changes in salmon populations from estuary restoration projects were defined by selecting stream segments that salmon inhabit upstream of restoration sites. Data on fish habitat was downloaded from the Oregon Department of Fish and Wildlife's (ODFW) Oregon Fish Habitat Distribution database (collected from 1996-2020) (*ODFW - ODFW Data Clearinghouse*, n.d.). I combined habitat data for fall and spring Chinook, Chum, Coho, Sockeye, and summer and winter Steelhead, and filtered out stream segments listed as 'historical' which do not currently support salmon populations. I selected stream segments upstream of estuary restoration projects represented using point, line, and polygon features. Two versions of this selection were created to refine the analysis; one that included segments and tributaries of the Columbia River in Oregon, and one that excluded the Columbia River. The decision to create this alternative selection was based on the large difference between including and excluding the Columbia River, and therefore the Willamette valley, where most of the Oregon's population resides. Analyzing upstream salmon habitat with and without the Columbia River allowed for a better understanding of the area and population impacted on Oregon's coast where most of the projects take place. Two of the 50 mapped locations are in the Columbia River estuary. Both stream segment selections (with and without the

Columbia River) were then converted to areas by creating a 10-mile buffer. The determination to use 10 miles as the area impacted was based on a study of recreational catfishing in Texas where survey respondents indicated that they were twice as likely to fish close to home (defined as within 10 miles) than further away (Hunt & Hutt, 2010; Villamagna et al., 2014).

The resulting polygon features for viewshed, driving time, and upstream salmon habitat with and without the Columbia River were then clipped to represent only areas where block level population counts were greater than zero in both the 2010 and 2020 U.S. Census data. This last step ensured that mapped areas represent ecosystem service flows to populations. When mapping ecosystem service flows, I assumed that restoration locations are visibly changed by restoration, restoration sites are accessible by the public, and that restoration activities at all sites have impacts on upstream salmonids. Mapping and analysis were performed using ArcGIS Pro version 2.9.0.

Demographic analysis

In order to assess race and class variables of populations impacted by changes in these ecosystem services due to estuary restoration I combined census data with the defined ecosystem service areas. I accessed census data from the American Community Survey (ACS) 5-year estimates from 2015-2019 using the R package tidycensus. As of 2019 there were 2,634 block groups in Oregon. Block group level data for race and household income was aggregated using R version 4.1.1 into race and ethnicity categories

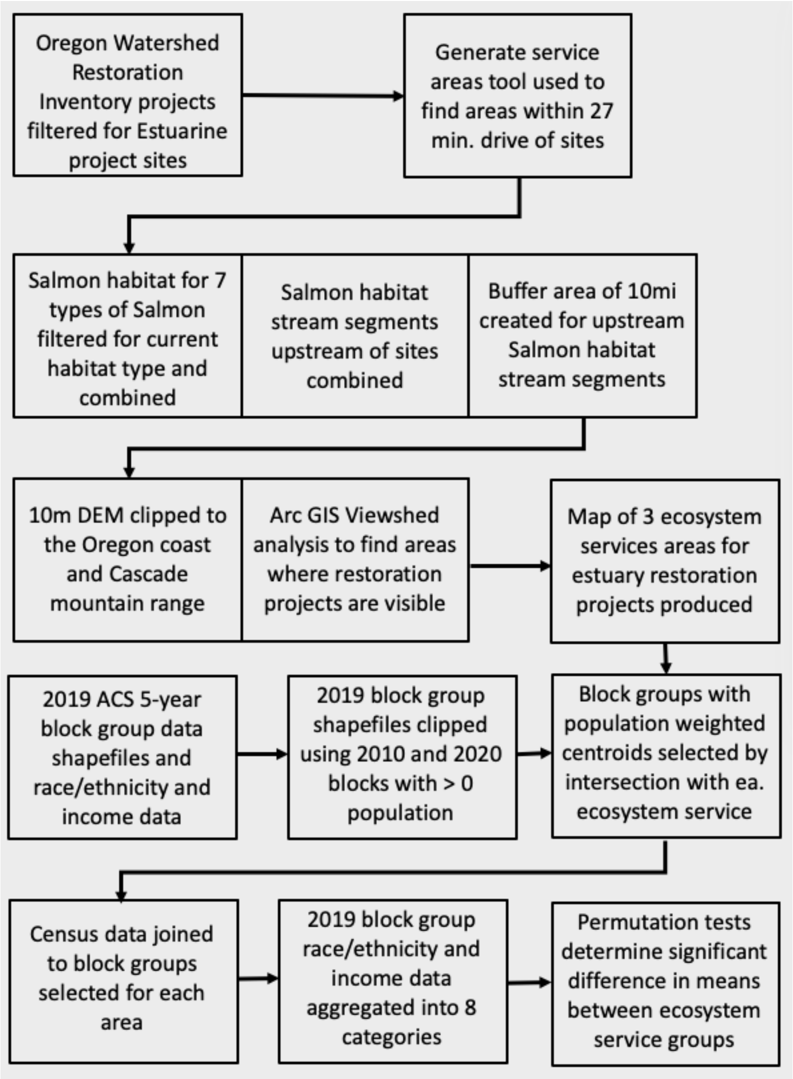


Figure 5. Workflow of to define ecosystem service flow areas and analyze demographics for each category of the three ecosystem service areas.

of White (non-Hispanic), Hispanic, and All other races (non- Hispanic). Household income was aggregated to create household income categories of \$0-\$24,999, \$25,000-\$49,999, \$50,000-\$74,999, \$75,000-\$99,999, and \$100,000 or more. This method of aggregation follows the method used by Haeffner et al. (2017). To normalize data among block groups of different populations, counts for each category were converted to a percent of the population. Then subsets of block groups were selected using the three ecosystem service areas.

As the income data from the 2020 census was not available, the 2019 ACS 5-year estimates were used for this study. ACS 5 year estimates are derived from surveys over a period of 5 years, provide more precise data than 1 or 3 year estimates, and are preferable for analyzing small populations or sub-groups (U.S. Census Bureau, n.d.). As much of the study area is rural with small populations and even smaller racial subgroups, the ACS 5-year estimates are appropriate for the study.

Census data from the ACS uses block groups as the finest resolution available. Block groups are generally composed of a minimum of 600 people with a maximum of 3,000 people (*Block Groups for the 2020 Census-Final Criteria*, 2018). The spatial implications of this are that block group areas vary according to population density with rural block groups often much larger to incorporate the minimum population than in urban areas of high population density. Decennial census data, in contrast, includes a finer scale of block level data. Blocks are more evenly sized as there is no minimum population designated, and many blocks have a population of zero.

To refine the process of selecting block groups with population impacted by each ecosystem service area, block group areas were modified to exclude areas that had populations of zero in both the 2010 and 2020 census (*2010 TIGER/Line® Shapefiles*, n.d.; *2020 TIGER/Line® Shapefiles*, n.d.). Block level data for the 2010 and 2020 census was filtered to exclude blocks with a population of 0, and the two sets of were combined into a multipart polygon layer. This polygon was then used to clip the 2019 ACS 5-year block group areas to exclude areas with no population. The reduced block group areas were then used to create centroid points within each block group. The three ecosystem service areas were then used to select centroid points that intersected with the area to create sets of block groups for each area. The centroid points for block groups within the viewshed area of restoration projects are mostly within 4 miles of projects except for two block groups that were approximately 11 miles away.

These sets were then exported and analyzed using R version 4.1.1. Block group sets for viewshed (n=16), driving distance (n=157), upstream salmon habitat (n=288), and upstream salmon habitat including the Columbia River and its tributaries (n=2,093) were joined with the 2019 ACS 5-year estimate data for race and income. The race and income data for each set were then analyzed using the independence test from the R *coin* package (version 1.4-2) to determine statistical differences in race and household income bracket between block group sets for each ecosystem service category. Block group sets with a p-value less than the alpha value of .05 were then evaluated using the post-hoc pairwise Permutation Test from the *rcompanion* R package (version 2.4.15) to determine which sets were significantly different from each other. Statistical significance is reported at the 95% confidence interval (p-values < 0.05).

Comparison between groups to determine statistical difference is a common method to investigate distributive environmental justice issues. Bullard's work for United Church of Christ (UCC) includes results from his study of the demographics of communities with toxic waste disposal sites with t-tests used for comparison (Bullard, 2000; Bullard et al., 2007). Other studies have investigated access to urban waterways or 'blue spaces' using t-tests, Pearson's Chi-Square tests, and ANOVA tests (Haeffner et al., 2017), access to forest benefits in Nepal using descriptive statistics and Chi-Square tests (Chaudhary et al., 2018), exposure to air pollution from highways in New York city (Jacobson et al., 2005). Permutation tests are the appropriate choice in this instance for comparing groups as the ANOVA and Kruskal-Wallis tests both assume independence between samples. As block groups can be included in more than one ecosystem service flow area due to ecosystem service area overlap this assumption is not met for this data. A block group that is within a 27-minute driving distance of a restoration project can also be within 10 miles of upstream salmon habitat for example. In addition, permutation tests have been used in studies by Klein in assessing transportation project impacts in an environmental justice framework in Philadelphia neighborhoods (Klein, 2007), and by Suárez et al. in their study of access to outdoor recreation opportunities in Oslo, Norway which used principle component analyses (PCA), RDA, and Monte Carlo permutation tests (Suárez et al., 2020).

Permutation testing is a non-parametric test that combines data from all study groups, imitating the null hypothesis that the groups do not differ, and randomly resamples this population to determine the likelihood the composition of the sample groups is a random occurrence. As the independence test from the R *coin* package is an asymptotic test rather than a full permutation of all possible combinations, and due to the fact that one block group can be present in more than one ecosystem service area, the test uses the replacement aspect of bootstrapping when resampling for permutations as well. The assumptions of this test are that the samples are exchangeable i.e. directly comparable in that they are the same kind of measurement, and that there is stationarity in the sample (LaFleur & Greevy, 2009). As values for all groups in this study are derived from the same set (2019 ACS 5-year census data), these assumptions are met.

Census data is the most comprehensive dataset available for studying the US population. However, it is important to acknowledge that ACS data are estimates with margins of error deemed acceptable for publication by the US census bureau. While it was anticipated that data from the 2020 census would be available for this research, delays in publication due to factors that include the COVID-19 pandemic resulted in unavailability of income data. It also bears noting that the census bureau acknowledged overcounting of non-Hispanic Whites and undercounting of “Black or African American population, the American Indian or Alaska Native population living on a reservation, the Hispanic or Latino population, and people who reported being of Some Other Race” (US Census Bureau, n.d.) occurred during the 2020 census with the Director of the bureau noting that the “2020 Census undercounted many of the same population groups we have historically undercounted” (US Census Bureau, n.d.).

Chapter 5
Results

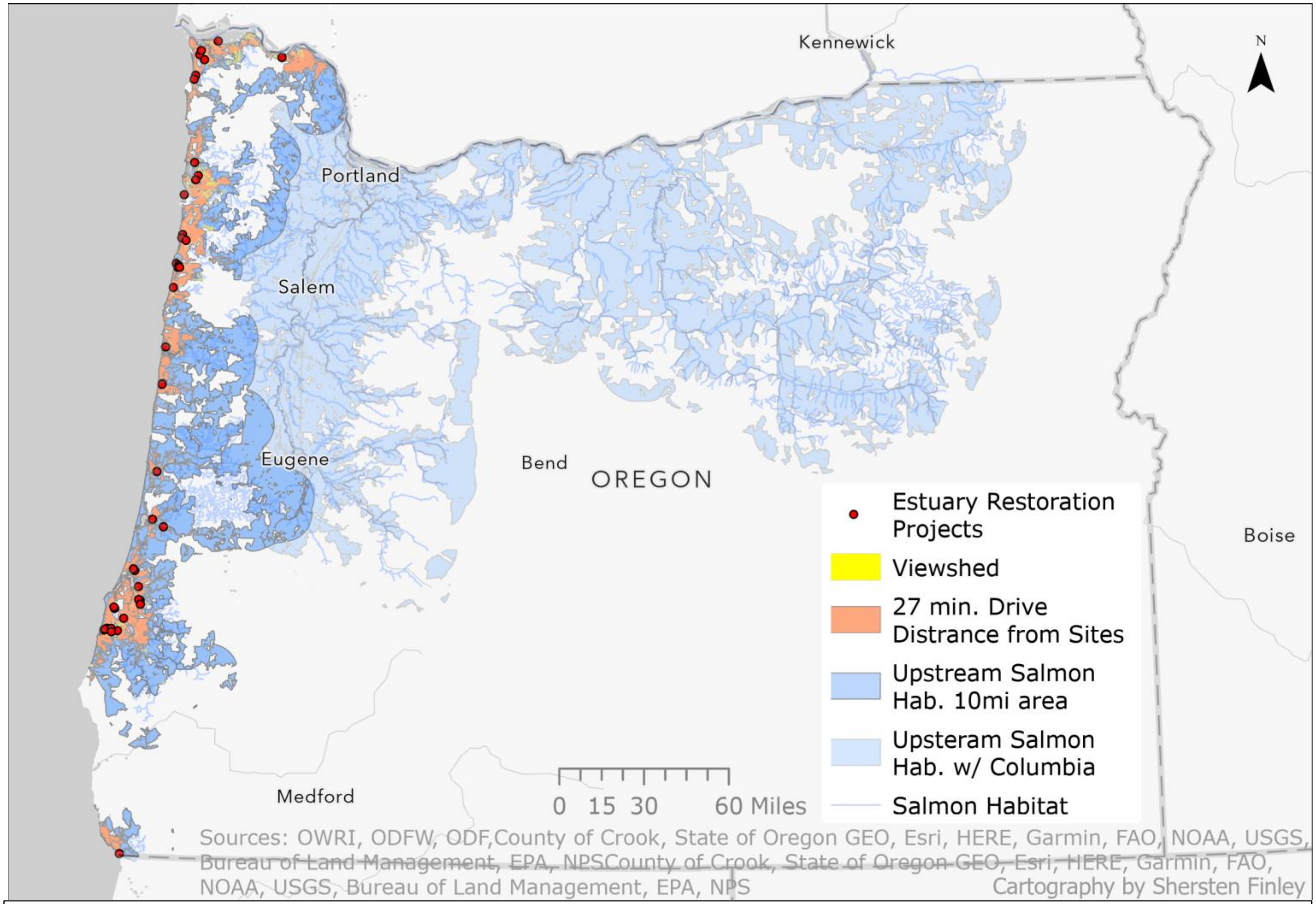
Ecosystem service flow areas

The maps generated (Figure 6 & 7) show the variation between areas impacted by the three categories of ecosystem service and aid in answering the question of who is impacted by estuary restoration activities on the Oregon coast. The viewshed for these restoration projects is relatively small compared to the area covered by driving distance, and much smaller than the reach of impacted upstream salmon habitat with or without the Columbia River as most of the stream networks east of the Oregon Coast Range are upstream of estuary restoration projects. Viewshed area for all projects combined totals 120 square miles (31280 ha).

Viewsheds for restoration projects are mostly made up of multiple small areas reflecting the rugged terrain of the coast range that contributes to Oregon’s rocky coastline. Many of the restoration projects are in more rugged terrain, thus creating smaller more fragmented viewsheds. Flat areas at the mouths of rivers tend to be occupied by urban areas and human infrastructure. For example, in Coos Bay on the south coast (Figure 7), the cities of Coos Bay and North Bend are located on relatively flat peninsula to the south of the river, an area where the viewshed would be a larger contiguous area were there restoration projects located there. In more rugged terrain such as the Salmon River estuary there is relatively little human infrastructure and multiple restoration projects have taken place.

