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Nature's Value in the Skykomish Watershed:

An Ecosystem Services Valuation of the Lower Skykomish and Braided Reach

EARTH ECONOMICS

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List of Abbreviations

BTM	Benefit Transfer Method
BCA	Benefit-Cost Analysis
CBO	Congressional Budget Office
ESV	Ecosystem Services Valuation
OBM	Office of Budget and Management
SLS	Sustainable Land Strategy

> "As long as we are forced to make choices, we are going through the process of valuation."
>
> -Robert Costanza

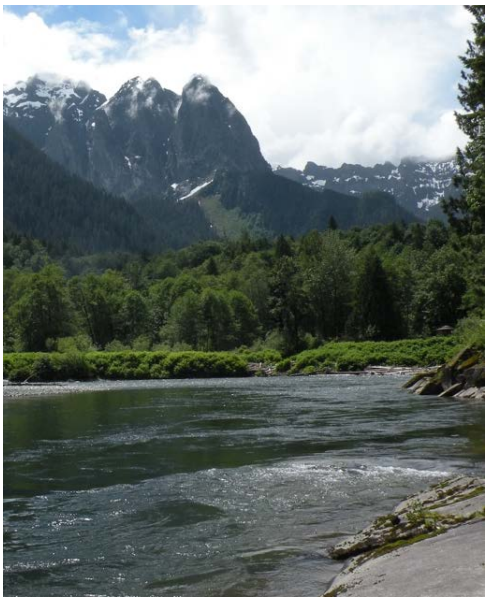
Executive Summary

Understanding the value of the goods and services that nature provides is a critical first step when making decisions regarding natural resource management. Nature's goods include fish, timber, drinking water and agricultural products, while services include food protection, drinking-water filtration, local weather and climate stability, beauty, and recreation. These are just a few examples of the natural goods and services which our communities rely on.

This report values some of the ecosystem goods and services provided by the Lower Skykomish Reach and the Braided Reach, including their associated sub-basins, in the Snohomish Watershed in Western Washington State. Our analysis reveals that **the combined ecosystems of the Lower Skykomish and Braided Reach provide between $888 million and $1.6 billion in economic value every year**. In present terms, the Lower Skykomish Reach and the Braided Reach are valued between $89 billion and $166 billion when considering a 100-year timeframe.

Resilient communities and economic sustainability rely on healthy ecosystems. Ecosystem Services Valuation (ESV) is key to advancing the Sustainable Lands Strategy (SLS) goals of safeguarding the agricultural sector, restoring and protecting salmon habitat, and reducing flood damage. When nature is included in the financial bottom line, it becomes harder to ignore costly impacts development decisions have on our ecosystems, and economy.

Introduction



The Skykomish River is a critical part of Snohomish County's ecosystem and economy. As a central source of clean water in the Snohomish Watershed, the river provides an array of natural goods, including agricultural products, salmon, timber, and drinking water. Moreover, the river provides services critical to the vitality of the county's economy, including food production, recreation opportunities, water filtration, and aesthetic value. The Lower Skykomish and Braided Reaches, each fed by a corresponding sub-basin in the Snohomish Watershed, comprise a critical area of the lower Skykomish River, particularly for local farmers.

Challenges arise when heavy precipitation events increase the Skykomish's flow. Unbounded by riparian buffers, the Skykomish cuts away at productive lands that border its banks. Local farmers estimate losses of 15 feet of bank per year since 1990 in some localized areas. Moreover, the area is prone to overbank flooding. While floods are natural and can be beneficial to ecosystems, they can also cause significant damage to private property and public infrastructure. Snohomish County reports that in 2006 alone, flooding was responsible for over $25 million worth of damage in the Snohomish Watershed.[1]

To address these issues, Snohomish County, the Tulalip and Stillaguamish Tribes, state and federal agencies, and agricultural and environmental stakeholders created the Sustainable Lands Strategy (SLS). The SLS works across sectors to develop natural resource management plans that support farmers, protect and establish fish habitat, and reduce the risk of flooding. Recognizing the importance of understanding the value of ecosystem services when making natural resource management decisions, Snohomish County contracted with Earth Economics to produce the report "*Nature's Value in the Skykomish Watershed: A Rapid Ecosystem Service Valuation.*" Released in 2011, our report quantified the annual economic value that nature supplies within the watershed and further recommended that the

As the source of a vast share of biodiversity and ecological services, floodplains are one of the plant's most valuable ecosystems.[1]

county consider the conservation and the restoration of these Skykomish Watershed ecosystems a key investment in the future economy.

The present report builds off our previous work and provides updated ecosystem services valuation (ESV) numbers with a specific focus on the Lower Skykomish Reach and the Braided Reach, including their associated sub-basins. By taking a narrower approach to valuing ecosystem services in sub-regions throughout the Snohomish Watershed, the County will be better positioned to **strategically prioritize flood mitigation and watershed restoration projects to protect productive land and natural habitat**.

This report is complemented by a sample benefit-cost analysis (BCA) of the Lower Skykomish Reach Restoration Site, entitled "*Flood Damage in the Snohomish Watershed: A Benefit-Cost Analysis of Interventions in the Lower Skykomish Reach.*" The sample BCA incorporates the updated ESV values reported below.

