GEM OF THE EMERALD CORRIDOR

NATURE'S VALUE IN THE MT. BAKER-SNOQUALMIE NATIONAL FOREST

EARTH ECONOMICS

Gem of the Emerald Corridor: Nature's Value in the Mt. Baker-Snoqualmie National Forest

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THE WILDERNESS SOCIETY

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Executive Summary

Nature provides water, clean air, food, timber, and so much more. It is fundamental to a functioning economy. Yet in our economic development plans, conservation efforts, and legislative decisions, we often fail to account for the value nature provides. Knowing where to develop or invest—identifying cost-effective and resilient means of managing natural capital and protecting built infrastructure—requires the most-complete economic information available. By taking nature into account, we can make better informed and more strategic decisions.

This study aims to highlight the relationship between providers and beneficiaries of natural capital by estimating the economic benefits provided by the natural environment of the Mt. Baker-Snoqualmie National Forest (MBSNF) to the Emerald Corridor, defined by the Bullitt Foundation as the region stretching from Portland, Oregon to Vancouver, British Columbia (bordered by the Cascades on the east).[1] The study estimates different types of value, including various forms of quality of life improvements and economic revenue flows.

In the context of rapid economic development in the Emerald Corridor, understanding the contributions of natural capital to human wellbeing will be critical to successful planning. As the region's technology, aerospace, healthcare, and other industries grow at historic rates, so does the need for natural places. The ecosystems of the MBSNF provide critical goods and services, including clean air and water, fish and wildlife, aesthetic beauty, and outdoor recreation opportunities. Moreover, the economies of the Forest's gateway communities depend on the outdoor recreation economy. The MBSNF itself protects diverse ecosystems all along the western slope of the Cascades, and preserves the high quality of life found in the Pacific Northwest.

Overall, this study finds that the non-market value of ecosystem services provided by the MBSNF, including ecological functions performed by the land and passive uses like recreation, amounts to between $3.8 and $30.8 billion in benefits per year. As these benefits provide an annual flow of value and will do so well into the foreseeable future, the asset value of the MBSNF, or the cumulative values provided by the forest over the next 100 years, is conservatively estimated at $159 billion to $1 trillion.

The MBSNF also supports social capital, or the formal and informal rules, responsibilities, and relationships critical to community resilience and productivity. Social capital is formed through the common interests in and values placed on the MBSNF. Pacific Northwest communities expend a great deal of time and effort caring for trails and natural areas, preserving their value and appeal while building communities. In 2015, more than 61,000 volunteer hours were recorded in the MBSNF alone. These contributions have been conservatively estimated at $2 million annually, reflecting not only interest, but an active investment in the health of the MBSNF.

Finally, visitation to the MBSNF is an important economic engine for gateway communities surrounding the MBSNF and the Emerald Corridor region as a whole. Our analysis estimates that about $79 million in annual

recreation-related expenditures occur within 50 miles of the forest, resulting from about 2.2 million visits (as recorded in FY2015).

The MBSNF is a multi-use forest that fuels local economies through recreation expenditures, forest product sales, forest management efforts, and payments to local government from forest activities. These translate into about 1,300 jobs supported by the MBSNF.

Jobs Supported by Economic Activity of the MBSNF

Program	Jobs
Outdoor Recreation	504
Forest Products	280
Resource Management	350
Payments to Local Government	160
Total	**1,294**

The values presented in this report reveal the breadth and magnitude of the economic benefits the MBSNF provides to the Emerald Corridor. Understanding the value of MBSNF ecosystem services and economic contributions to downstream beneficiaries and surrounding communities can help to build shared goals and sustainable funding mechanisms for upstream land management.

Key Findings:

- The Mt. Baker-Snoqualmie National Forest provides between $3.8 and $30.8 billion in ecosystem services every year.
- Treated as an asset that will continue to deliver benefits well into the future, the asset value of the Mt. Baker-Snoqualmie National Forest is conservatively estimated at $159 billion to $1 trillion.
- Outdoor recreation participants spend $79 million on trip-related expenditures within 50 miles of the forest. This does not include previously purchased equipment (mountain bikes, hiking shoes, etc.).
- The Mt. Baker-Snoqualmie National Forest supports about 1,300 jobs within the region.
- Physical activity in the Mt. Baker-Snoqualmie National Forest accounts for three billion calories burned every year, or the equivalent of 872,000 pounds of fat, and reduces the health risks and related economic tolls associated with inactivity.