Mapping recreation access via road networks reveals that most of the urban areas on the coast are within a 27-minute drive of an estuary restoration site except for Port Orford and Gold Beach on the south coast. Area within a 27-minute drive of an estuary restoration site totals 1,177 square miles (304,860 ha). While visiting preference and frequency of access are also part of the equation when discussing recreational access, the increased area within a relatively short drive from these sites indicates that the stakeholders included in this area are a larger group than those in the viewshed area.

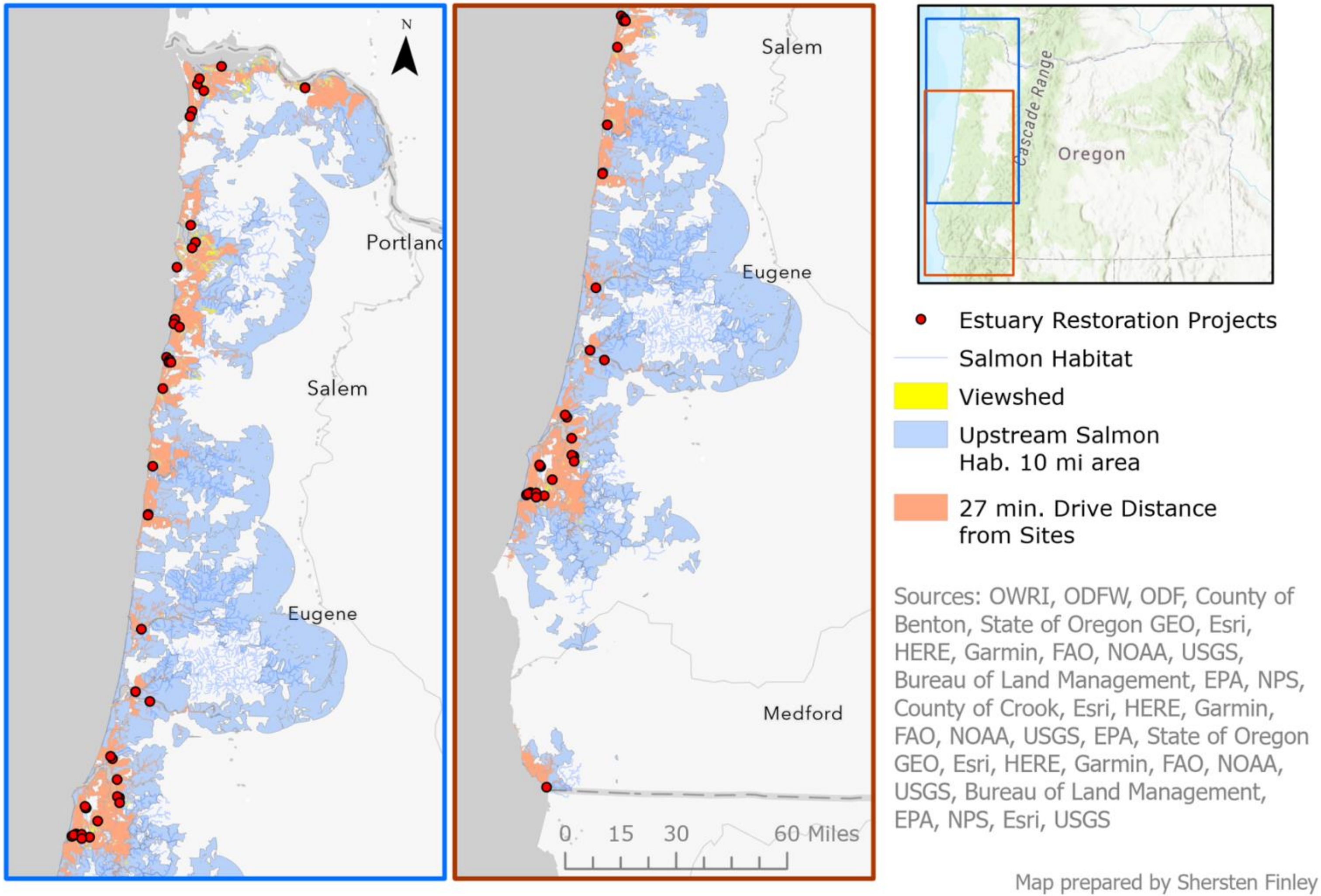
The area covered by upstream salmon habitat area without the Columbia River is 5,628 square miles (1,457,846 ha) while upstream salmon habitat area with the Columbia River is 21,582 square miles (5,589,761 ha). The importance of estuary ecosystems to salmon populations means that the impacts of restoration affect fish populations far inland where these fishes’ current ranges reach. Restoration in the Columbia estuary has the most far-reaching effects in this large river system, but smaller watersheds up and down the coast are also affected by restoration activities.



Sources: OWRI, ODFW, ODF,County of Crook, State of Oregon GEO, Esri, HERE, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPSCounty of Crook, State of Oregon GEO, Esri, HERE, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPS

Cartography by Shersten Finley

Figure 6. Ecosystem service flow areas for viewshed, driving time (isochrone map), and upstream salmon habitat with and without the Columbia River for estuary restoration projects on the Oregon coast.



Sources: OWRI, ODFW, ODF, County of Benton, State of Oregon GEO, Esri, HERE, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPS, County of Crook, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, State of Oregon GEO, Esri, HERE, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPS, Esri, USGS

Map prepared by Shersten Finley

Figure 7. Detail maps of the North and South coast with areas for viewshed, drive time, and upstream salmon habitat without the Columbia River shown.

Demographic analysis by Race and Class

Using the mapped ecosystem service flow areas (Figures 6 & 7), each ecosystem service flow area was used to select the set of intersecting block groups representing impacted populations. Block group sets for viewshed (n=16), driving distance (n=157), upstream salmon habitat (n=288), and upstream salmon habitat including the Columbia River and its tributaries (n=2,093) were selected. Race and income data for these sets of block groups were summarized using boxplots to answer the question, for each impact what is the race and income distribution of stakeholder block groups? Permutation tests were then used to compare mean values for the set of block groups for each ecosystem service area to answer the question, do the distributions of race and income of the block groups of stakeholders vary among the three different types of restoration-related services examined?

Race

When excluding the Columbia River from the analysis all three ecosystem service areas had high mean percent White non-Hispanic populations with 85.52% for viewshed, 85.02% for driving time, and 86.43% for upstream salmon habitat (Figures 8, 9 & 10). As the data was converted to percentages for comparison, the mean percent of Hispanic/Latino and all other races combined are predictably small. Mean percent Hispanic population is 7.55% and for all other races 6.92% for block groups within the viewshed area of restoration projects. Drive time area shows slightly more diversity with 8.19% Hispanic population but 6.74% all other races. Upstream salmon habitat area, though larger than the other areas, is the least diverse with 6.97% Hispanic population and 6.6% all other races. While the non-white mean percent population is quite low for all three areas, it is important to note that both driving time and upstream salmon habitat areas contain block groups with much higher levels of diversity. Permutation tests comparing race/ethnicity between the block group sets for viewshed, driving time, and upstream salmon habitat area without the Columbia River did not detect any significant difference between the groups (Figures 8, 9, & 10).

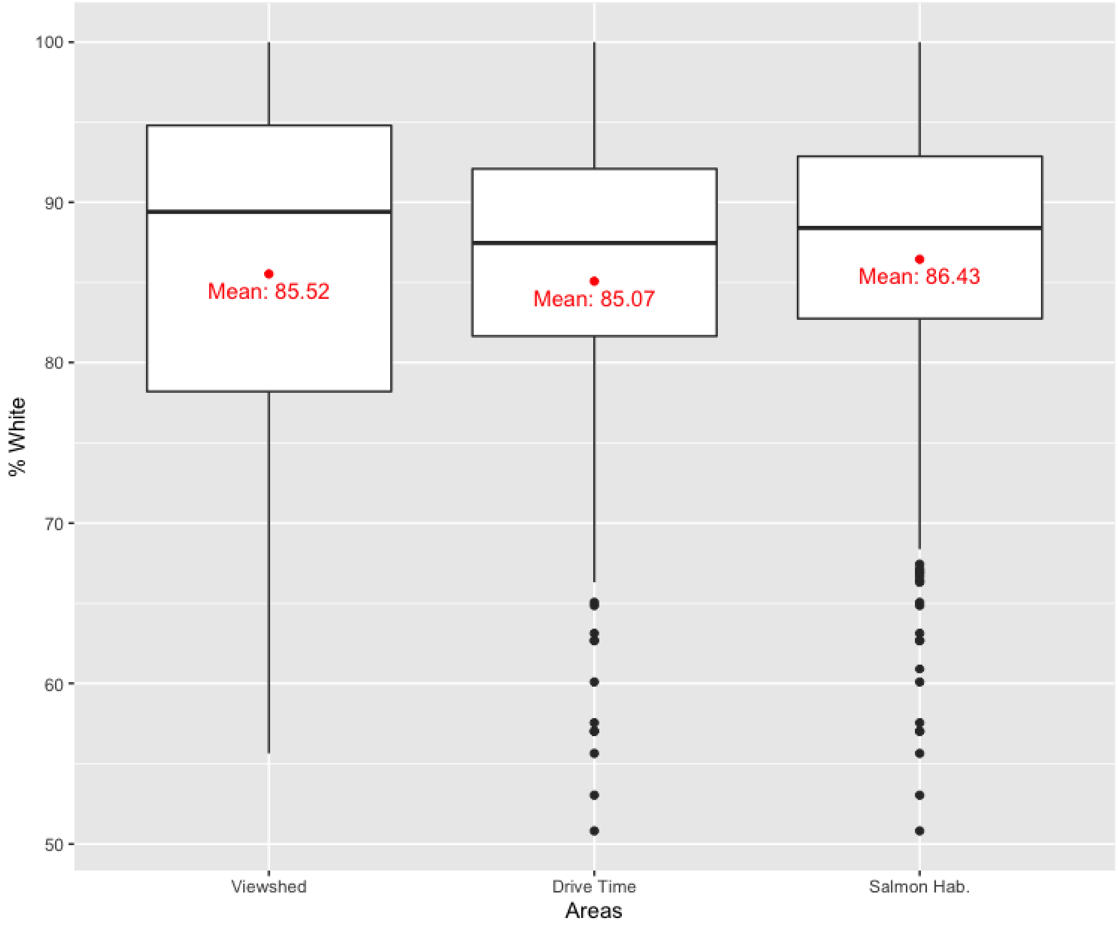


Figure 8. Distribution of percent White non-Hispanic population for each ecosystem service area excluding the Columbia River.

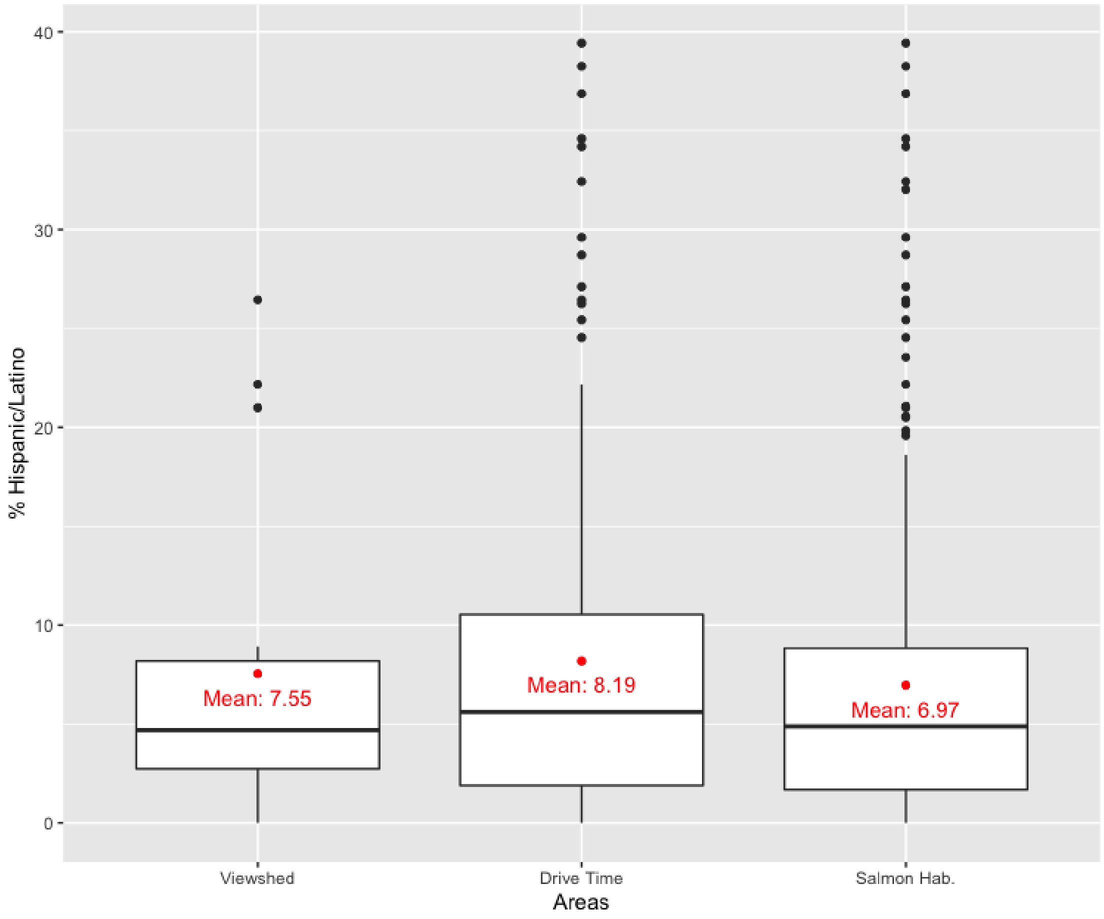


Figure 9. Distribution of percent Hispanic/Latino population for each ecosystem service area excluding the Columbia River.