Study Site Overview

This assessment focuses on a portion of the larger Skykomish Watershed. For county planning efforts, the Skykomish River floodplain is separated into floodplain planning area reaches, all with varying characteristics. These reach segments allow for focused analysis. This valuation focuses on the sub-watersheds that drain into two Skykomish River floodplain planning reaches, the Lower Skykomish Reach and Braided Reach.

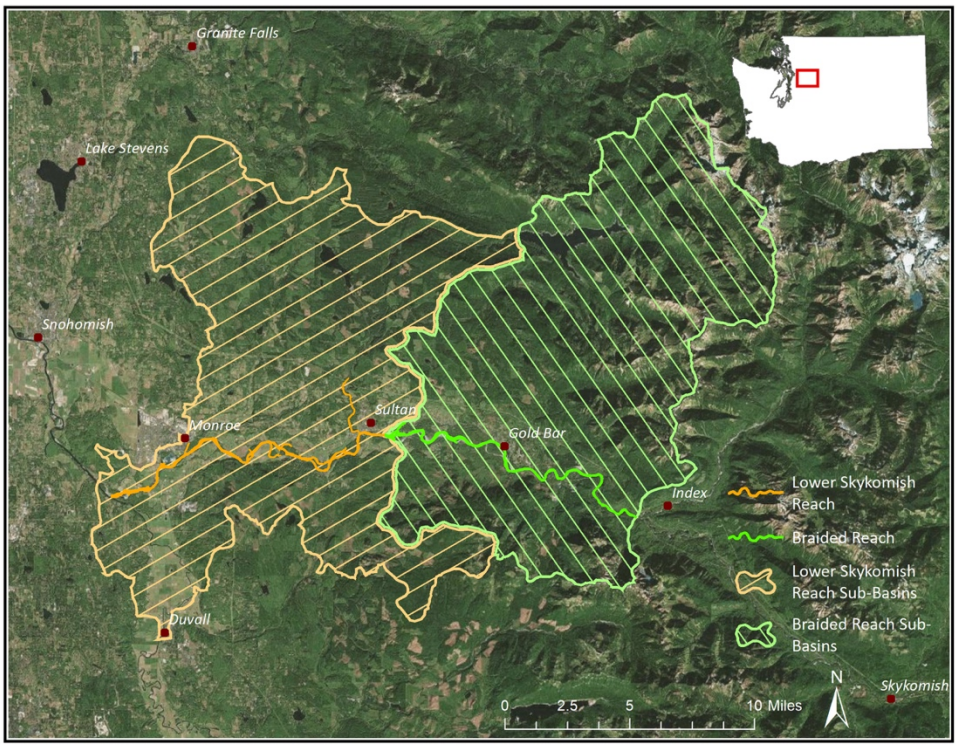
The Lower Skykomish Reach represents the portion of the Skykomish River from river mile zero to 13.5. The five sub-basins that flow into this reach are aggregated to create a larger sub-basin; these sub-basins include Snoqualmie Mouth, Lower Mainstem Skykomish, Lower Sultan River, Woods Creek, West Fork Woods Creek, and Lower Woods Creek. This group of sub-basins includes the urban areas of Monroe and Sultan, as well as significant agricultural lands in the fertile Skykomish River floodplain. Lake Chaplain, a water source for the City of Everett, is also included in this sub-basin.

The Braided Reach of the Skykomish River runs from river mile 13.5 to 23.15 and its associated sub-basins include May Creek, Upper Mainstem Skykomish, Upper Wallace River, Olney Creek, Bear Creek, and Upper Sultan River. This group of sub-basins includes the urban area of Gold Bar, a small portion of Sultan, and Spada Lake, a water supply reservoir for the City of Everett.

Further upstream, these sub-basins are characterized by forested foothills, a portion of which is the federally owned Mount Baker-Snoqualmie National Forest.

Figure 1 depicts the aggregated sub-basins for the Lower Skykomish Reach and Braided Reach.

Figure 1. Study Area, Lower Skykomish and Braided Reaches with Associated Sub-basins



Ecosystem Services Valuation in Lower Skykomish Reach and Associated Sub-basins

Ecosystem Services Framework

Like other forms of capital, natural capital provides a flow of goods and services. These goods and services are the basis of all other economic activity as they provide clean water, breathable air, nourishing food, flood risk reduction, waste treatment, climate stability, and other critical services. Without natural capital, many of the benefits we receive for free could not exist and

would need to be replaced and maintained at a high cost. Working together, economists and ecologists can often identify the presence, quantity, and economic contribution of ecosystem services in a particular location.

This study involves four major steps:

Step 1. Identification and Quantification of Landcover Classifications: Geographic Information Systems (GIS) data, including landcover (CCAP 2011, WSDA 2015, NWI) and sub-basin outlines, were used to calculate the extent of each landcover type (e.g. wetland, forest, shoreline) within the study area.

Step 2. Identification and Valuation of Ecosystem Services: The economic contribution of each ecosystem service–landcover combination (e.g. Disaster Risk Reduction–Forests) was estimated using the benefit transfer method (described below). Where the supporting research provided low and high value estimates, these have been reported. Where valuation estimates for particular ecosystem service–landcover combinations were not available, values were not reported. This is not meant to suggest that such ecosystem services contribute no value at all – only that rigorous research on those contributions was not publicly available at this time.

Step 3. Annual Value of Ecosystem Services: The sum of all annual estimates for the ecosystem services provided per-acre by each landcover type were then scaled by the extent of corresponding landcover classes within the study area to calculate the total annual contribution of ecosystem services within the study area. The annual contributions of all landcover types were then combined to calculate the total annual value of ecosystem services.