Introduction

Every economy, regardless of size, is nested within nature.

Nature provides water, clean air, food, timber, and cultural experiences, and so much more. Nature is fundamental to a functioning economy, providing natural resources, like timber and minerals. Yet, we often fail to account for the value of the goods and services provided by nature in our decision making. Knowing where to develop or invest—or identifying cost-effective and resilient means of managing natural capital and protecting built infrastructure—requires the most-complete economic information available. By taking nature into account, we move closer to that goal.

This study aims to reveal the relationship between providers and beneficiaries of natural capital by estimating the economic benefits the Mt. Baker-Snoqualmie National Forest (MBSNF) provides to a significant part of the Emerald Corridor (Whatcom, Skagit, Snohomish, King, and Pierce counties; see Figure 1). These five counties, currently home to more than 4 million residents and contributing $347 billion dollars to the GDP each year, is one of the fastest-growing regions in the country, in terms of both population and economic activity.[2]

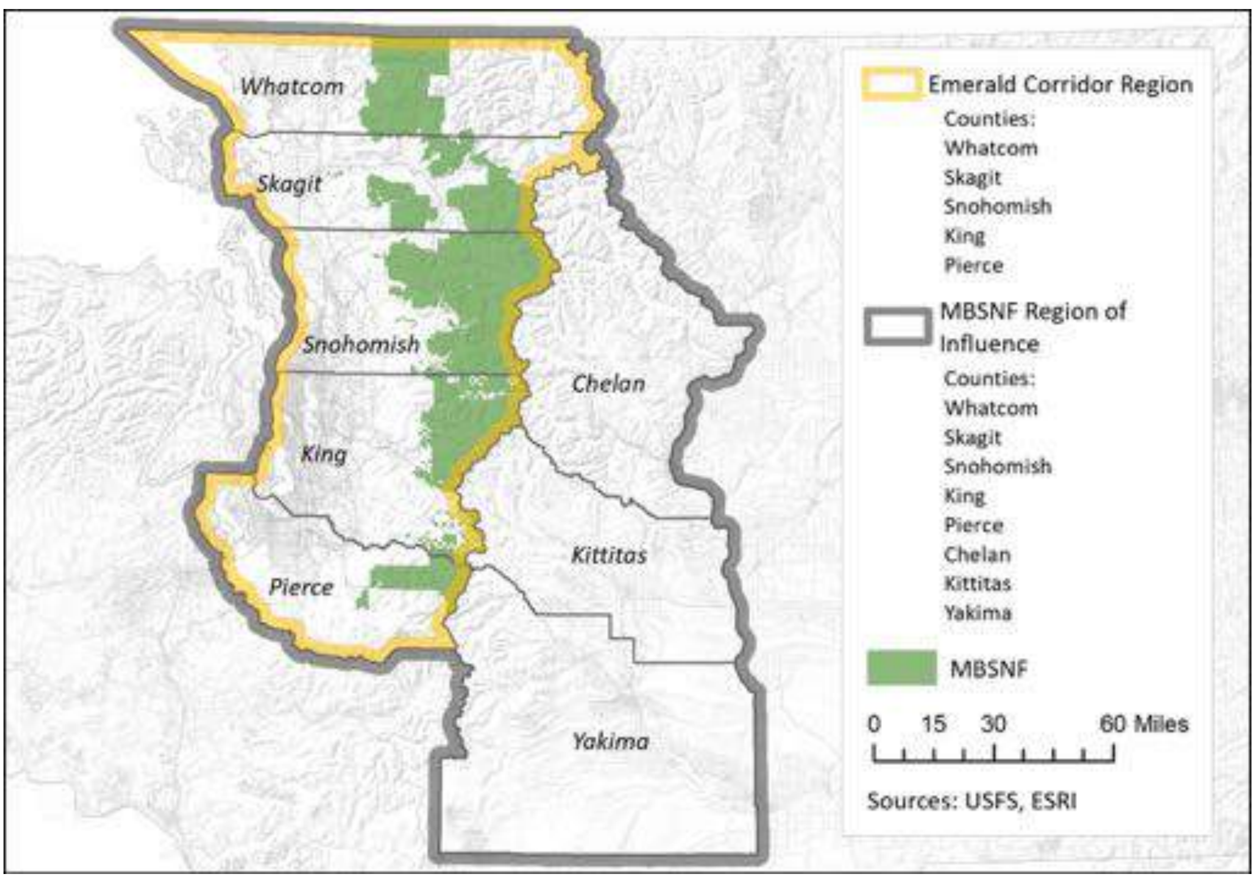

Figure 1. Economic Analysis Study Area

Our public lands are vast and yet undervalued. As growing populations increase stresses on natural capital and public lands, such as National Forests, it becomes critical to take a systematic approach to land-use planning that incorporates economic, social, and environmental costs and benefits. Having more complete information will help public land-managers like the United States Forest Service (USFS) achieve its mission "to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations."[3]

Report Organization

This report is organized as follows: Chapter One provides an overview of the Mt. Baker-Snoqualmie National Forest (MBSNF), discussing the characteristics of the MBSNF and how it is managed. Chapter Two looks at the sources of the forest's value—natural capital, ecosystem goods and services, and economic contribution. Chapter Three takes a closer look at the ecosystem benefits provided by the landscape of the MBSNF and presents an estimate of the annual and asset value of the forest's ecosystem goods and services, including recreation benefits. Chapter Four discusses human and social direct-use benefits of the forest, such as health and community cohesion and volunteerism, and cultural significance. Chapter Five addresses the economic contribution of the MBSNF. Lastly, Chapter Six provides concluding remarks for the report, a discussion of the importance of including ecosystem services in forest management planning, and recommended future areas of work. Appendix A provides a case study of two watersheds.