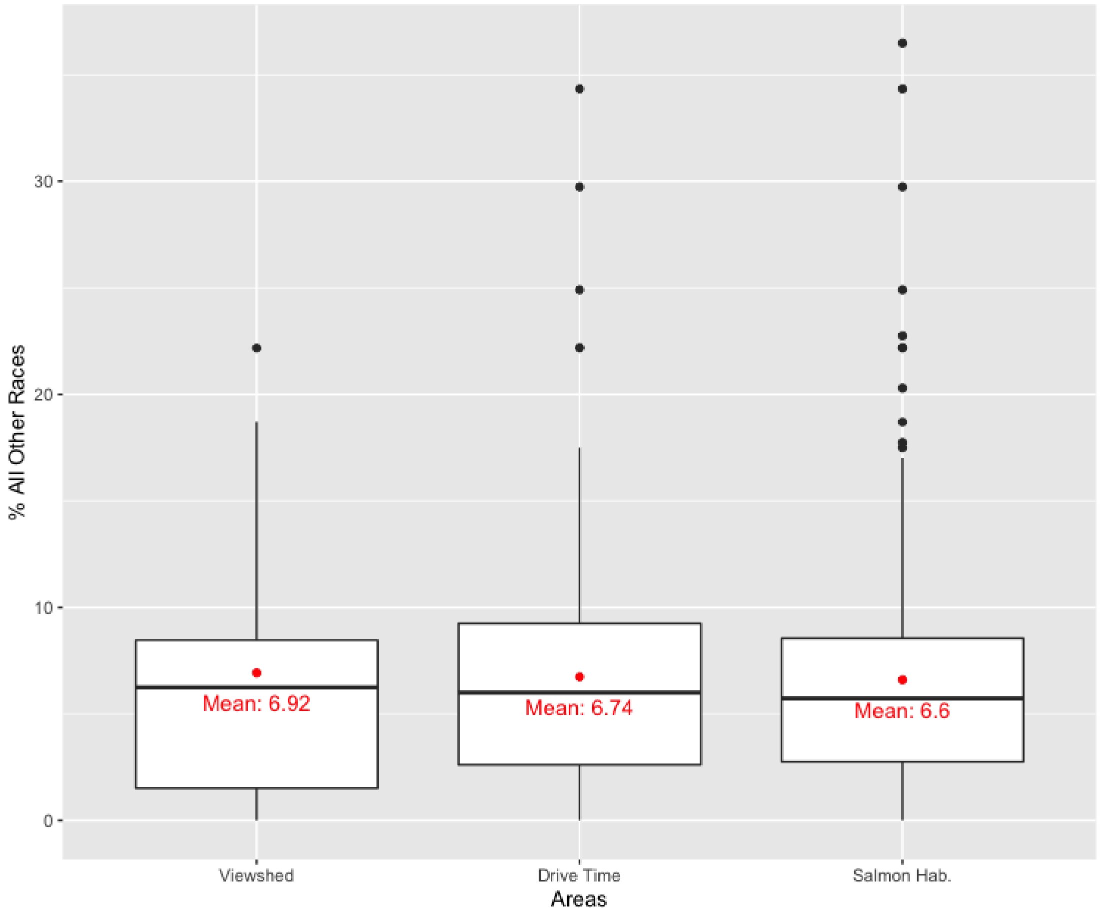


Figure 10. Distribution of percent all other races population for each ecosystem service area excluding the Columbia River.

When the Columbia River is included in the upstream salmon habitat area the race/ethnicity picture changes somewhat with the inclusion of block groups in the urban centers of the Willamette valley. This larger salmon habitat area has a mean White non-Hispanic population of 76.1%, mean Hispanic/Latino population of 12.43%, and mean population of all other races of 11.47% (Figures 11, 12, & 13). Permutation tests comparing race/ethnicity between the block group sets for viewshed, driving time, and upstream salmon habitat area with the Columbia River show significant differences between viewshed and salmon habitat (p-value <0.05), and between driving time and salmon habitat (p-value <0.0001). In addition, significant difference was found between driving time and upstream salmon habitat for both Hispanic (p-value <0.0001) and all other populations (p-value <0.0001) when the Columbia River was included (Figures 11, 12, & 13).

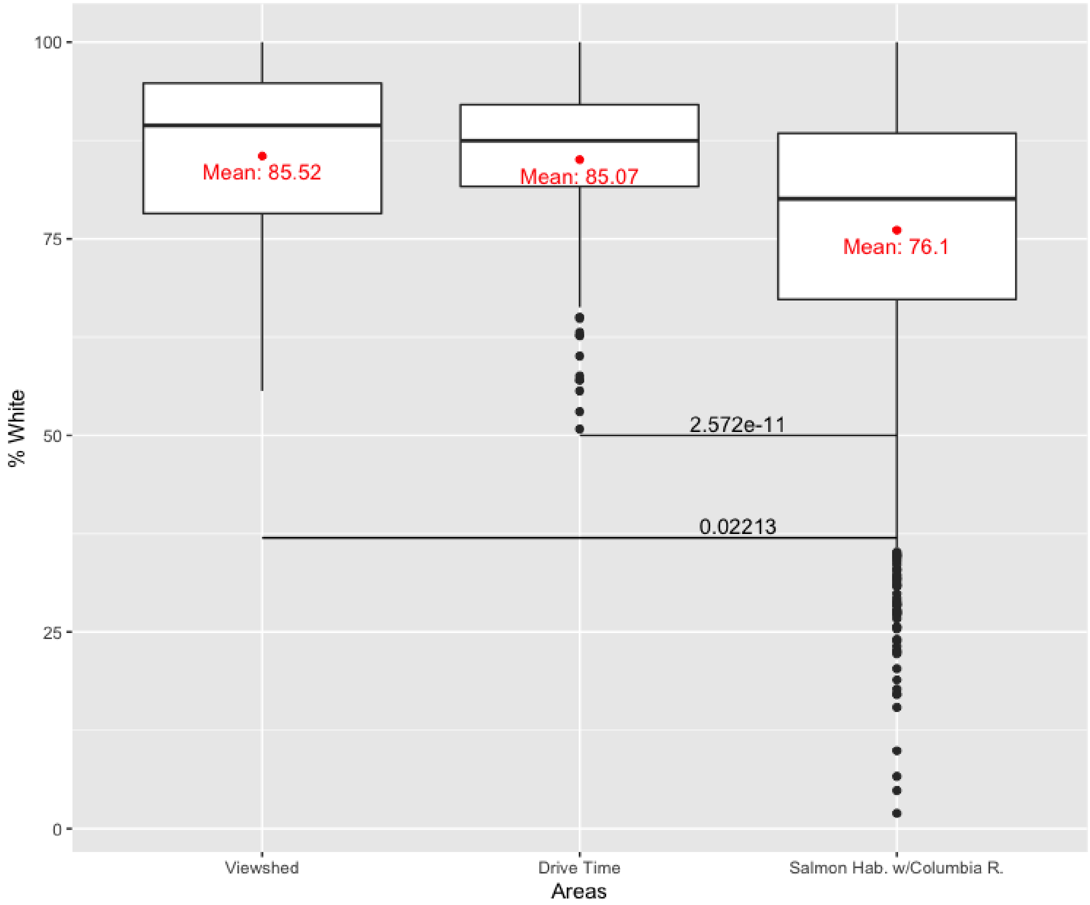


Figure 11. Plot of percent White non-Hispanic population by ecosystem service area with statistically significant differences between areas indicated by horizontal lines with pairwise permutation test p-value.

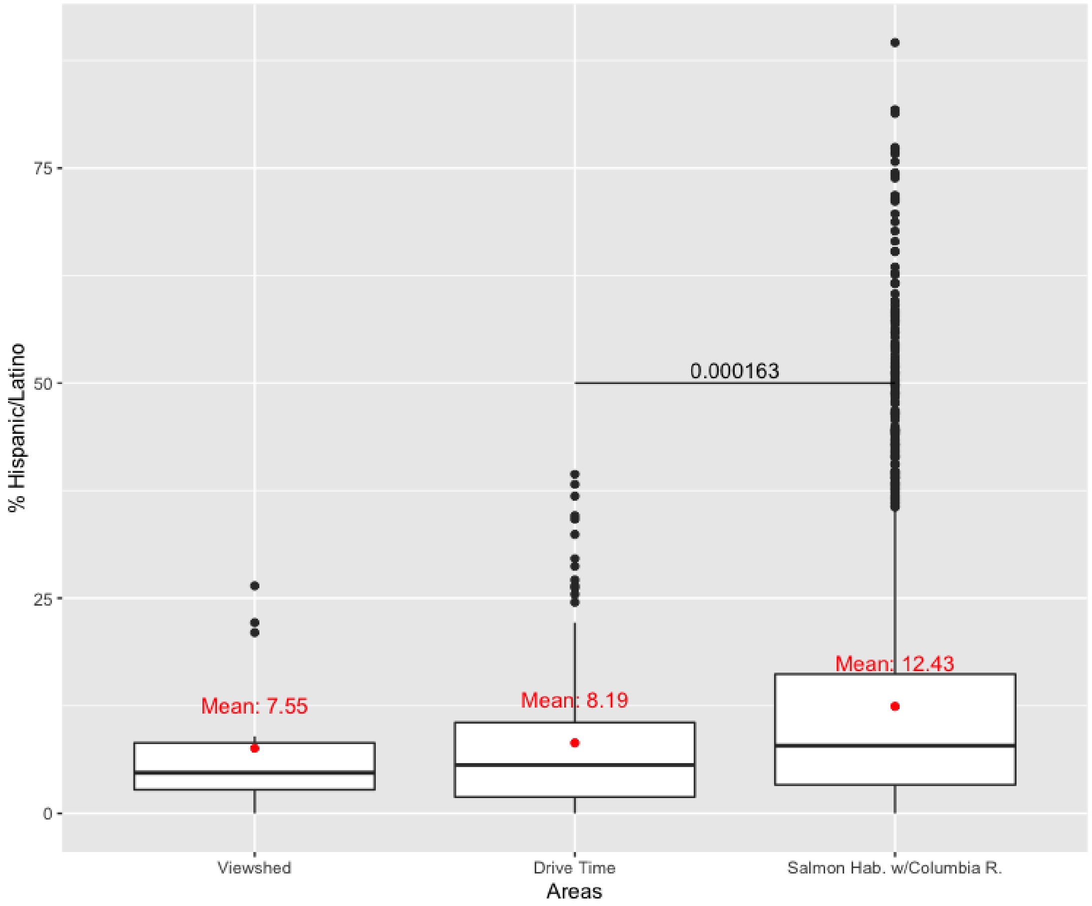


Figure 12. Plot of percent Hispanic population by ecosystem service area with statistically significant differences between areas indicated by horizontal lines with pairwise permutation test p-value.

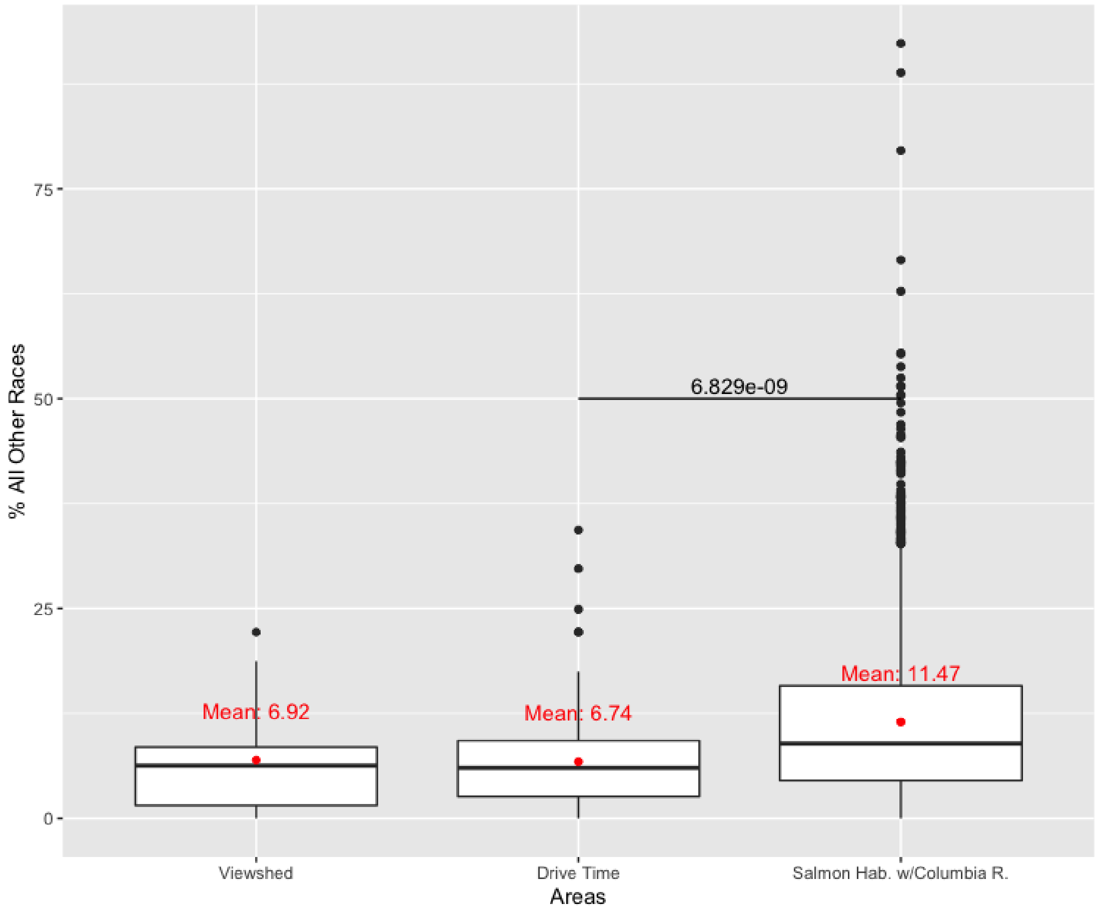


Figure 13. Plot of percent all other races population by ecosystem service area with statistically significant differences between areas indicated by horizontal lines with pairwise permutation test p-value.

Income – Without the Columbia River

The household income distributions for ecosystem service areas excluding the Columbia River show a general trend of more households at the mid to lower end of the spectrum than in high income brackets (Figures 14-18). Over a quarter of the households in the Viewshed area fall within the $25,000 - $49,999 income bracket (26.98%) with almost half the households with incomes of less than $49,999 (Table 2). The Driving time area shows a similar pattern with just over half the households with incomes less than $49,999 (Table 2). Upstream salmon habitat has slightly fewer households with incomes of less than $49,999, and the largest percent of households with incomes over $100,000 of the three areas (Table 2). Income distributions also show a more consistent pattern than race/ethnicity data with fewer outliers seen in the distributions (Figures 14-18). Permutation tests did not detect any significant difference between ecosystem service areas for income except for the higher mean percent of households earning $100,000 or more in the upstream salmon habitat area (20.26%) than in the driving distance area (17.26%) (p-value <0.01).

Table 2. Mean percent household income by ecosystem service area with significance indicated with *.