Step 4. Net Present Value Calculations: The net present value was calculated for the study site over 100 years at three discount rates: zero, three, and seven percent. Net present value and discount rates are methods designed to allow the benefits accrued over many years to be compared to investments and returns in the present day.

The ecosystem service descriptions and categorizations used in this report (see Table 1) are derived from work by DeGroot et al. (2002) and Sukhdev et al. (2010).[3,4]

Table 1. Ecosystem Services Definitions

Good/Service	Economic Benefit to People
Provisioning Services	
Food	Producing crops, fish, game, and fruits
Medicinal Resources	Providing traditional medicines, pharmaceuticals, and assay organisms
Ornamental Resources	Providing resources for clothing, jewelry, handicrafts, worship, and decoration
Energy and Raw Materials	Providing fuel, fiber, fertilizer, minerals, and energy
Water Storage	The quantity of water held by a water body (surface or ground water) and its capacity to reliably supply water
Regulating Services	
Air Quality	Providing clean, breathable air
Biological Control	Providing pest and disease control
Climate Stability	Supporting a stable climate at global and local levels through carbon sequestration and other processes
Disaster Risk Reduction	Preventing and mitigating natural hazards such as floods, hurricanes, fires, and droughts
Pollination and Seed Dispersal	Pollination of wild and domestic plant species
Soil Formation	Creating soils for agricultural and ecosystems integrity; maintenance of soil fertility, sediment transport for fish spawning areas
Soil Quality	Improving soil quality by decomposing human and animal waste and removing pollutants
Soil Retention	Retaining arable land, slope stability, and coastal integrity
Water Quality	Improving water quality by decomposing human and animal waste and removing pollutants
Water Capture, Conveyance, and Supply	Providing natural irrigation, drainage, groundwater recharge, river flows, drinking water supply, and water for industrial use
Navigation	Maintaining water depth that meets draft requirements for recreational and commercial vessels
Supporting Services	
Habitat and Nursery	Maintaining genetic and biological diversity, the basis for most other ecosystem functions; promoting growth of commercially harvested species
Information Services	
Aesthetic Information	Enjoying and appreciating the presence, scenery, sounds, and smells of nature
Cultural Value	Using nature as motifs in art, film, folklore, books, cultural symbols, architecture, media, and for religious and spiritual purposes
Recreation and Tourism	Experiencing the natural world and enjoying outdoor activities
Science and Education	Using natural systems for education and scientific research

Benefit Transfer Method

The benefit transfer method (BTM) is broadly defined as "the use of existing data or information in settings other than for what it was originally collected".[5] As such, BTM is an efficient means of generating broad-based estimates at a fraction of the cost and time necessary to conduct multiple primary studies, which may require more than $50,000 per service–landcover combination. BTM plays an important role in the field of ecosystem services valuation, as it is often the most practical option available for producing reasonable estimates.[6]

BTM begins by identifying primary studies of similar ecosystems and communities as reported in peer-reviewed journals, and reviews each to ensure that only those with compatible assumptions and landcover types are included. Each value estimate in these studies is then standardized for units of measure, inflation, and landcover classification to ensure "apples-to-apples" comparisons, as these estimates are "transferred" to the study site. In this sense, BTM is similar to a home appraisal, in which the features and pricing of similar nearby homes are used to estimate the appraised value of other homes. While neither process is perfect, they are able to quickly and efficiently generate reasonable values for policy and project analysis. Where primary studies report a range of values (to reflect the uncertainty or variability within the research area), low and high per-acre value estimates have been reported.

Valuation Methods

The primary studies from which values are drawn employ a range of valuation techniques depending on the specific circumstances, including:

- **Market Pricing:** The current market value of goods produced within an ecosystem (e.g., food, timber).
- **Replacement Cost:** The cost of replacing the services provided by functional natural systems with man-made infrastructure (e.g., the installation of a levee to replace natural floodplain protection).
- **Avoided Cost:** Ecosystem services can help communities avoid harm that would have incurred in the absence of those services (e.g. flooding reduction by wetlands and riparian buffers).
- **Production Approaches:** Ecosystem services which enhance output (e.g. rain-fed irrigation can increase crop productivity).

- **Travel Cost:** Demand for some ecosystem services may require travel, the cost of which reflects the implicit value of those services (e.g., recreation and tourism).
- **Hedonic Pricing:** Property values vary by proximity to some ecosystem services (e.g. homes with water views often sell for higher prices than similar homes without such views).
- **Contingent Valuation:** Estimates of value based on surveys of the values assigned to certain activities (e.g., willingness-to-pay to protect water quality).

The valuation of most ecosystem services is well-understood and straightforward. However, for ecosystem services that are difficult to value, the benefits are often better described qualitatively.

Asset Valuation

The asset value of built capital, such as a road, levee, home, or business, can be calculated as the net present value of its expected future benefits. In the same way that a home holds value year after year, natural capital also provides value overtime. Provided the natural capital of Snohomish County is not degraded or depleted, the annual flow of ecosystem services will continue into the future. As such, analogous to built capital, we can calculate the asset value of natural capital in Snohomish County.

The asset value calculated in this report is based on a snapshot of the current landcover, consumer preferences, population base, and productive capacities. It provides a measure of the expected benefits flowing from the study area's natural capital over time. The net present value formula is used to compare benefits that are produced at various points in time. In order for this to be accomplished, a discount rate must be used.