How to Use This Report

Building awareness about the value of goods and services provided by natural capital strengthens understanding about synergies between the environment, communities, and the economy. Education also helps to garner public support for financing public land preservation and stewardship. This report should be used to reveal connections between the MBSNF and the beneficiaries that receive value from the forest, both directly and indirectly. However, this report is only a start to possible analyses. This study provides a baseline estimate of the values provided by the MBSNF and should not be used as the final ruling. As ecosystem services continue to be studied, many of the data gaps presented in this study will close. Additionally, many of the MBSNF's benefits simply cannot be valued; some benefits truly are priceless. This analysis serves as a step towards understanding the magnitude of contributions that functioning ecosystems make to the economic well-being of the region.

This report does not provide explicit values for comparing ecosystem types and therefore these values should not be used for trade-off analysis (e.g., forest vs grasslands). This study lays the groundwork for conducting site-specific analyses (e.g., Snoquera Landscape Analysis) that combine the values in this report with more robust models that will allow for a greater understanding of the complex issues that land managers face.

Chapter 1: The Mt. Baker-Snoqualmie National Forest

The Mt. Baker-Snoqualmie National Forest spans 1.75 million acres along the western slope of the Cascade Mountains between Canada and Mount Rainier National Park. Covered by stands of old-growth Douglas fir and western red cedar, alpine meadows and glaciers, the MBSNF is home to black bears, elk, marmots, owls, eagles, and other wildlife; its lakes and streams provide habitat for salmon, steelhead, trout, and other regionally prized species. Yet these rich, diverse habitats are just steps from one of the nation's largest regional economies.

Rock, ice, and snow dominate the alpine elevations of the MBSNF; lower elevations support a mosaic of mixed-age conifer forests. The forest contains approximately 50 percent congressionally designated wilderness, with nine wilderness areas encompassing more than 827,000 acres. Much of the rest of the forest lies within late-successional Reserve, managed to protect and enhance late-successional and old-growth forest ecosystems, which serve as habitat for thousands of unique regional species like the northern spotted owl,