Mean % Household Income	Viewshed	Drive time	Upstream Salmon Hab.
0$ - $24,999	21.96%	23.95%	22.15%
$25K - $49,999	26.98%	26.48%	25.21%
$50K - $74,999	19.81%	20.05%	19.53%
$75K - $99,999	15.04%	12.26%	12.85%
$100K plus	16.2%	17.26%*	20.26%*

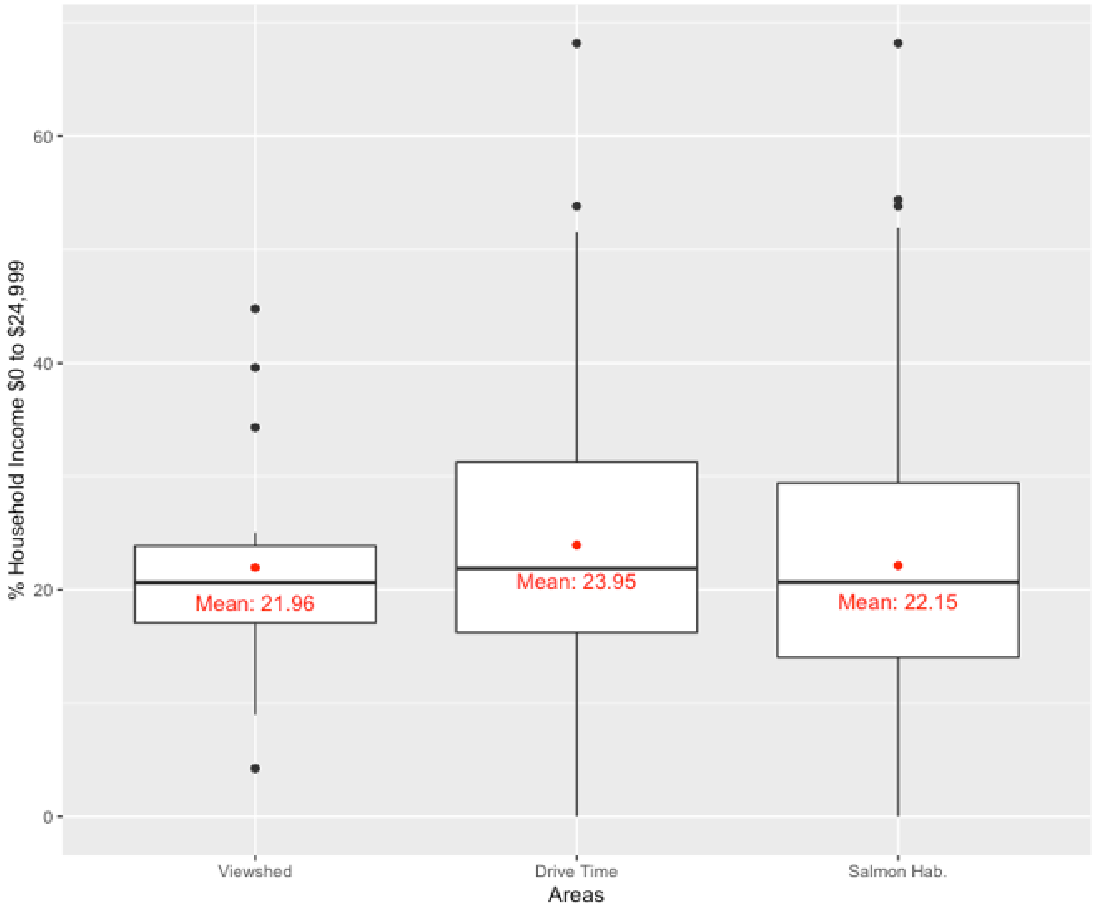


Figure 14. Boxplot of percent of households with incomes of $0 to $24,999 by ecosystem service area excluding the Columbia River.

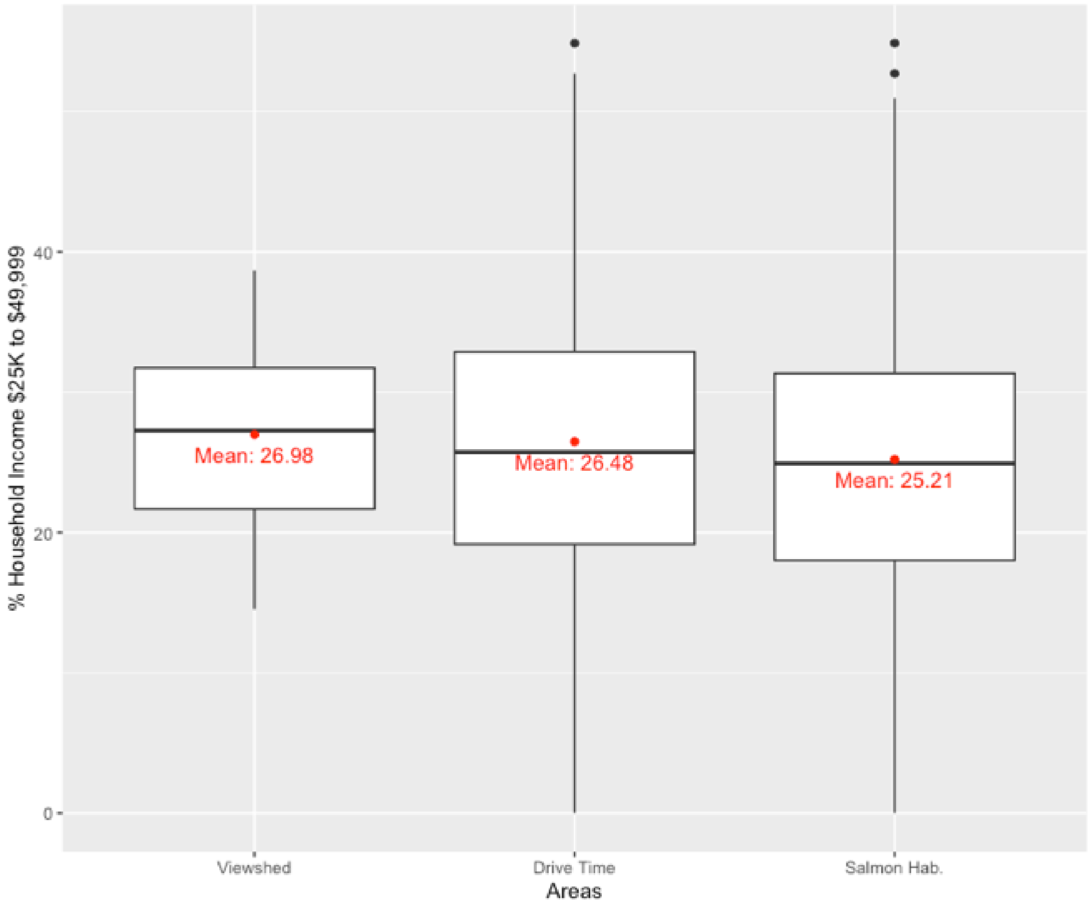


Figure 15. Boxplot of percent of households with incomes of $25,000 to $49,999 by ecosystem service area excluding the Columbia River.

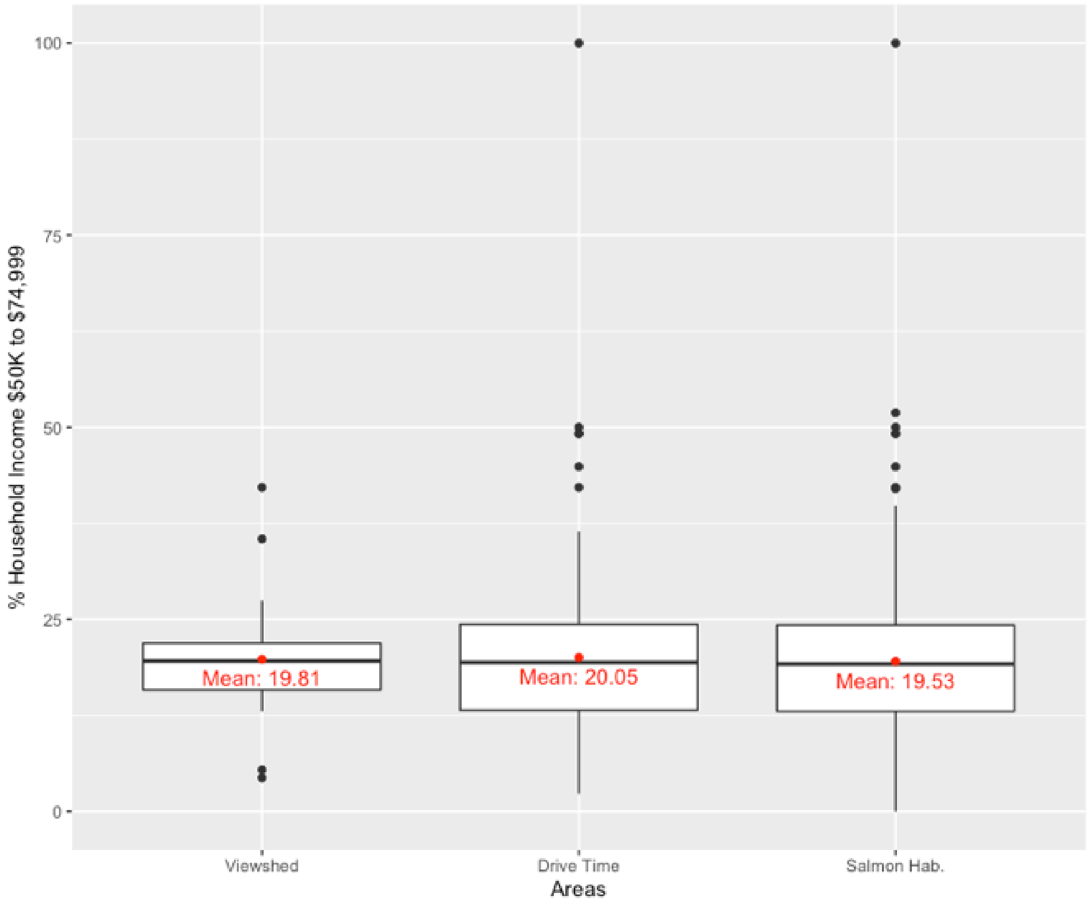


Figure 16. Boxplot of percent of households with incomes of $50,000 to $74,999 by ecosystem service area excluding the Columbia River.

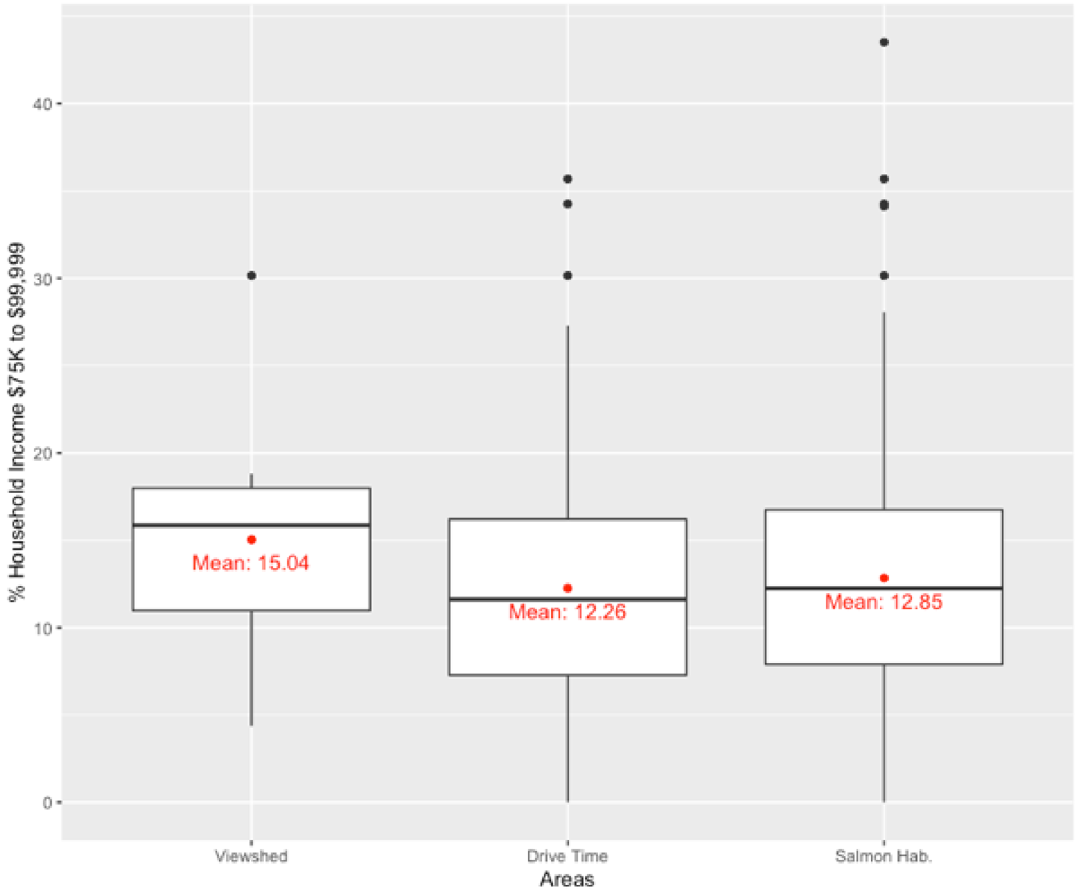


Figure 17. Boxplot of percent of households with incomes of $75,000 to $99,999 by ecosystem service area excluding the Columbia River.

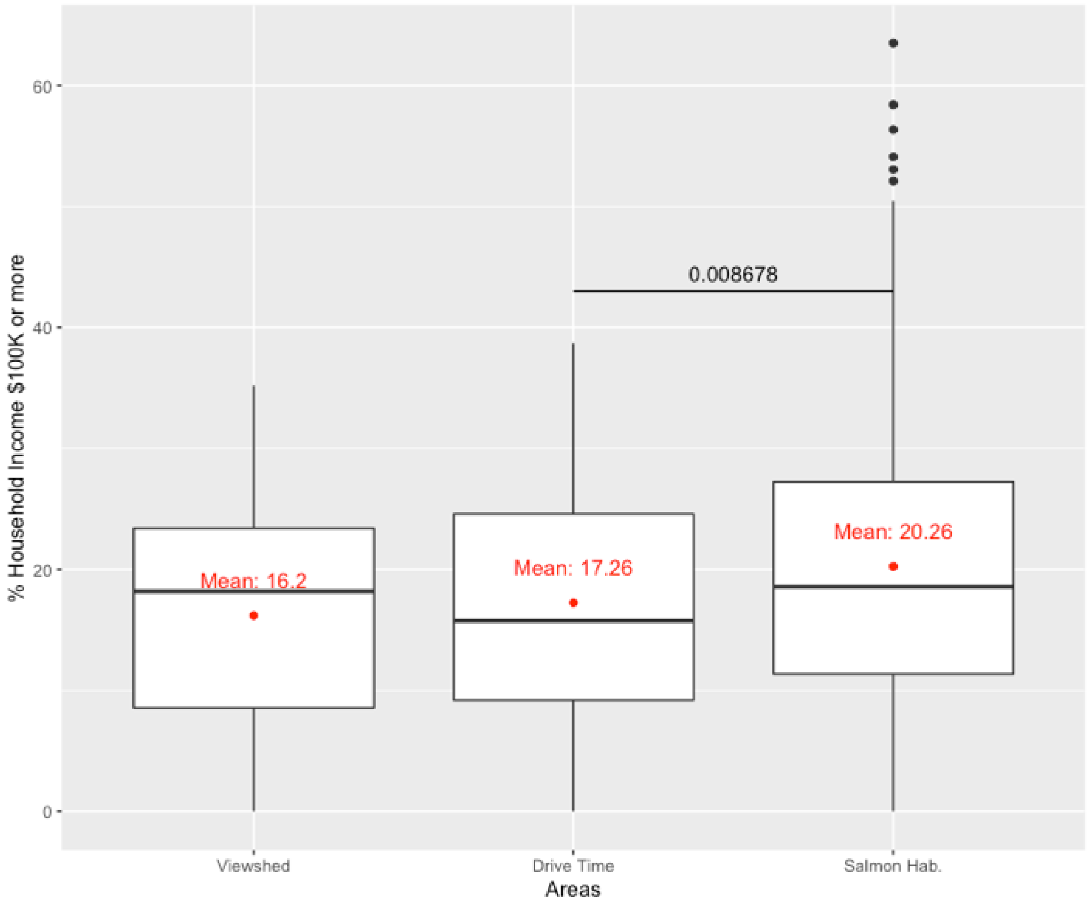


Figure 18. Boxplot of percent of households with incomes of $100,000 or more by ecosystem service area excluding the Columbia River. Statistically significant differences between areas are indicated by horizontal lines with the pairwise permutation test p-value.

Table 3. Mean percent household income by ecosystem service area with the Columbia River included. Significance indicated with pairs of symbols.