Discounting allows for sums of money occurring in different time periods to be compared by expressing the values in present terms. In other words, discounting shows how much future sums of money are worth today. Discounting is designed to take two major factors into account:

1. Time preference. People tend to prefer consumption now over consumption in the future, meaning a dollar today is worth more than a dollar received in the future.
2. Opportunity cost of investment. Investment in capital today provides a positive return in the future but renders those funds unavailable for other investment opportunities.

However, experts disagree on the appropriate discount rate for natural capital benefits. Public and private agencies vary widely in their standards for discount rates. The Office of Management and Budget (OMB) recommends a seven percent rate for average investments, while the Congressional Budget Office (CBO) recommends a two percent rate for long-term investments. The choice of discount rate is critical, however, as it heavily influences the outcome of the present values of benefits which occur over a long period of time. This report uses three discount rates to analyze the asset value of Snohomish County: a standard seven percent discount rate, a lower three percent discount rate, and a zero percent discount rate. Lower discount rates better demonstrate the value of long-term assets, as benefits hundreds of years into the future are discounted at a smaller rate.

Present values can be calculated over different timeframes depending on the purpose of the analysis and the nature of the project. In the case of natural capital valuations, ecosystems, if kept healthy, show long-term stability and productivity. Although many built capital projects are valued for shorter timespans, we chose a 100-year timeframe to reflect the longevity of ecosystems' stability and productivity. If kept healthy, Snohomish County natural capital can provide benefits for much longer than 100 years.

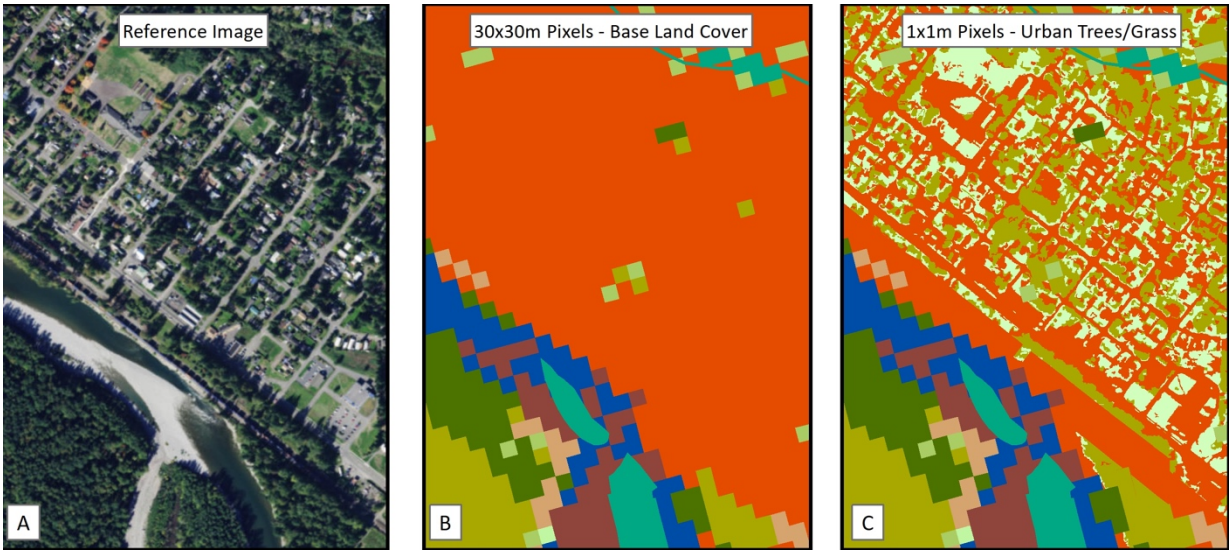
Landcover Approach

This ecosystem service valuation for the Lower Skykomish and Braided Reach Sub-Basins used a landcover-based approach, assigning value based on remotely derived landcover classifications. GIS was used to aggregate primary datasets, creating a better understanding of natural asset characteristics in both urban and rural settings. The base landcover for this analysis is NOAA's 2011 C-CAP data, which provides 30x30m resolution categorization of landcover. We overlaid several additional datasets to refine this dataset.

First, to better characterize croplands, field-level agricultural data from the Washington State Dept. of Agriculture was used to designate additional cultivated land not identified in C-CAP data. Next, we used the Washington Urban Growth Area boundaries to classify urban areas. Our base dataset identified areas of low-, medium-, and high-density development, but it did not designate the full extent of urban areas. The value of ecosystem services provided by urban open spaces can differ from rural natural capital value. Within the study area, the 30x30m base C-CAP data does not identify urban green space known to be present. To better describe the landcover within Urban Growth Areas, we used 1x1m resolution landcover data developed by Ken Pierce at the Washington State Department of Fish and Wildlife. This data accounts for a

larger percentage of urban trees and green space, originally designated as 'developed' by C-CAP data. Figure 2 compares the spatial resolution of the two datasets (30x30m vs. 1x1m pixels); Panel B depicts base landcover (C-CAP, 2011) and Panel C depicts high resolution (1x1m) vegetation overlaid on base landcover showing the increased urban trees/grass identified.