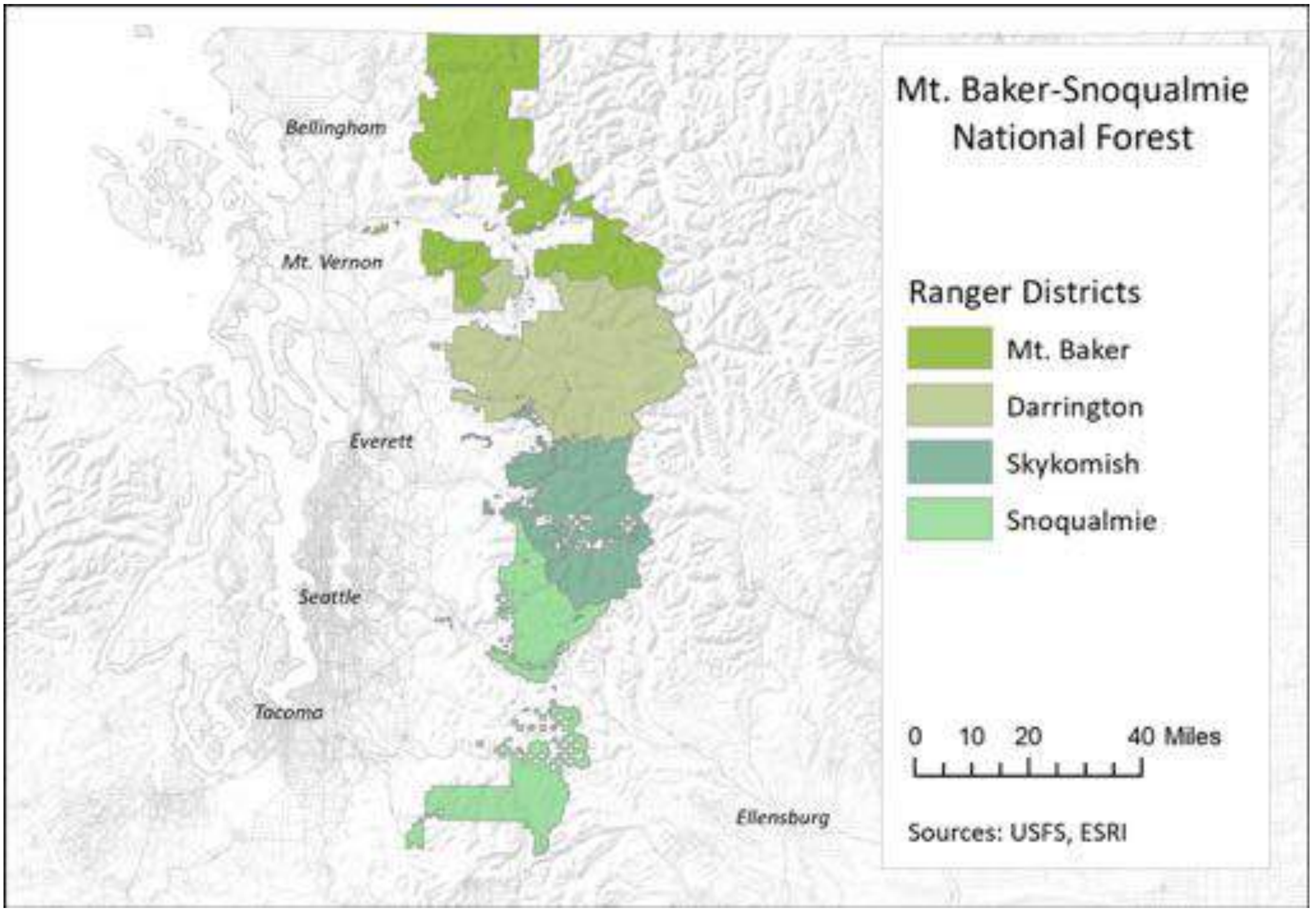

Figure 2. The Mt. Baker-Snoqualmie National Forest

marbled murrelet and several species of salmon. [4]

The MBSNF has two active volcanoes, Mount Baker and Glacier Peak, and more than 250 glaciers, though many are retreating and shrinking.[5] Abundant snowfall high in the Cascades and rain in the lower elevations strongly influence ecological processes in this region, with large glacial-fed rivers. The MBSNF also has one of the largest wild and scenic river systems in Washington State, the Skagit Wild and Scenic River System, which was established by Congress in 1978. The system includes 158.5 miles of the Skagit and its tributaries—Illabot Creek, the Sauk, Suiattle, and Cascade rivers—and aims to protect the free-flowing nature of the river as well as critical habitat and recreational opportunities.