Mean % Household Income	Viewshed	Drive time	Upstream Salmon Hab. with the Columbia
0$ - $24,999	21.96%	23.95% *	17.63%*
$25K - $49,999	26.98%†	26.48%*	21.3%*†
$50K - $74,999	19.81%	20.05%*	18.06%*
$75K - $99,999	15.04%	12.26%	13.61%
$100K plus	16.2%†	17.26%*	29.4%*†

Income - With the Columbia River included

By including the Columbia River in the upstream salmon area, the income distribution changes with about 38% percent of households earning less than $49,999 a year and a much higher percent of the population in this area with incomes of over $100,000 (29.4%) (Table 3). The larger number of block groups (n=2093) included by incorporating the Columbia River also has a more varied distribution of households within each income bracket with more block groups falling outside of the interquartile range, and up to 100% of households with incomes of $25,000 to $49,999 and $50,000 to $74,999 for some block groups (Figures 19-23).

Permutation tests indicate significant differences (p-values <0.01) between driving time and upstream salmon habitat with the Columbia River for all household incomes brackets except the $75 - $99,999 range with more households earning lower incomes and fewer households earning higher incomes in the drive time area than the upstream salmon habitat with Columbia River area (Table 3). In addition, viewshed is significantly different from upstream salmon habitat with the Columbia River for Household incomes of $25,000 to $49,999 (p-value <0.05) and $100,000 or more (p-value <0.01) with more low-income households and fewer high-income households (Figures 20 & 23).

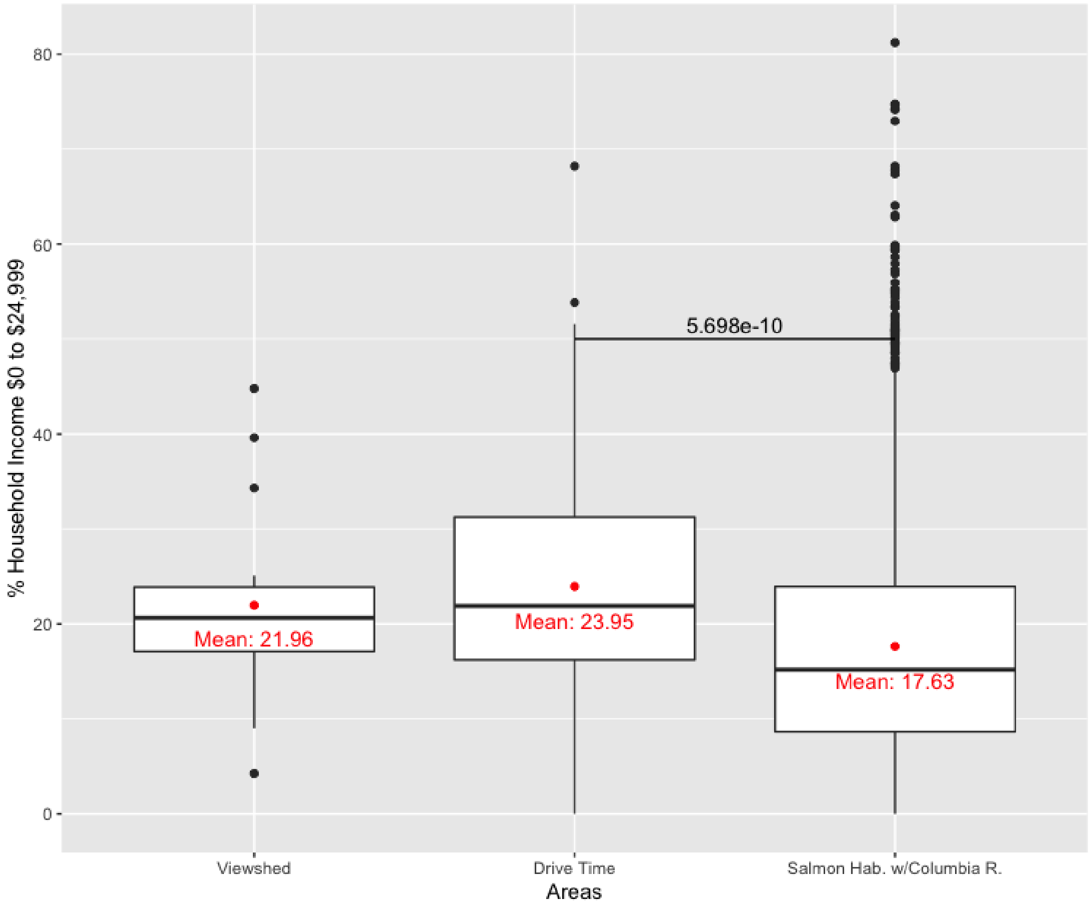


Figure 19. Boxplot of percent of households with incomes of $0 to $24,999 by ecosystem service area excluding the Columbia River. Statistically significant differences between areas are indicated by horizontal lines with the pairwise permutation test p-value.

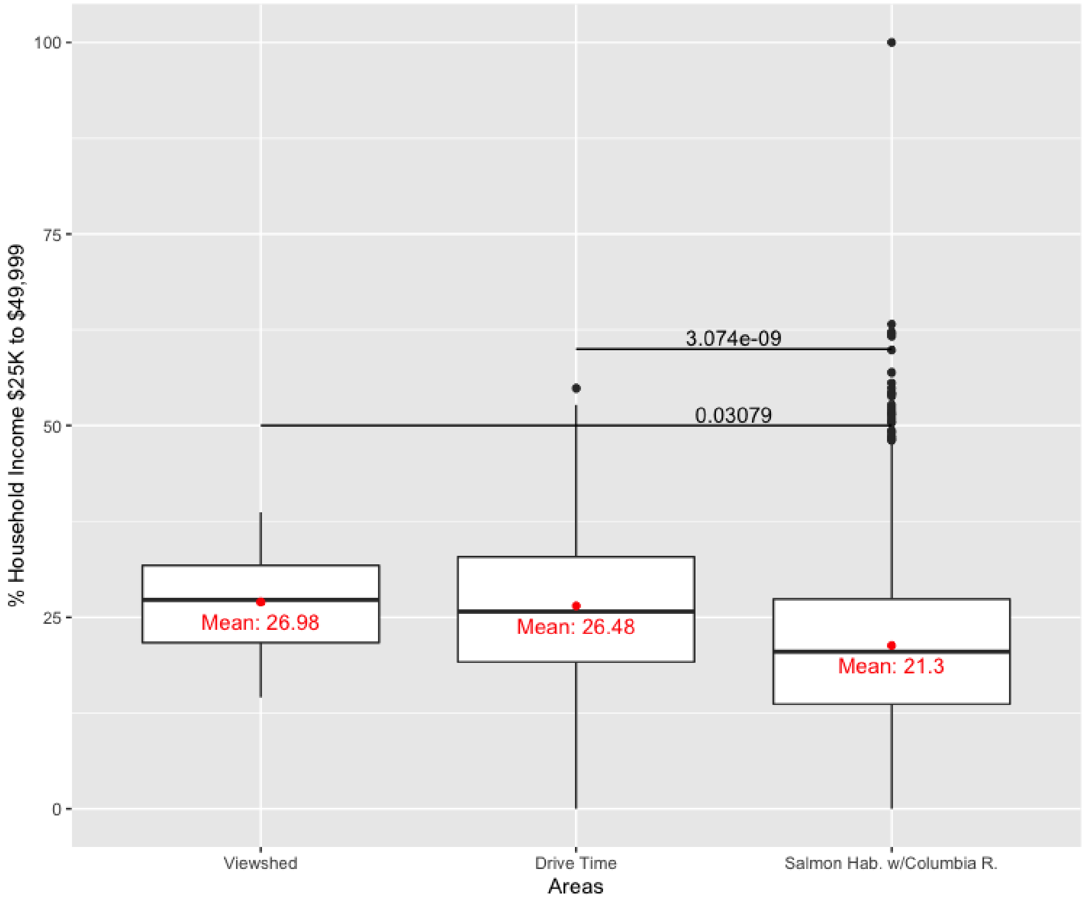


Figure 20. Boxplot of percent of households with incomes of $25,000 to $49,999 by ecosystem service area excluding the Columbia River. Statistically significant differences between areas are indicated by horizontal lines with pairwise permutation test p-value.

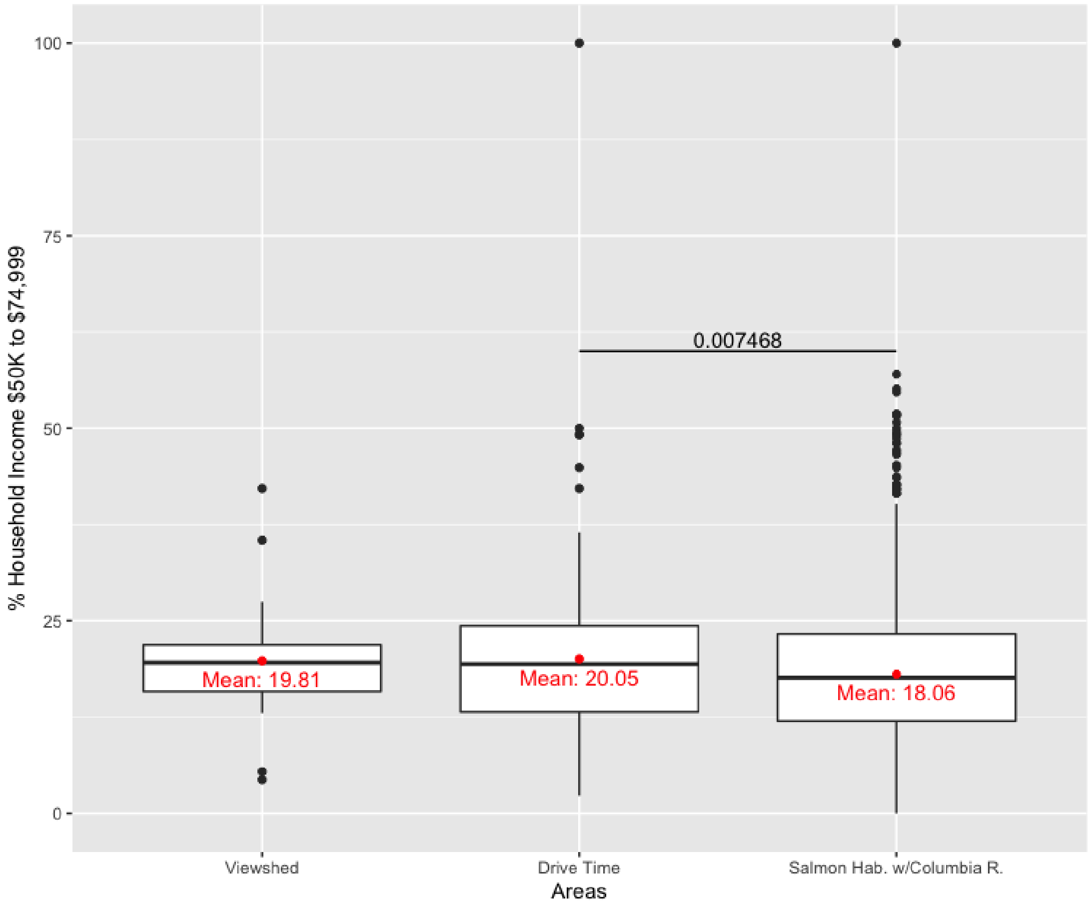


Figure 21. Boxplot of percent of households with incomes of $50,000 to $74,999 by ecosystem service area excluding the Columbia River. Statistically significant differences between areas are indicated by horizontal lines with pairwise permutation test p-value.

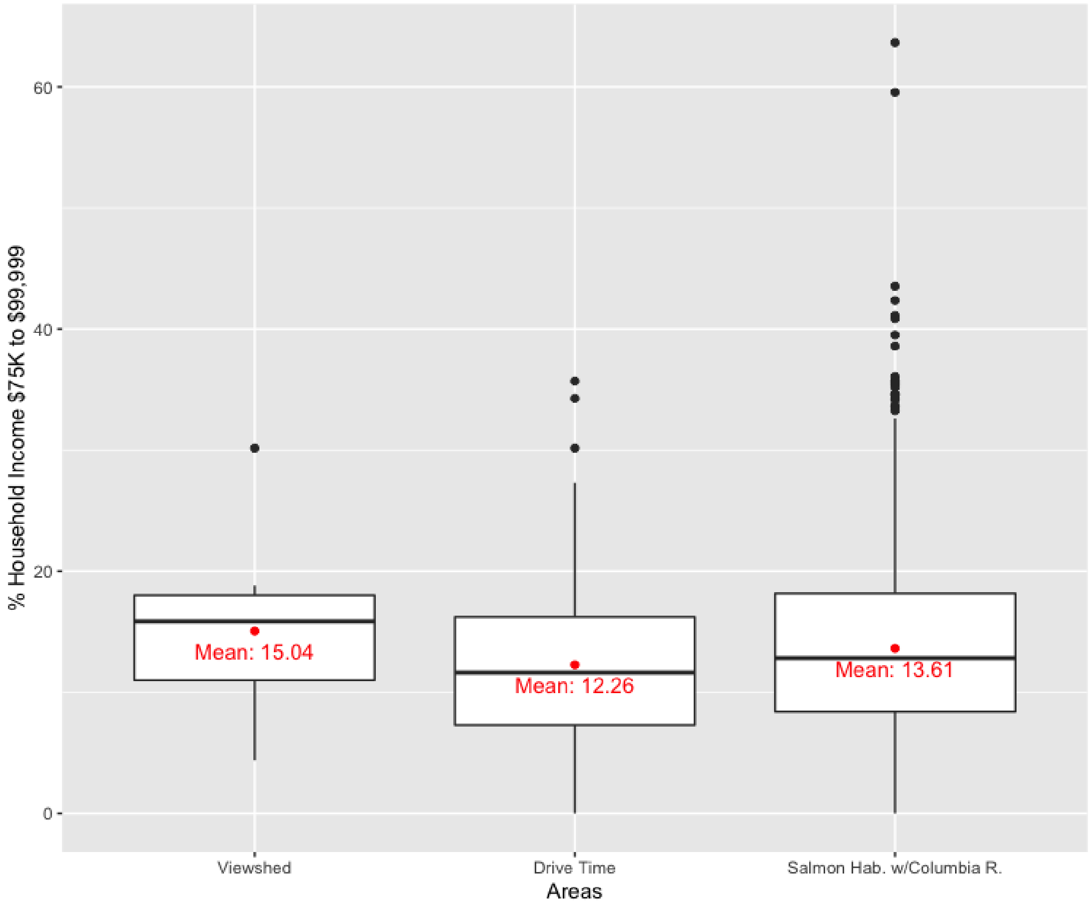


Figure 22. Boxplot of percent of households with incomes of $75,000 to $99,999 by ecosystem service area excluding the Columbia River.