Figure 2. Land Cover Resolution Comparison



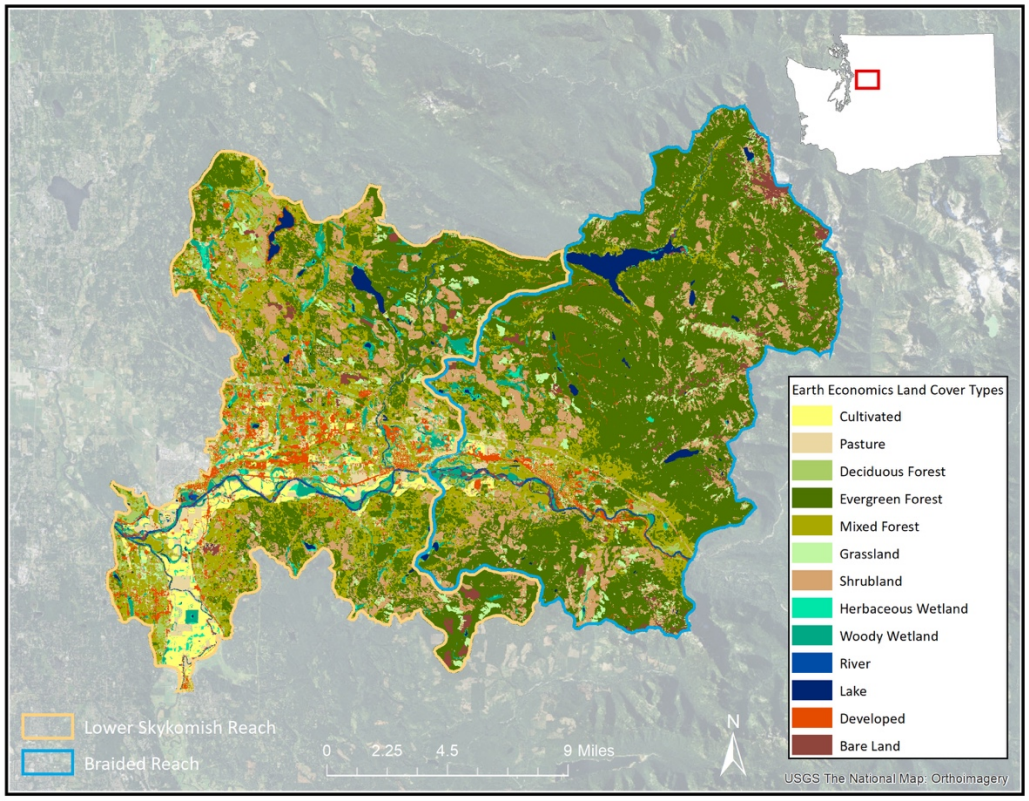
An additional refinement was made to assess the riparian areas present along the lakes, rivers, and upland streams in the study area. The National Wetlands Inventory (NWI) provides greater detail and is used to classify wetlands, lakes, and streams. Utilizing upland streams identified in the NWI, we classified forested riparian areas in the upper watershed areas of the sub-basins. Similar to urban areas, high-functioning riparian forests provide different value from non-riparian forest.

Table 2 and Figure 3 below depict the aggregation of C-CAP data, WSDA crop data, and NWI wetlands data used to generate the base landcover classifications for this valuation. After establishing these classes, agricultural, urban, and riparian attributes were assigned to base landcover types. The sources for attributes are described above and outlined in Table 3.

Table 2. C-CAP 2011 Landcover Classification and Earth Economics Landcover Classification (C-CAP Unless Noted Otherwise)

C-CAP 2011 Landcover Classification (unless noted)	Earth Economics Landcover Classification
Cultivated Crops	Crops
Crops (excluding Hay/Silage) (WSDA 2016 Ag Land Use)	
Pasture/Hay	Pastures
Hay/Silage (WSDA 2016 Ag Land Use)	
Deciduous Forest	Forests, Deciduous
Evergreen Forest	Forests, Evergreen
Mixed Forest	Forests, Mixed
High Intensity Vegetation, within Developed Urban (HRLC, Pierce 2017)	
Grassland/Herbaceous	Grassland
Scrub/Shrub	Shrubland
Developed, Open Space	Urban Open Space
Low Intensity Vegetation (HRLC, Pierce 2017)	
Freshwater Pond (NWI, 2017)	Lake
Lake (NWI, 2017)	
Open Water	River
Palustrine Aquatic Bed	
Riverine (NWI, 2017)	
Palustrine Scrub/Shrub Wetland	Woody Wetland
Freshwater Forested/Shrub Wetland (NWI, 2017)	
Palustrine Emergent Wetland	Herbaceous Wetland
Freshwater Emergent Wetland (NWI, 2017)	
Developed, High Intensity	Developed
Developed, Medium Intensity	
Developed, Low Intensity	
Barren Land	Bare Land
Unconsolidated Shore	
Perennial Ice/Snow	

Figure 3. Land Cover of the Lower Skykomish and Braided Reach Sub-Basins



Attribute Filters

As described above, base landcover was modified in several ways to enable a more detailed description of the natural capital of the study area. “Spatial attributes” were constructed to describe unique locations of ecosystems within the landscape. In this analysis, we considered three spatial attributes that affect ecosystem service values: proximity to agricultural areas and the location of landcovers within riparian and urban zones. Table 3 describes how each spatial attribute was derived and the datasets involved in calculating the boundaries of each spatial attribute. For example, classifying a certain acre of forest as “riparian” allows us to choose ecosystem service values unique to riparian forests. Identifying the spatial attributes of landcover data allows the application of more granular study values. This can increase accuracy as each attribute provides information that narrows the scope of values and mitigates uncertainty. Valuations tend to be more accurate when the spatial distribution of values is taken into account. [7]