The proximity of the growing Seattle-Tacoma metropolitan region to the MBSNF fuels consistent and increasing visitation to the forest with year-round recreational opportunities for all levels of ability, from mountaineering in the rugged North Cascades to hiking along rivers and streams that flow through the Cascade foothills. The top five recreational activities in MBSNF are viewing natural features, hiking, viewing wildlife, relaxing, and driving for pleasure. The MBSNF has more than 1,500 miles of trails, nearly 40 developed campgrounds, hundreds of lakes, rivers, and streams, and four downhill ski resorts (Snoqualmie Pass, Crystal Mountain, Stevens Pass, and Mt. Baker). Nearly 60 percent of visitors hike on established trails.[6]

MBSNF is a multiple-use forest. As such, many groups have an active interest in the management of the Forest and its resources. Beyond recreation, the USFS also manages for fisheries and wildlife habitat, soil and watershed health, minerals, fire, timber, and human and cultural resources. Management activities are designed to protect, maintain, and enhance the natural resources of the forest. Interest groups include environmentalists, recreationists, and timber industry representatives. Additionally, nineteen federally recognized Native American Tribes use areas of the MBSNF that were once inhabited or used by their ancestors.

Management Laws and Regulations

The Multiple Use-Sustained Yield Act (1960), The Wilderness Act (1964), Wild and Scenic Rivers Act (1968), National Environmental Policy Act (1969), Clean Air Act (1970, 1977), National Forest Management Act (NFMA) (1976), Endangered Species Act (1973), the Land and Resource

Management Plan (1990), and Northwest Forest Plan (1994) all regulate and guide management activities within the MBSNF. An area of significant rulemaking in the decades following NWFP adoption included the revision of the U.S. Forest Service Planning Rule, which details how national forests should create long-term plans as required under the NFMA. A purpose of the Planning Rule, finalized in 2012, is to "provide people and communities with ecosystem services and multiple uses that provide a range of social, economic, and ecological benefits for the present and into the future" (36 CFR 219.1(c). The rule requires assessment of ecosystem services – i.e. the benefits people obtain from the national forest (36 CFR 219.6(b)(7)) – along with a variety of other resource conditions and uses. Furthermore, the rule calls for integrated resource management to provide for ecosystem services and multiple uses of national forests (36 CFR 219.10(a)), including not only timber harvest but also aesthetic value, access to fishing, hunting and gathering, and access to recreation and water supplies.[7]

This study is relevant and timely given the Planning Rule's emphasis on ecosystem services. The rule introduced the concept of "ecosystem services" to forest management planning. It defines ecosystem services as the human benefits derived from provisioning, regulating, supporting, and cultural services (36 CFR 219.19). The rule sets forth processes and content requirements to guide the development, amendment, and revision of land management plans to maintain and restore National Forest System land and resources while providing for ecosystem services and multiple uses.

The USFS formed the National Ecosystem Services Strategy Team (NESST) in 2013 to collaboratively develop national strategy and policy around ecosystem services and integrate them into USFS programs and operations. The long-term goal of the NESST effort is to identify how integrating ecosystem services concepts and tools into Forest Service programs can serve agency goals, and to make recommendations for doing so through collaborative strategy and policy.[8] NESST was re-chartered in 2016 with revised objectives: (1) articulate and demonstrate the relevance of ecosystem services concepts across the agency in fulfilling the Forest Service mission; (2) promote an enabling framework of formal policy and informal guidance to support an ecosystem services approach to manage federal, state, private, and tribal forests and grasslands; (3) build capacity and infrastructure across Forest Service deputy areas to manage or secure forests and grasslands to deliver public ecosystem service benefits; (4) design inventory methodologies and data management solutions to improve reporting of ecosystem service flows, benefits, and—where appropriate—values; and (5) foster two-way communication and learning inside and outside the Forest Service regarding ecosystem services and their values to support management objectives and improve outcomes.

As Deal, et al.[9] detail, applying the ecosystem services concept to operations and management decisions provides value to the agency in the following ways:

1. The ecosystem services concept highlights the broad suite of services that national forests provide to the public.
2. The ecosystem services concept can help USFS management describe and measure activities as outcomes to complement the

output-related targets required by Congress.