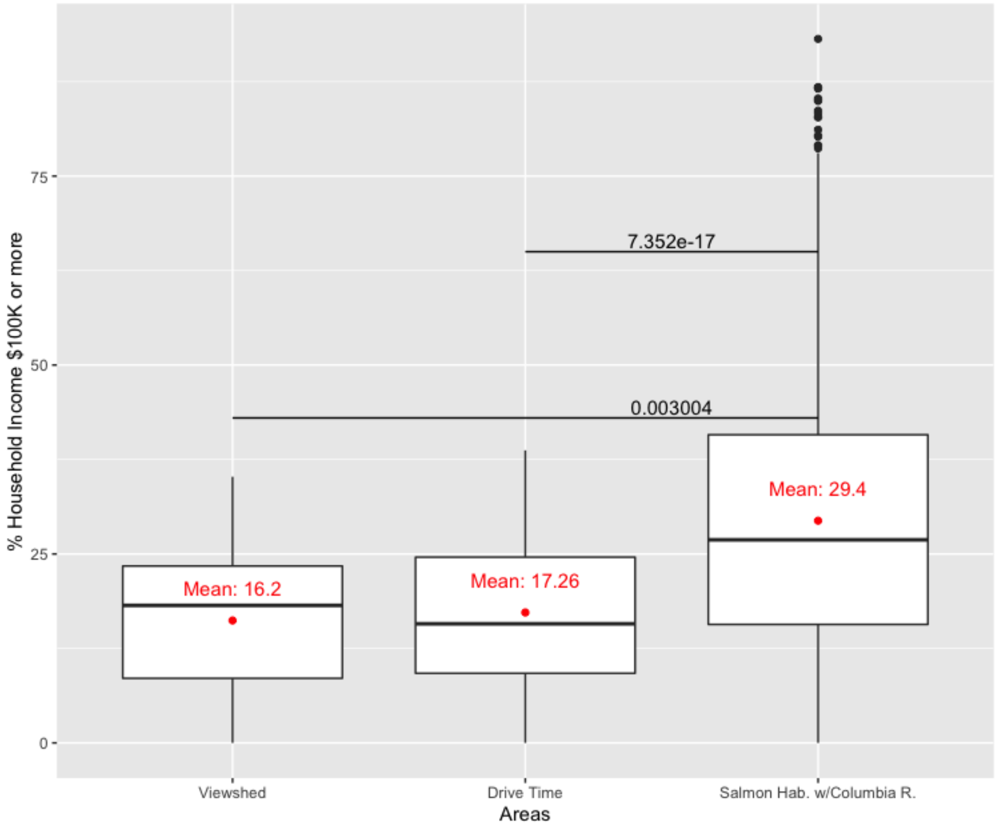


Figure 23. Boxplot of percent of households with incomes of $100,000 or more by ecosystem service area excluding the Columbia River. Statistically significant differences between areas are indicated by horizontal lines with pairwise permutation test p-value.

Chapter 7

Discussion & Conclusion

This study brought together concepts from ecosystems service flow mapping, stakeholder theory, and environmental justice to examine who is impacted by restoration activities on the Oregon coast and gain insights into the race and income distribution of, and differences between, groups of stakeholders. The method used in this study is related to Jackson et al.'s Polyscape GIS framework in that it aims to assist in stakeholder engagement and land management decision making using multiple ecosystem service flow areas (Jackson et al., 2013). While ecosystem service flows are often mapped using density maps (Chalkiadakis et al., 2022), the use of defined areas as used in the Polyscape (Jackson et al., 2013) and SPAN (Bagstad et al., 2013) models allow for the incorporation of census data into the analysis. The combination of census data with ecosystem service flow mapping is a novel approach that enables land managers and project coordinators to use a systematic approach for identifying stakeholders. Systems for identifying stakeholders have been identified as key to ethical and sustainable decision making (Bryson, 2004; Mathur et al., 2007) both of which are also environmental justice goals.

I have used the term impacts rather than benefits thorough this study as changes to ecosystem services are not always seen as beneficial to all parties. The concept that management decisions often require tradeoffs is discussed in stakeholder analysis literature (Bryson, 2004; Mathur et al., 2007) as well as in ecosystem service and environmental justice discourse (D. K. Loomis & Paterson, 2014b; Sikor, 2013).

Ecosystem service flow areas

Returning to the first question this paper sought to answer, who is impacted by estuary restoration activities on the Oregon coast, we can see that there are several differences between these ecosystem service flows which have implications for which stakeholders are included in each ecosystem service flow area. Stakeholders within viewshed areas are not necessarily incorporated in a 27-minute driving distance due to the views from higher elevations, though the 10-mile buffer on salmon habitat stream segments does incorporate most of the drive time area. This investigation of ecosystem service flows of restoration projects on the Oregon coast reveals upstream salmon habitat that reaches inland to non-coastal areas, indicating far reaching impacts of estuary restoration for stakeholders who don't live on the Oregon coast.

The difference between upstream salmon habitat area when the Columbia River is included or not is quite large and, due to the geography and population distribution in Oregon, has consequences for both area and population considered. While this study set the outer boundary of analysis at the state boarders of Oregon, a more expansive analysis of estuary restoration impacts in the Northwest would make including or excluding the Columbia River even more impactful to study results. It should be noted that the study area for this project did not extend beyond the state of Oregon's boundaries which arbitrarily divide both the Columbia and Klamath River basins. Tracing impacts of estuary restoration on the Oregon coast upstream via salmon populations potentially has impacts for human populations in multiple states including Washington, Idaho, Montana, California, and in Canada. It is worth noting that, while the Columbia River basin is by far the largest river system considered in this study, the current OWRI database only includes two estuary restoration projects in this estuary. Contrasting these three categories of ecosystem service flows highlights the difference in area and population impact depending on the ecosystem service considered. This gives a fuller picture to judge the impacts of undertaking restoration of these ecosystems.

These findings are in line with ecosystem service flow mapping studies that point out the great difference in scale between flow areas for various ecosystem services that range from local to global (Chalkiadakis et al., 2022). While this study focuses on three service category stakeholder groups, future work investigating additional categories would indicate other groups who are also impacted by estuary restoration projects.

Demographics race and class

When addressing this study's second question, for each impact what is the race and income distribution of stakeholder block groups, the population distribution of the state is an important factor. Oregon's I-5 corridor, which largely coincides with the Willamette valley, is home to most of its population. The relatively large urban centers in this part of the state are more racially/ethnically diverse, and host much of the high-income economic activity of the state. Thus, the difference between income and race/ethnicity comparisons with and without the Columbia River are drastically different as the Willamette River valley is either included or excluded. When isolating communities on the coast and in the Cascades in the analysis by excluding the Columbia River, the results show that populations impacted by estuary restoration have a high percentage of White non-Hispanic residents, and small non-White populations, though block groups with high percentages of non-White individuals do exist within driving distance and upstream salmon population areas.

When addressing the study's third question, do the distributions of race and income of the block groups of stakeholders vary among the three different types of restoration-related services examined, we see that there are some differences, though the hypothesis that that there would be significant differences in race and income between all groups with less racial diversity in the group impacted by aesthetic changes from restoration than in the other defined stakeholder groups was not confirmed by this analysis.

There is less difference in race between ecosystem service flow areas than expected, though this depends on which version of upstream salmon habitat area is used. Differences in race/ethnicity between viewshed, drive time, and upstream salmon habitat without the Columbia are not significant, and the only significant difference in income categories was between household incomes of $100,000 or more with more high earning households in the upstream salmon habitat area than drive time area. This indicates that, while there may be differences in impacts to these populations, they are similar populations in terms of race/ethnicity and for most income brackets.

For this analysis viewshed was not significantly different than any other area in five out of the eight categories. This may be due to the small number of block groups included in this area (n=16) and the low population density on the Oregon coast. The Oregon coast is relatively rugged resulting in dispersed viewshed areas. In addition, many restoration projects are located outside of urban areas where the aesthetics of a project impact very small populations.

Known sources of error

It was discovered after completing the analysis that one estuary restoration site of type ‘estuarine’ was excluded from the set due to the fact that it was filtered out when selecting for sites with activity type ‘Estuarine’ (lowercase versus uppercase e discrepancy). This site is located in the Florence estuary about 3.5 miles upstream of another site in the estuary, therefore the upstream salmon habitat area is not affected by its exclusion. While its inclusion would have expanded the viewshed area slightly, it is unlikely that it would have led to the inclusion of another block group as it is in a rural area with large block groups with centroid points over 3 miles away over rugged terrain. It is also unlikely that it would have affected the driving distance area as all roads that reach the site are already included, and road networks in the area are sparce.

Two census block groups included in the analysis were found to have race data only with income data listed as ‘NaN.’ These block groups were part of the largest area, upstream salmon habitat including the Columbia River. It is unlikely that their exclusion based on incomplete data would have changed the results of the analysis.

Conclusion

Restoration of largely depleted estuarine systems is increasingly recognized as key to solving a variety of problems coastal communities face currently, as well as those issues that will become more acute with climate change and sea level rise (Battin et al., 2007; Burger, 2002; Stephenson et al., 2014). Historic losses of estuary area, and recognition of the ecosystem services provided by functioning estuary ecosystems have resulted in current impetus to pursue voluntary, or non-regulatory, estuary restoration. In this study I discuss a framework for mapping ecosystem service flows as a method to identify stakeholder groups impacted by estuary restoration projects. I explore the impacts of estuary restoration, drawing from the ecosystem services framework for acknowledging non-resource extraction-based ecosystem value and using ecosystem service flow mapping and census data to connect this value to human populations. By mapping ecosystem service flows for three aggregated ecosystem service categories relevant to coastal management I found that area each category was different, and that smaller areas were not completely incorporated in larger areas. Therefore, stakeholders can be included in any number and combination of the three impacted areas. Drawing on an environmental justice framework, analysis of race and income for populations in these areas show a lower income population with low diversity represented in all three ecosystem service flow areas when the Columbia River is excluded.

In her book *Thinking In Systems*, Donella Meadows notes that the process of building a systems model necessitates decisions about what to include and where to draw the boundaries to define what will be excluded (Meadows, 2008). As the study of restoration ecology has progressed over the last 90 years the conceptual models in western science about the connections that make up ecosystems have progressed prompting ecosystems based management approaches (Kelble et al., 2013; D. K. Loomis & Paterson, 2014b; Lubchenco & Sutley, 2010). As a result, ecosystem models have expanded to include a wider range of variables such as impacts to a range of physical and biotic systems. The acknowledgement that humans are an integral part of natural systems, rather than external meddlers and beneficiaries had resulted in new methods of incorporating human factors into land management decisions. Agencies, local jurisdictions, individuals, and groups of private citizens have a diverse set of goals and values that affect their judgment of the value of estuary restoration. While studies of prospective estuary restoration sites on the Oregon coast have been compiled (Brophy, 1999; Fuss, 1999), information about the populations affected by the various systems impacted by the condition of estuary ecosystems is less well documented.

Mapping ecosystem services to gain a spatially explicit understanding of the potential impacts of restoration projects has valuable applications for stakeholder analysis and outreach for potential restoration projects. By mapping these potential impacts, we can make connections to stakeholders more systematically with information about the ways they are likely to be impacted by a given project, information that has been shown to improve project outcomes (Aggestam, 2014; Freeman et al., 2010). Investigating the differences in the human demographics at these different scales provides insight into how these impacts are distributed across demographic variables of race and income. This information can inform future efforts to communicate with populations near estuary restoration projects. Spatial information on the ecosystem service flows from estuary restoration projects can be used to assist in outreach both for assessing impacts of past projects and to inform outreach for future restoration work.

Extending this methodology to include the West Coast of the US would be an interesting next step as watershed boundaries, and therefore impacts, are not actually cut off by the presence of a state boundary. The variations in terrain, population distribution, and prevalence of estuary restoration projects on coastlines in Washington and California, as well as in other parts of the US or internationally, have the potential to reveal important findings for resource management. With research showing positive outcomes from including stakeholders and social factors in project planning (Aggestam, 2014; Eskerod et al., 2015; Sikor, 2013) restoration ecologists and other natural resource managers will need more and better information about who and where project stakeholders are.

References

2010 TIGER/Line® Shapefiles. (n.d.). Retrieved April 20, 2022, from https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2010&layergroup=Blocks

2020 TIGER/Line® Shapefiles. (n.d.). Retrieved April 20, 2022, from https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2020&layergroup=Blocks+%282020%29

Acquiring Reservation Land. (n.d.). Retrieved April 24, 2022, from https://www.oregonhistoryproject.org/articles/acquiring-reservation-land/

Aggestam, F. (2014). Wetland Restoration and the Involvement of Stakeholders: An Analysis Based on Value-Perspectives. *Landscape Research*, *39*(6), 680–697.

Bagstad, K. J., Johnson, G. W., Voigt, B., & Villa, F. (2013). Spatial dynamics of ecosystem service flows: A comprehensive approach to quantifying actual services. *Ecosystem Services*, *4*, 117–125. https://doi.org/10.1016/j.ecoser.2012.07.012

Bagstad, K. J., Villa, F., Batker, D., Harrison-Cox, J., Voigt, B., & Johnson, G. W. (2014). From theoretical to actual ecosystem services: Mapping beneficiaries and spatial flows in ecosystem service assessments. *Ecology and Society*, *19*(2), art64. https://doi.org/10.5751/ES-06523-190264

Barbier, E. B., Hacker, S. D., Kennedy, C., Koch, E. W., Stier, A. C., & Silliman, B. R. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs*, *81*(2), 169–193. https://doi.org/10.1890/10-1510.1

Battin, J., Wiley, M. W., Ruckelshaus, M. H., Palmer, R. N., Korb, E., Bartz, K. K., & Imaki, H. (2007). Projected impacts of climate change on salmon habitat restoration. *Proceedings of the National Academy of Sciences*, *104*(16), 6720–6725. https://doi.org/10.1073/pnas.0701685104

Bell, D., & Carrick, J. (2017). Procedural environmental justice. In *The Routledge Handbook of Environmental Justice*. Routledge.

Berg, L. (2007). *The First Oregonians, Second Edition* (2nd edition). Oregon State University Press.

Block Groups for the 2020 Census-Final Criteria. (2018, November 13). Federal Register. https://www.federalregister.gov/documents/2018/11/13/2018-24570/block-groups-for-the-2020-census-final-criteria

Boone, C. G., Buckley, G. L., Grove, J. M., & Sister, C. (2009). Parks and People: An Environmental Justice Inquiry in Baltimore, Maryland. *Annals of the Association of American Geographers*, *99*(4), 767–787. https://doi.org/10.1080/00045600903102949

Brophy, L. S. (1999). *Final Report: Yaquina and Alsea River Basins Estuarine Wetland Site Prioritization Project*. https://appliedeco.org/report/final-report-yaquina-and-alsea-river-basins-estuarine-wetland-site-prioritization-project/

Brophy, L. S. (2019). *Comparing historical losses of forested, scrub-shrub, and emergent tidal wetlands on the Oregon coast, USA: A paradigm shift for estuary restoration and conservation*. https://doi.org/10.13140/RG.2.2.25732.68481

Bryson, J. M. (2004). What to do when Stakeholders matter. *Public Management Review*, *6*(1), 21–53. https://doi.org/10.1080/14719030410001675722

Bullard, R. D. (2000). *Dumping In Dixie: Race, Class, And Environmental Quality, Third Edition* (3rd edition). Routledge.

Bullard, R. D., Mohai, P., Saha, R., & Wright, B. (2007). *Toxic Wastes and Race at Twenty 1987—2007*. https://www.ucc.org/wp-content/uploads/2021/03/toxic-wastes-and-race-at-twenty-1987-2007.pdf

Burdon, D., Potts, T., McKinley, E., Lew, S., Shilland, R., Gormley, K., Thomson, S., & Forster, R. (2019). Expanding the role of participatory mapping to assess ecosystem service provision in local coastal environments. *Ecosystem Services*, *39*, 101009. https://doi.org/10.1016/j.ecoser.2019.101009

Burger, J. (2002). *Assessing Perceptions about Ecosystem Health and Restoration Options in Three East Coast Estuaries*. 18.

Burkhard, B., Kandziora, M., Hou, Y., & Müller, F. (2014). Ecosystem service potentials, flows and demands-concepts for spatial localisation, indication and quantification. *Landscape Online*, *34*, 1–32. https://doi.org/10.3097/LO.201434

Casagrande, D. G. (1997). *The Full Circle: A Historical Context for Urban Salt Marsh Restoration*.