Table 3. Data for Definition of Attributes

Attribute	Source
Riparian	U.S. Fish and Wildlife Service, 2016 National Wetlands Inventory
Agricultural	Washington State Department of Agriculture, 2016 Agricultural Land Use
Urban	Washington State Office of the Chief Information Officer (OCIO) and the Department of Ecology, 2015 Urban Growth Area Boundaries

Table 4. Landcover Acreages for the Lower Skykomish and Braided Reaches

Lower Skykomish and Braided Reach Land Cover					
Landcover Classification	Attribute			Lower Skykomish Sub-basin (Acres)	Braided Sub-basin (Acres)
	Agricultural	Riparian	Urban		
Cultivated					
Cultivated Crops	A			5,796	328
Pasture	A			4,938	589
Forests					
Deciduous Forest				5,056	1,887
		R		481	290
			U	303	31
Evergreen Forest				29,046	58,983
		R		3,138	9,779
			U	58	38
Mixed Forest				22,317	8,877
		R		2,569	1,345
			U	816	308
Grasslands					
Grassland				3,778	3,233
		R		202	579
Shrubland					
Shrubland				14,749	15,206
		R		998	2,344
Open Space					
Open Space			U	351	167

Water					
Lake				1,244	2,266
River				898	489
Wetlands					
Woody Wetland				4,566	1,496
	A			85	2
			U	390	24
Herbaceous Wetland				984	255
	A			347	12
			U	144	1
Total Area Valued				**103,254**	**108,529**
Other Land (Not Valued)					
Developed				6,592	1,664
Bare Land				1,503	2,963
Total Sub-basin Area				**111,350**	**113,157**

Annual Value of Natural Capital in the Lower Skykomish and Braided Reach Sub-basins

Ecosystem Services Identified

For this analysis, 15 ecosystem services were valued across 12 landcover types. The greatest limitation to this analysis is a lack of valuation studies representing all of the ecosystem services provided in Snohomish County. Many ecosystem services that clearly have economic value provided by a landcover type could not be assigned value due to a lack of applicable values available in the literature. In particular, grasslands and scrublands provide habitat for numerous species but could not be assigned full ecosystem service values due to data gaps. Table 5 presents the ecosystems services valued for each landcover type. Grey squares indicate the services that were valued.

Table 5. Ecosystem Services Valued in both Lower Skykomish and Braided Reach Watersheds

Gap Analysis																			
	Attributes																		
Attribute/ES	Agriculture	Riparian	Urban	Aesthetic Information	Air Quality	Biological Control	Disaster Risk Reduction	Energy & Raw Materials	Food	Habitat	Pollination & Seed Dispersal	Recreation & Tourism	Soil Formation	Soil Quality	Soil Retention	Water Capture, Convevance, & Supply	Water Quality	Water Storage
Cultivated																		
Crops	A																	
Pasture	A																	
Forests																		
Deciduous																		
		R																
			U															
Evergreen																		
		R																
			U															
Mixed																		
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Open Space																		
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Grasslands																		
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		R																
Water																		
Lakes																		
Rivers																		

Wetlands																		
Woody																		
	A																	
			U															
Herbaceous																		
	A																	
			U															

The Value of Ecosystem Services

Non-urbanized areas of the Lower Skykomish sub-basin are dominated by forests, crops and scrublands. Table 6 and Table 7 summarize the values calculated across all landcover types present in the Lower Skykomish and Braided Reach. For example, each acre of shrubland in the Lower Skykomish Reach has been estimated to provide about $10 in soil retention[8] and $59 for recreation and tourism[9] annually. To that you add the value of climate stability, $89, the value of energy and raw material, $33, and $1 for air quality[10] each year to equal a total sum of $192 in yearly benefits per acre of shrubland (see Table 6).

Table 6. Value of Ecosystem Services in Lower Skykomish Watershed (acre/year)*

Lower Skykomish Reach								
	Attributes				USD/acre/year		USD/year	
	Agriculture	Riparian	Urban	Acres	Low	High	Low	High
Cultivated								
Crops	A			5,796	$322	$2,400	$1,869,000	$13,890,000
Pastures	A			4,938	$501	$2,580	$2,476,000	$12,745,000
Forests								
Deciduous				5,056	$2,860	$5,940	$14,436,000	$30,029,000
		R		481	$4,840	$9,480	$2,326,000	$4,562,000
			U	303	$1,620	$5,420	$490,000	$1,641,000
Evergreen				29,046	$3,480	$6,790	$100,967,000	$197,329,000
		R		3,138	$5,430	$10,810	$17,047,000	$33,920,000