Chalkiadakis, C., Drakou, E. G., & Kraak, M.-J. (2022). Ecosystem service flows: A systematic literature review of marine systems. *Ecosystem Services*, *54*, 101412. https://doi.org/10.1016/j.ecoser.2022.101412

Chaudhary, S., McGregor, A., Houston, D., & Chettri, N. (2018). Environmental justice and ecosystem services: A disaggregated analysis of community access to forest benefits in Nepal. *Ecosystem Services*, *29*, 99–115. https://doi.org/10.1016/j.ecoser.2017.10.020

Coleman, H. M., Kanat, G., & Aydinol Turkdogan, F. I. (2009). Restoration of the Golden Horn Estuary (Halic). *Water Research*, *43*(20), 4989–5003. https://doi.org/10.1016/j.watres.2009.08.047

Costanza, R., Arge, Groot, R., Farberk, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., neill, R., Paruelo, J., Raskin, R., Sutton, P., & Belt, M. (1997). The Value of the World's Ecosystem Services and Natural Capital. *Nature*, *387*, 253–260. https://doi.org/10.1016/S0921-8009(98)00020-2

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, *28*, 1–16. https://doi.org/10.1016/j.ecoser.2017.09.008

Culhane, P. J. (2013). *Public Lands Politics: Interest Group Influence on the Forest Service and the Bureau of Land Management*. Routledge.

Douglas, E. M., Kirshen, P. H., Paolisso, M., Watson, C., Wiggin, J., Enrici, A., & Ruth, M. (2012). Coastal flooding, climate change and environmental justice: Identifying obstacles and incentives for adaptation in two metropolitan Boston Massachusetts communities. *Mitigation and Adaptation Strategies for Global Change*, *17*(5), 537–562. https://doi.org/10.1007/s11027-011-9340-8

Elkind, S. S. (2006). Environmental Inequality and the Urbanization of West Coast Watersheds. *Pacific Historical Review*, *75*(1), 53–61. https://doi.org/10.1525/phr.2006.75.1.53

Ellings, C. S., Davis, M. J., Grossman, E. E., Woo, I., Hodgson, S., Turner, K. L., Nakai, G., Takekawa, J. E., & Takekawa, J. Y. (2016). Changes in habitat availability for outmigrating juvenile salmon (Oncorhynchus spp.) following estuary restoration. *Restoration Ecology*, *24*(3), 415–427. https://doi.org/10.1111/rec.12333

EPA. (2008). *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. EPA. http://www.epa.gov/owow/nps/watershed_handbook.

Eskerod, P., Huemann, M., & Ringhofer, C. (2015). Stakeholder Inclusiveness: Enriching Project Management with General Stakeholder Theory1. *Project Management Journal*, *46*(6), 42–53. https://doi.org/10.1002/pmj.21546

Evan Hayduk. (2018, September 27). *Dan Bottom Short*. https://www.youtube.com/watch?v=u0t70IMWeJw

Fredrickson, A. (2013). The California Coastal Act and Ports: The Unintended Environmental Justice Implications of Preserving California's Coastline. *Coastal Management*, *41*(3), 258–271. https://doi.org/10.1080/08920753.2013.784888

Freeman, R. E., Harrison, J. S., Wicks, A. C., Parmar, B. L., & Colle, S. de. (2010). *Stakeholder Theory: The State of the Art*. Cambridge University Press.

Fresh, K., Casillas, E., Johnson, L., & Bottom, D. (2005). *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of the Effects of Selected Factors on Salmonid Population Viability*. 125.

Fretwell, J. D., Williams, J. S., Redman, P. J., & Survey (U.S.), G. (1996). *National Water Summary on Wetland Resources*. U.S. Government Printing Office.

Fuss, J. D. (1999). *Identifying potential wetland restoration sites for estuary-wide restoration planning in Oregon: A pilot project in the Coos Estuary*. Oregon State University.

Gagnon Thompson, S. C., & Barton, M. A. (1994). Ecocentric and anthropocentric attitudes toward the environment. *Journal of Environmental Psychology*, *14*(2), 149–157. https://doi.org/10.1016/S0272-4944(05)80168-9

Garibaldi, A., & Turner, N. (2004). Cultural Keystone Species: Implications for Ecological Conservation and Restoration. *Ecology and Society*, *9*(3). http://www.jstor.org/stable/26267680

Gilby, B. L., Olds, A. D., Duncan, C. K., Ortodossi, N. L., Henderson, C. J., & Schlacher, T. A. (2020). Identifying restoration hotspots that deliver multiple ecological benefits. *Restoration Ecology*, *28*(1), 222–232. https://doi.org/10.1111/rec.13046

Gilio-Whitaker, D. (2019). *As Long as Grass Grows: The Indigenous Fight for Environmental Justice, from Colonization to Standing Rock*. Beacon Press.

Goldenberg, R., Kalantari, Z., Cvetkovic, V., Mörtberg, U., Deal, B., & Destouni, G. (2017). Distinction, quantification and mapping of potential and realized supply-demand of flow-dependent ecosystem services. *Science of The Total Environment*, *593–594*, 599–609. https://doi.org/10.1016/j.scitotenv.2017.03.130

Graham, J. D., Beaulieu, N. D., Sussman, D., Sadowitz, M., & Li, Y. (1999). Who Lives Near Coke Plants and Oil Refineries? An Exploration of the Environmental Inequity Hypothesis. *Risk Analysis*, *19*(2), 171–186. https://doi.org/10.1111/j.1539-6924.1999.tb00398.x

Gray, A., Simenstad, C. A., Bottom, D. L., & Cornwell, T. J. (2002). Contrasting Functional Performance of Juvenile Salmon Habitat in Recovering Wetlands of the Salmon River Estuary, Oregon, U.S.A. *Restoration Ecology*, *10*(3), 514–526. https://doi.org/10.1046/j.1526-100X.2002.01039.x

Haeffner, M., Jackson-Smith, D., Buchert, M., & Risley, J. (2017). Accessing blue spaces: Social and geographic factors structuring familiarity with, use of, and appreciation of urban waterways. *Landscape and Urban Planning*, *167*, 136–146. https://doi.org/10.1016/j.landurbplan.2017.06.008

Hardy, R. D., Milligan, R. A., & Heynen, N. (2017). Racial coastal formation: The environmental injustice of colorblind adaptation planning for sea-level rise. *Geoforum*, *87*, 62–72. https://doi.org/10.1016/j.geoforum.2017.10.005

Hindsley, P., Hamilton, S. E., & Morgan, O. A. (2013). Gulf Views: Toward a Better Understanding of Viewshed Scope in Hedonic Property Models. *The Journal of Real Estate Finance and Economics*, *47*(3), 489–505. https://doi.org/10.1007/s11146-012-9365-0

Hunold, C., & Young, I. M. (1998). Justice, Democracy, and Hazardous Siting. *Political Studies*, *46*(1), 82–95. https://doi.org/10.1111/1467-9248.00131

Hunt, Dr. K. M., & Hutt, C. P. (2010). *Characteristics of Texas Catfish Anglers and their Catch and Management Preferences*. Texas Parks & Wildlife Department Inland Fisheries Division Austin, Texas.

Isenberg, N. (2017). *White Trash: The 400-Year Untold History of Class in America*. Atlantic Books, Limited.

Jackson, B., Pagella, T., Sinclair, F., Orellana, B., Henshaw, A., Reynolds, B., Mcintyre, N., Wheater, H., & Eycott, A. (2013). Polyscape: A GIS mapping framework providing efficient and spatially explicit landscape-scale valuation of multiple ecosystem services. *Landscape and Urban Planning*, *112*, 74–88. https://doi.org/10.1016/j.landurbplan.2012.12.014

Jacobson, J. O., Hengartner, N. W., & Louis, T. A. (2005). Inequity Measures for Evaluations of Environmental Justice: A Case Study of Close Proximity to Highways in New York City. *Environment and Planning A: Economy and Space*, *37*(1), 21–43. https://doi.org/10.1068/a36225

Kelble, C. R., Loomis, D. K., Lovelace, S., Nuttle, W. K., Ortner, P. B., Fletcher, P., Cook, G. S., Lorenz, J. J., & Boyer, J. N. (2013). The EBM-DPSER Conceptual Model: Integrating Ecosystem Services into the DPSIR Framework. *PLOS ONE*, *8*(8), e70766. https://doi.org/10.1371/journal.pone.0070766

Kim, J., & Nicholls, S. (2016). Influence of the measurement of distance on assessment of recreation access. *Leisure Sciences*, *38*(2), 118–139. https://doi.org/10.1080/01490400.2015.1071211

Kjelstrom, L. C., & Williams, J. S. (n.d.). *National Water Summary Wetland Resources: Oregon*. 6.

Klein, N. (2007). Spatial Methodology for Assessing Distribution of Transportation Project Impacts with Environmental Justice Framework. *Transportation Research Record: Journal of the Transportation Research Board*, *2013*(1), 46–53. https://doi.org/10.3141/2013-07

Klopfenstein, R. (2016). *Restoring the Columbia River Estuary: Chinook Salmon Recovery and Invasive Species Management.* Oregon State University.

Laatikainen, T. E., Piiroinen, R., Lehtinen, E., & Kyttä, M. (2017). PPGIS approach for defining multimodal travel thresholds: Accessibility of popular recreation environments by the water. *Applied Geography*, *79*, 93–102. https://doi.org/10.1016/j.apgeog.2016.12.006

LaFleur, B. J., & Greevy, R. A. (2009). Introduction to Permutation and Resampling-Based Hypothesis Tests∗. *Journal of Clinical Child & Adolescent Psychology*, *38*(2), 286–294. https://doi.org/10.1080/15374410902740411

Larson, A. J., Belote, R. T., Williamson, M. A., & Aplet, G. H. (2013). Making Monitoring Count: Project Design for Active Adaptive Management. *Journal of Forestry*, *111*(5), 348–356. https://doi.org/10.5849/jof.13-021

Leciejewski, M., & Perkins, H. A. (2015). Environmental Justice in Appalachia: Procedural Inequities in the Mine Permitting Process in Southeast Ohio. *Environmental Justice*, *8*(4), 111–116. https://doi.org/10.1089/env.2015.0010

Loomis, D. (2005). *Human Dimensions of Coastal Restoration. In Science-Based Restoration Monitoring of Coastal Habitats.* (p. 14.1-14.67).

Loomis, D. K., & Paterson, S. K. (2014a). Human dimensions indicators of coastal ecosystem services: A hierarchical perspective. *Ecological Indicators*, *44*, 63–68. https://doi.org/10.1016/j.ecolind.2013.12.022

Loomis, D. K., & Paterson, S. K. (2014b). The human dimensions of coastal ecosystem services: Managing for social values. *Ecological Indicators*, *44*, 6–10. https://doi.org/10.1016/j.ecolind.2013.09.035

Lubchenco, J., & Sutley, N. (2010). Proposed U.S. Policy for Ocean, Coast, and Great Lakes Stewardship. *Science*. https://doi.org/10.1126/science.1190041

Lundrigan, T. A., Moran, P., Teel, D. J., Marshall, A. R., Young, S. F., & Bottom, D. L. (2004). *Conservation and Genetic Stock Identification: A Study Investigating the Stock-Specific Distribution and Performance of Juvenile Chinook Salmon in the Columbia River Estuary*. 2.

Mathur, V. N., Price, A. D. F., Simon Austin, & Cletus Moobela. (2007, June 27). Defining, identifying and mapping stakeholders in the assessment of urban sustainability. *Horner, M. ... et al (Eds.). SUE-MoT Conference 2007*. International Conference on Whole Life Sustainability and its Assessment, Glasgow, Scotland.

McCauley, D. J. (2006). Selling out on nature. *Nature*, *443*(7107), 27–28. https://doi.org/10.1038/443027a

Meadows, D. H. (2008). *Thinking in Systems: A Primer*. Chelsea Green Publishing.

Mitsch, W. J., & Gosselink, J. G. (2010). *Wetlands*. John Wiley & Sons, Incorporated. http://ebookcentral.proquest.com/lib/psu/detail.action?docID=819004

Mohai, P. (1995). THE DEMOGRAPHICS OF DUMPING REVISITED: EXAMINING THE IMPACT OF ALTERNATE METHODOLOGIES IN ENVIRONMENTAL JUSTICE RESEARCH. *Virginia Environmental Law Journal*, *14*(4), 615–653.

Moss, M. L. (2016). The nutritional value of Pacific herring: An ancient cultural keystone species on the Northwest Coast of North America. *Journal of Archaeological Science: Reports*, *5*, 649–655. https://doi.org/10.1016/j.jasrep.2015.08.041

Mueller, J. M., Springer, A. E., & Lima, R. E. (2018). Willingness to pay for forest restoration as a function of proximity and viewshed. *Landscape and Urban Planning*, *175*, 23–33. https://doi.org/10.1016/j.landurbplan.2018.03.006

Native Lands and Reservations, Maps. (n.d.). Retrieved May 16, 2022, from https://www.oregonhistoryproject.org/native-lands/

ODFW - ODFW Data Clearinghouse—View Record. (n.d.). Retrieved May 25, 2021, from https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=202&XMLname=1167.xml

Oregon Explorer Topics | oregonexplorer | Oregon State University. (n.d.). Retrieved December 4, 2020, from https://oregonexplorer.info/topics/wetlands?qt-subtopic_quicktab=4&ptopic=98

Oregon Spatial Data Library. (n.d.). Retrieved June 8, 2021, from https://spatialdata.oregonexplorer.info/geoportal/details;id=161c9568b5584a6d9ff9b019da09f034

Oregon Watershed Restoration Tool. (n.d.). Retrieved May 23, 2021, from https://tools.oregonexplorer.info/OE_HtmlViewer/Index.html?viewer=owrt

Orr, E., & Orr, W. (2005). *Oregon Water: An Environmental History* (0 edition). Inkwater Press.

Ortner, P. B., Fletcher, P. J., & Kelble, C. R. (2014). Introduction to tools to support ecosystem based management of South Florida's coastal resources. *Ecological Indicators*, *44*, 2–5. https://doi.org/10.1016/j.ecolind.2014.04.020

Padawangi, R. (2012). Climate Change and the North Coast of Jakarta: Environmental Justice and the Social Construction of Space in Urban Poor Communities. In *Research in Urban Sociology* (Vol. 12, pp. 321–339). UK: Emerald.

Palomo, I., Martín-López, B., Potschin, M., Haines-Young, R., & Montes, C. (2013). National Parks, buffer zones and surrounding lands: Mapping ecosystem service flows. *Ecosystem Services*, *4*, 104–116. https://doi.org/10.1016/j.ecoser.2012.09.001

Poudyal, N. C., Hodges, D. G., Fenderson, J., & Tarkington, W. (2010). Realizing the Economic Value of a Forested Landscape in a Viewshed. *Southern Journal of Applied Forestry, 34*(2), 72–78. https://doi.org/10.1093/sjaf/34.2.72

Rigolon, A. (2017). Parks and young people: An environmental justice study of park proximity, acreage, and quality in Denver, Colorado. *Landscape and Urban Planning*, *165*, 73–83. https://doi.org/10.1016/j.landurbplan.2017.05.007

Root-Bernstein, M., & Frascaroli, F. (2016). Where the fish swim above the birds: Configurations and challenges of wetland restoration in the Po Delta, Italy. *Restoration Ecology*, *24*(6), 773–784. https://doi.org/10.1111/rec.12369

Ruiz-Frau, A., Hinz, H., Edwards-Jones, G., & Kaiser, M. J. (2013). Spatially explicit economic assessment of cultural ecosystem services: Non-extractive recreational uses of the coastal environment related to marine biodiversity. *Marine Policy, 38*, 90–98. https://doi.org/10.1016/j.marpol.2012.05.023

Shepard, C. C., Crain, C. M., & Beck, M. W. (2011). The Protective Role of Coastal Marshes: A Systematic Review and Meta-analysis. *PLOS ONE*, *6*(11), e27374. https://doi.org/10.1371/journal.pone.0027374

Sikor, T. (2013). *The Justices and Injustices of Ecosystem Services*. Routledge.