			U	58	$1,920	$8,910	$111,000	$517,000
Forests Cont.								
Mixed				22,317	$2,730	$5,370	$61,023,000	$119,837,000
		R		2,569	$4,690	$9,380	$12,040,000	$24,108,000
			U	816	$2,380	$4,890	$1,938,000	$3,988,000
Grasslands								
Grassland				3,778	$178	$184	$672,000	$695,000
		R		202	$8,260	$9,550	$1,669,000	$1,929,000
Shrublands								
Shrubland				14,749	$192	$192	$2,825,000	$2,825,000
		R		998	$18,720	$19,270	$18,681,000	$19,232,000
Open Space								
Open Space			U	351	$1,870	$3,040	$656,000	$1,069,000
Water								
Lakes				1,244	$44	$4,520	$55,000	$5,622,000
Rivers				898	$23,740	$24,700	$21,322,000	$22,180,000
Wetlands								
Woody Wetland				4,566	$33,940	$57,330	$154,960,000	$261,771,000
	A			85	$37,790	$56,090	$3,212,000	$4,768,000
			U	390	$39,380	$71,070	$15,358,000	$27,717,000
Herbaceous Wetland				984	$18,610	$34,740	$18,313,000	$34,182,000
	A			347	$38,350	$57,490	$13,306,000	$19,948,000
			U	144	$37,550	$54,360	$5,407,000	$7,827,000
Totals				**103,254**			**$471,158,000**	**$852,330,000**

*Totals on bottom row are based on unrounded per landcover totals.

Table 7. Value of Ecosystem Services in Braided Reach Watershed (acre/year)*

Braided Reach				
	Attributes	**Acres**	**USD/acre/year**	**USD/year**

	Agriculture	Riparian	Urban		Low	High	Low	High
Cultivated								
Crops	A			328	$322	$2,400	$106,000	$786,000
Pastures	A			589	$501	$2,580	$295,000	$1,520,000
Forests								
Deciduous				1,887	$2,860	$5,940	$5,388,000	$11,207,000
		R		290	$4,840	$9,480	$1,402,000	$2,750,000
			U	31	$1,620	$5,420	$50,000	$168,000
Evergreen				58,983	$3,480	$6,790	$205,031,000	$400,712,000
		R		9,779	$5,430	$10,810	$53,124,000	$105,706,000
			U	38	$1,920	$8,910	$73,000	$339,000
Mixed				8,877	$2,730	$5,370	$24,273,000	$47,667,000
		R		1,345	$4,690	$9,380	$6,304,000	$12,622,000
			U	308	$2,380	$4,890	$732,000	$1,505,000
Grasslands								
Grassland				3,233	$178	$184	$575,000	$595,000
		R		579	$8,260	$9,550	$4,784,000	$5,529,000
Shrublands								
Shrubland				15,206	$192	$192	$2,912,000	$2,912,000
		R		2,344	$18,720	$19,270	$43,877,000	$45,170,000
Open Space								
Open Space			U	167	$1,870	$3,045	$312,000	$509,000
Water								
Lakes				2,266	$44	$4,520	$101,000	$10,242,000
Rivers				489	$23,740	$24,700	$11,611,000	$12,078,000
Wetlands								
Woody Wetland				1,496	$33,940	$57,330	$50,771,000	$85,766,000
	A			2	$37,790	$56,090	$76,000	$112,000
			U	24	$39,380	$71,070	$945,000	$1,706,000
Herbaceous Wetland				255	$18,610	$34,740	$4,746,000	$8,858,000

	A			12	$38,350	$57,490	$460,000	$690,000
			U	1	$37,550	$54,360	$38,000	$54,000
Totals				**108,529**			**$417,983,000**	**$759,203,000**

*Totals on bottom row are based on unrounded per landcover totals.

Net Present Value Calculations (Zero, Three, and Seven Percent)

In addition to the annual flow of ecosystem service benefits summarized in Table 6 and Table 7, it is useful to calculate the "asset value" for the sub-basins' natural capital, or the net present value (NPV) of all benefits from ecosystem services that will accrue over the course of a hundred years. This report calculates NPV using a three percent discount rate which is in the range proposed by many economists for valuation of natural capital. We also include results using a seven percent discount rate which is the standard rate for many traditional infrastructure projects (e.g., roads, piped, dykes). The purpose and application of discount rates is one of the more hotly debated topics in economics, but despite this, asset values help policy makers to appreciate the total worth of an asset over time, and are a critical tool for planning long-term investment and stewardship efforts.

For the Lower Skykomish Reach sub-basins, a conservative estimate of the asset value of the natural capital (with a seven percent discount rate) is between $7 billion and $14 billion over 100 years; when valued at a three percent discount rate, the NPV estimate is between $15 billion and $29 billion over 100 years. At a zero percent discount rate, the Lower Skykomish Reach asset value is estimated between $47 billion and $87 billion, as seen in Table 8.

Table 8. NPV for Lower Skykomish Reach (0%, 3% and 7% discount rates)

NPV Lower Skykomish Reach - 100 yr.		
Annual Totals ($/year)	$471,158,000	$852,330,000
Discount Rate	**Low(USD)**	**High(USD)**
0%	$47,000,000,000	$87,000,000,000
3%	$15,000,000,000	$29,000,000,000
7%	$7,000,000,000	$14,000,000,000

Similarly, for the Braided Reach sub-basins, a conservative estimate of the asset value of the natural capital (with a seven percent discount rate) is between $6 billion and $11 billion over

100 years; when valued at a three percent discount rate, the NPV estimate is between $14 billion and $25 billion over 100 years. At a zero percent discount rate, the Braided Reach asset value is estimated between $42 billion and $79 billion, as seen in Table 9.