Stallworthy, M. (2006). Sustainability, Coastal Erosion and Climate Change: An Environmental Justice Analysis. *Journal of Environmental Law*, *18*(3), 357–373. https://doi.org/10.1093/jel/eql017

Stephenson, J., Berkes, F., Turner, N. J., & Dick, J. (2014). Biocultural conservation of marine ecosystems: Examples from New Zealand and Canada. *IJTK Vol.13(2) [April 2014]*. http://nopr.niscair.res.in/handle/123456789/27907

Suárez, M., Barton, D. N., Cimburova, Z., Rusch, G. M., Gómez-Baggethun, E., & Onaindia, M. (2020). Environmental justice and outdoor recreation opportunities: A spatially explicit assessment in Oslo metropolitan area, Norway. *Environmental Science & Policy*, *108*, 133–143. https://doi.org/10.1016/j.envsci.2020.03.014

Thrush, C. (2006). City of the Changers. *Pacific Historical Review*, *75*(1), 89–117. https://doi.org/10.1525/phr.2006.75.1.89

U.S. Census Bureau. (n.d.). *3. Understanding and Using ACS Single-Year and Multiyear Estimates*. https://www.census.gov/content/dam/Census/library/publications/2018/acs/acs_general_handbook_2018_ch03.pdf

US Census Bureau. (n.d.). *Census Bureau Releases Estimates of Undercount and Overcount in the 2020 Census*. Census.Gov. Retrieved March 11, 2022, from https://www.census.gov/newsroom/press-releases/2022/2020-census-estimates-of-undercount-and-overcount.html

US Department of Commerce, N. O. and A. A. (n.d.). *Estuaries Tutorial: NOAA's National Ocean Service Education*. Retrieved May 24, 2021, from https://oceanservice.noaa.gov/education/tutorial_estuaries/est01_whatis.html

Villamagna, A. M., Mogollón, B., & Angermeier, P. L. (2014). A multi-indicator framework for mapping cultural ecosystem services: The case of freshwater recreational fishing. *Ecological Indicators*, *45*, 255–265. https://doi.org/10.1016/j.ecolind.2014.04.001

Vorstius, A. C., & Spray, C. J. (2015). A comparison of ecosystem services mapping tools for their potential to support planning and decision-making on a local scale. *Ecosystem Services*, *15,* 75–83. https://doi.org/10.1016/j.ecoser.2015.07.007

Weinstein, M. P. (2007). Linking restoration ecology and ecological restoration in estuarine landscapes. *Estuaries and Coasts*, *30*(2), 365–370. https://doi.org/10.1007/BF02700179

Wilkerson, I. (2010). *The Warmth of Other Suns: The Epic Story of America's Great Migration*. Random House.

Wilkinson, C. (2010). *The People Are Dancing Again: The History of the Siletz Tribe of Western Oregon*. Seattle: University of Washington Press.

Wolff, S., Schulp, C. J. E., & Verburg, P. H. (2015). Mapping ecosystem services demand: A review of current research and future perspectives. *Ecological Indicators*, *55,* 159–171. https://doi.org/10.1016/j.ecolind.2015.03.016

Yamashita, H. (2021). *Coastal Wetlands Restoration: Public Perception and Community Development*. Routledge.

Zhang, L., Lü, Y., Fu, B., Dong, Z., Zeng, Y., & Wu, B. (2017). Mapping ecosystem services for China's ecoregions with a biophysical surrogate approach. *Landscape and Urban Planning*, *161*, 22–31. https://doi.org/10.1016/j.landurbplan.2016.12.015

Appendix A

Analysis of estuary restoration project treatments

Table of mapped estuary restoration projects from the Oregon Watershed Restoration Inventory database (1995-2020) with indication of treatment impact for each mapped ecosystem service. When projects have multiple treatments project numbers repeat with all treatments for a project listed consecutively.

Project Number	Activity	Treatment	Description	Aesthetics impact	Recreation impact	Salmon impact
20000116	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	Built a new levee to protect private property and restore estuarine wetlands by first removing portions of the existing damaged Dawson levee and the levee around Stowe Marsh that is owned by Oregon Department of Fish and Wildlife. The levee removal from	X	X	X
20000617	Estuarine improvement	Existing estuary improved by debris removal	Removed over 30 cu yards of garbage and 100 tires from Nestucca bay. Local citizen activists and the watershed council organized the one-day event that attracted over 90 volunteers. More, see form. 8.2 miles of shoreline cleaned	X	X	X
20020814	Estuarine vegetation planting	Estuarine vegetation planted	Native plant revegetation--above high tide line in area of disturbance seeded with native grass, sitka spruce on 4' centers interspersed with willow cuttings and twin berry plants. --below high tide line: salt marsh plants on	X	X	X

			2' centers collected from sit			
20020814	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	Removed 2300 cubic yard earthen dam to restore full tidal flow and salt water circulation. Plugged lower end of bypass canal to assure flow from Lint Creek went through slough.	X	X	X
20030197	Estuarine vegetation planting	Estuarine vegetation planted	Trees planted in estuary (willows & conifers).	X	X	X
20030197	Estuarine restoration	Estuarine connection restored by removal of existing fill material (other than dike)	15,000 cubic yards removed from Winchuck Estuary to restore function Other activity: gate installed to prevent vandalism.	X	X	X
20040843	Estuarine restoration	Estuarine connection restored by estuarine culvert modification / removal	Replacement of culvert in order to re-connect wetland to Caching Slough. Raised Sealander Rd 1ft to protect adjacent landowner from wetland flooding.	X	X	X
20040844	Estuarine restoration	Estuarine connection restored by estuarine culvert modification / removal	Replacement of failing culvert and tidegates with culvert, filled two additional cedar culverts. Project re-connected	X	X	X

			freshwater wetlands to tidal influence.			
20040845	Estuarine improvement	Existing estuary improved by channel modification	Large wood placed into the tidal upper part of Winchester Creek and the lower tidal part of Anderson Cr	X		X
20040847	Estuarine improvement	Existing estuary improved by debris removal	50 acres of trash removed, and site design completed.	X	X	X
20040848	Estuarine vegetation planting	Estuarine vegetation planted	Pasture and drain areas planted with riparian trees and shrubs.	X	X	X
20040848	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	Breached dike filled with compacted earth, deteriorating levee repaired, fish passage structure weir-pool ladder with 48' pipe for passage both ways into and out of wetland. 100 ft spillway installed in the dike to provide hydraulic connection over the d	X	X	X
20040851	Estuarine vegetation planting	Estuarine vegetation planted	Planting of native wetland riparian trees and shrubs. Invasive species control of Himalayan blackberry and Reed Canary grass controlled with herbicide.	X	X	X

20040851	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	Planting of native wetland riparian trees and shrubs. Invasive species control of Himalayan blackberry and Reed Canary grass controlled with herbicide.	X	X	
20050046	Estuarine improvement	Existing estuary improved by channel modification	One whole tree and five stumps with rootwads were placed within 0.2 acre of Stanley Marsh. See "Other Activity" below for details. One LWD structure placed in marsh consisting of 6 total pieces. One piece was a whole tree with rootwad and limbs. Five p	X	X	X
20050445	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	+/- 1100 feet of dike was removed to allow diurnal tidal flooding to enter the site that was previously isolated from the tide.	X	X	X
20050854	Estuarine improvement	Existing estuary improved by channel modification	Easement only. Restoration plan completed, but landowner resisted implementation. Grazing removed. To date, no additional restoration has been carried out. Latest landowner contact in 8/2004 re-opened discussions, but landowner intends to sell property.	X		
20060432	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	NA	X	X	

20060433	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	NA	X	X	
20070106	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	Re-establish full wetland values and functions on former tidal wetland in the Little Nestucca River estuary by breaching and/or removing 3,400 feet of dike, filling drainage ditches and re-establishing former tidal channels.	X	X	X
20070754	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	levee removed	X	X	X
20080221	Estuarine improvement	Existing estuary improved by reintroduction of native animal species	planting Olympia oysters in eelgrass estuarine habitat - native Oysters were reintroduced to a portion of Netarts Bay. Three acres were planted and monitored for interactions with native eelgrass.		X	
20090275	Estuarine creation	Estuarine habitat created from non-estuarine/non-wetland area	Additional estuarine habitats from the former uplands were created after the dikes and berms were removed.	X	X	X

20090275	Estuarine improvement	Existing estuary improved by channel modification	Improved tidal hydrology over 130 acres of mudflats and marshes. Removed impediments to tidal function and process. Two and a half acres of estuarine habitat were created. Half of remaining area was existing estuary improved by channel modification and	X	X	X
20090275	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	Improved tidal hydrology over 130 acres of mudflats and marshes. Removed impediments to tidal function and process. Two and a half acres of estuarine habitat were created. Half of remaining area was existing estuary improved by channel modification and	X	X	X
20090336	Estuarine vegetation planting	Estuarine vegetation planted	planted with 3000 willow and 400 conifers.	X	X	X
20090336	Estuarine improvement	Existing estuary improved by channel modification	Large wood placed, stream channel restored, planted with 3000 willow and 400 conifers	X	X	X
20090336	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	NA	X	X	X
20100191	Estuarine restoration	Estuarine connection restored by estuarine culvert modification / removal	Restored tidal flow to 6 acre marsh/ wetland - Tidal flow can now access 6 acre area.	X	X	X

20110214	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	In 2010 & 2011, reed canary grass and Himalayan blackberries were cleared around the plantings to help them attain 'free-to-grow' status. A 3 person crew used weed whackers and a DR mower to accomplish this activity.	X	X	
20110314	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	By draining and filling artificial ditches, grading artificial fill to original marsh floor elevation, reestablishing channels, removing invasive plants and planting native species, project partners completed Phase I of an effort to return this estuarine	X	X	X
20110435	Estuarine vegetation planting	Estuarine vegetation planted	NA	X	X	
20110435	Estuarine improvement	Existing estuary improved by channel modification	Placed 125 logs at 20 sites and planted sitka spruce into placed nurse logs	X	X	X
20120712	Estuarine vegetation planting	Estuarine vegetation planted	NA	X	X	
20120712	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	NA	X		

20120712	Estuarine improvement	Existing estuary improved by channel modification	The project actions involved extensive marsh plain lowering, channel creation and restoration, LWD installation, re vegetation and levee breaching. A cross levee was also constructed to US Army Corps standards to provide flood protection to the diking di	X	X	X
20120712	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	Approximately 0.1 mile of levee was breached. The pre-existing levee on the project site was approximately 2,000 feet. The project removed approximately 500 feet of levee in 6 breach locations so 0.1 mile of levee removal.	X	X	X
20120718	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	This project entailed the control of reed canary grass, as well as the removal of blackberry, scotch broom, knot weed, Robert's geranium, English ivy, English holly, cotoneaster and periwinkle. Invasive control techniques included mowing, landscape fabri	X	X	X
20120720	Estuarine restoration	Estuarine connection restored by estuarine culvert modification / removal	Replaced culvert for unimpeded fish passage and tidal connectivity.	X	X	X
20140003	Estuarine improvement	Existing estuary improved by channel modification	Constructed 2400 linear feet of new, meandering channel	X	X	X

20140003	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	Removed 2000 linear feet of dike	X	X	X
20140118	Estuarine vegetation planting	Estuarine vegetation planted	Replanted 35 acres of wetland with native trees, shrubs and emergent vegetation	X	X	
20140118	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	Stripped out reed canarygrass and grubbed out blackberry	X	X	
20140118	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	Remove approximately 1700 ln. ft. of levee to reconnect 35 acres of floodplain	X	X	X
20140201	Estuarine vegetation planting	Estuarine vegetation planted	3 acres of wetland previously re-graded and reconnected to tidal influence under other funding were re-vegetated through this project. The plant materials included willow and red-osier cuttings from on site as well as potted trees and plant plugs from the	X	X	X
20140361	Estuarine improvement	Existing estuary improved by channel modification	NA	X	X	X
20140361	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	NA	X	X	X

20140393	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	Trees growing on the dike were felled and dragged to an upland site. 400 feet of dike were removed with 1,200 cubic yards of dike earth removed. Dike site was excavated to the natural marsh level. Earth was hauled by track dump truck to an upland disposa	X	X	X
20140424	Estuarine vegetation planting	Estuarine vegetation planted	NA	X	X	
20150126	Estuarine vegetation planting	Estuarine vegetation planted	NA	X	X	
20150128	Estuarine vegetation planting	Estuarine vegetation planted	Streambank restoration through plantings of Scripus, Pacific Water Parsley, Tufted Hair Grass, Juncus and Pacific Silverweek based on the existing plant communities in the estuary (PDC #36). This included disturbed areas planted with Juncus, Carex, Descha	X	X	
20150128	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	Estuarine Upland Non native treated species: Phalaris arundinacea	X	X	

20150128	Estuarine improvement	Existing estuary improved by channel modification	a. See the berm removal treatment b. Channel modification treatment (6 foot wide channel): Filling of 510,Äô of the boat basin ditch c. Construction of a new meandering channel at the bottom of Mink Creek (PDC #24). Channel designs were reviewed and ap	X	X	X
20150128	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	The removal of 766,Äô long and approximately 90,Äô wide (PDC #27) berm, and placement of those spruce trees removed from the berm within the floodplain (PDC #22).	X	X	X
20150346	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	NA	X	X	
20150352	Estuarine vegetation planting	Estuarine vegetation planted	NA	X	X	
20150352	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	NA	X	X	
20170103	Estuarine improvement	Existing estuary improved by channel modification	3730' tidal channel re-created	X	X	X

20170103	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	1900' dikes removed and 5000' agricultural ditches filled; former tidal slough system was blocked and farmed historically. project re-opened Stasek Slough and connected tidal channels in project area (access through former slough reopened and connected to	X	X	X
20170240	Estuarine vegetation planting	Estuarine vegetation planted	NA	X	X	
20170240	Estuarine improvement	Existing estuary improved by channel modification	NA	X	X	X
20170279	Estuarine restoration	Estuarine connection restored by dike or berm modification / removal	NA	X	X	X
20180246	Estuarine vegetation planting	Estuarine vegetation planted	NA	X	X	
20180246	Estuarine invasive plant control	Estuary treated for non-native or noxious plant species	Noxious plant species included reed canarygrass, Himalayan blackberry, bindweed and Canadian thistle have been the targets for invasive plant control and we are making steady success in reducing their cover at the site and replacing them with native shrub	X	X	
20200302	Estuarine improvement	Existing estuary improved by channel modification	NA	X	X	X

20200302	Estuarine restoration	Estuarine connection restored by estuarine culvert modification / removal	NA		X	X	X
20200406	Estuarine improvement	Existing estuary improved by channel modification	NA		X	X	X