Table 9. NPV for Braided Reach (0%, 3% and 7% discount rates)

NPV Braided Reach - 100 yr.		
Annual Totals ($/year)	$417,983,000	$759,203,000
Discount Rate	**Low(USD)**	**High(USD)**
0%	$42,000,000,000	$79,000,000,000
3%	$13,000,000,000	$25,000,000,000
7%	$6,000,000,000	$11,000,000,000

From this, it is clear that the natural assets of the study area provide enormous value to local and regional economies and communities. Again, it is important to remember that these are conservative estimates, owing to the limited valuation research relevant to the area's ecosystem services (

Table 5). Furthermore, while these estimates are limited to 100 years, with effective stewardship, these ecosystems will likely continue to provide benefits in perpetuity.

Recommendations and Next Steps

This report provides a valuation of the ecosystem services provided by the Lower Skykomish Reach and Braided Reach and their associated sub-basins every year. By providing an array of natural goods and services, including salmon habitat, drinking water, recreation opportunities, aesthetic value, and improved water and air quality, **the combined ecosystems of the Lower Skykomish and Braided Reach provide between $888 million and $1.6 billion in economic value every year.**

Treating these ecosystem services like an economic asset that provides a stream of benefits over time, a discount rate can be applied to calculate their present (or asset) value. Using a zero percent discount rate, which recognizes the renewable nature of natural capital and that people 100 years from now will enjoy the same level of benefits, **the Lower Skykomish and Braided Reach and their associated sub-basins are valued between $89 billion and $166 billion.**

Understanding the immense value of ecosystem services, which ultimately shape the regional economy, is a critical step in developing plans to implement policies, invest public dollars, and make decisions regarding natural resource management and flood mitigation. With this in mind, Earth Economics presents the following recommendations:

- **Include Ecosystem Services Valuation in Future Benefit-Cost Analyses.** As county officials and SLS stakeholders consider courses of action to address floodplain management needs in the region, they should consider the costs and benefits of their actions with regard to ecosystem services. BCAs that incorporate ESV can provide governments, organizations, and private landowners a way to calculate the true rate of return on conservation and restoration investments. Including ecosystem services values also allows for the full consideration of green and grey alternatives to infrastructure projects. A handful of state and federal agencies, including FEMA, already include ESV in their formal BCAs (Mitigation Policy FP-108-024-01, 2013). Snohomish County should join the ranks of these leading agencies and include ESV in future BCAs.

- **Secure Funding to Scale ESV Research.** Both the County and SLS stakeholders should consider various funding mechanisms that would support additional ESV research throughout the county. Additional studies will support the prioritization of flood mitigation and watershed restoration projects by allowing decision makers to calculate the rate of return on various conservation efforts.

- **Protect and Restore Natural Capital.** Farmland preservation, salmon habitat restoration, and flood damage mitigation are priorities for Snohomish County and SLS stakeholders. SLS partners can help accelerate this work by advocating for the acceptance and application of ecosystem service valuation in the County's planning process. Including ecosystem services values allows for the full consideration of green and grey alternatives to infrastructure projects which will support the long-term economic growth of the region.

Resilient communities and economic sustainability relies on healthy ecosystems. The Lower Skykomish and Braided Reaches, and their associated sub-basins, provide valuable goods and services to Snohomish County and the greater region. Protecting these areas from flood damage, and restoring the Skykomish Watershed, is critical to maintaining the quality of life for Snohomish residents, as well as promoting sustainability and economic progress within the region.

Appendix A. Study Limitations

Valuation exercises have limitations, yet these limitations should not detract from the core finding that ecosystems produce significant economic value for society. Like any economic analysis, the benefit transfer method (BTM) has strengths and weaknesses. Some arguments against benefit transfer include:

- Every ecosystem is unique; per-acre values derived from another location may be of limited relevance to the ecosystems under analysis.

- Even within a single ecosystem, the value per acre depends on the size of the ecosystem; in most cases, as the size decreases, the per-acre value is expected to increase, and vice versa. (In technical terms, the marginal cost per acre is generally expected to increase as the quantity supplied decreases; a single average value is not the same as a range of marginal values).

- Gathering all the information needed to estimate the specific value for every ecosystem within the study area is not currently feasible. Therefore, the full value of all of the shrubland, grassland, et cetera in a large geographic area cannot yet be ascertained. In technical terms, far too few data points are available to construct a realistic demand curve or estimate a demand function.

- The prior studies upon which calculations are based encompass a wide variety of time periods, geographic areas, investigators, and analytic methods. Many of them provide a range of estimated values rather than single-point estimates. The present study preserves this variance; no studies were removed from the database because their estimated values were deemed too high or too low. In addition, only limited sensitivity analyses were performed. This approach is similar to determining an asking price for a piece of land based on the prices of comparable parcels ("comps"): Even though the property being sold is unique, realtors and lenders feel justified in following this procedure to the extent of publicizing a single asking price rather than a price range.

- The objection to the absence of even an imaginary exchange transaction was made in response to the study by Costanza et al. (1997) of the value of all of the world's ecosystems. Even this is not necessary if one recognizes the different purpose of valuation

at this scale–a purpose that is more analogous to national income accounting than to estimating exchange values.[11]

This report displays study results in a way that allows one to appreciate the range of values and their distribution. It is clear from inspection of the tables that the final estimates are not precise. However, they are much better estimates than the alternative of assuming that ecosystem services have zero value, or, alternatively, of assuming they have infinite value. Pragmatically, in estimating the value of ecosystem services, it would be better to be approximately right than precisely wrong.

Appendix B. Ecosystem Services Valuation References

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