3. An ecosystem services approach can also help agency staff identify and communicate why particular management actions are needed and clarify relationships between the condition of forest ecosystems and the quantity or quality of services they provide.
4. Managing forests and grasslands to sustain ecosystem functions and processes with a focus toward ecosystem services encourages a cross-disciplinary and landscape-scale perspective.
5. The ecosystem services approach can help the agency better understand how human values relate to natural resources and ecological conditions.

Lastly, an ecosystem services framework, if implemented collaboratively, can strengthen relationships among communities, tribes, private stakeholders, and other organizations by defining common natural resource stewardship objectives.

Chapter 2: Key Ecological and Economic Concepts

How much is a forest worth? Local residents may say it is “priceless,” yet that word often means two different things. While the intrinsic value of a forest’s natural systems may be too great to estimate, in practice the value is often zero. That is, land-use decisions are often made without knowledge of the economic contribution of natural systems. This study aims to estimate the value of ecosystem goods and services and the economic contributions of recreation and other activities within the MBSNF to the Emerald Corridor Region.

Through this analysis, we evaluate two types of benefits: ecosystem goods and services, and economic contributions. Ecosystem services refer to the benefits that nature provides humans, often for free but with critical importance to everyday activities. The economic contribution analysis evaluates the activity in the formal economy (measured in dollars) associated with the MBSNF’s resources, such as recreation or forest products. The following section describes: (1) ecosystem services and the methods used to value them; and (2) how the MBSNF drives economic activity within the region through employment, income, and consumer spending.

Introduction to Natural Capital and Ecosystem Goods and Services

Natural capital is comprised of the mineral resources, nutrient and hydrological cycles, plants, animals, fungi and bacteria, and the networked natural processes which yield a continual return of benefits, referred to as ecosystem goods and services.[10]

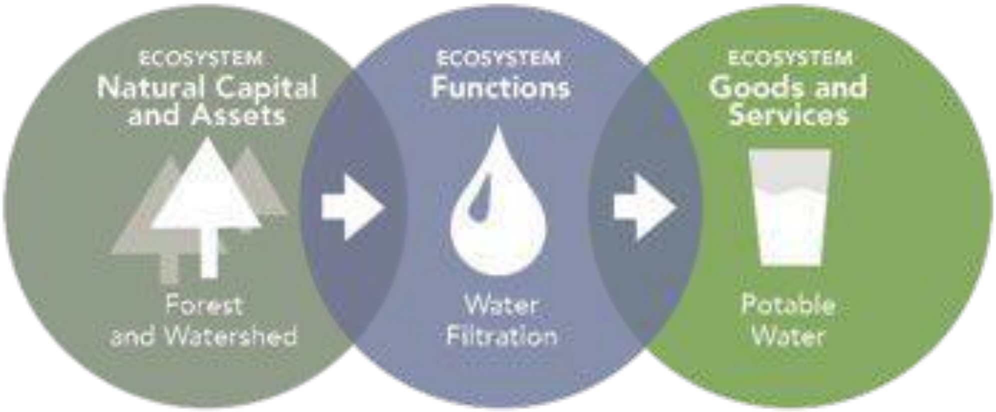

Figure 3. The link between Natural Infrastructure and Ecosystem Goods and Services

Functional ecosystems contribute both directly and indirectly to human wellbeing[11,12] by providing natural water filtration, raw materials, flood-risk reduction, recreation, climate regulation, and much, much more.

Following an approach developed by the Millennium Ecosystem Assessment and de Groot et al,[13, 14] 21 ecosystem services can be categorized in four main types: provisioning, regulating, information, and supporting (Figure 4). These services often overlap. For example, forests in the MBSNF provide energy and raw materials such as timber, add aesthetic value to the landscape, improve air quality, and prevent erosion, among other benefits. To get a comprehensive assessment of the value provided by the MNSNF, we will examine each of its many benefits.

Figure 4. 21 Ecosystem Services

Valuation of Ecosystem Goods and Services

Healthy ecosystems provide essential goods and services that enable cities, communities, and individuals to thrive. Yet society often undervalues, or is unaware of, the importance of functioning ecosystems, leading to the degradation or destruction of natural assets. The forests of the MBSNF provide benefits that would be impractical or even impossible to replace, including pollination, aesthetic beauty, cultural inspiration, and habitat for threatened and endangered species. Should those ecosystems be destroyed, we would rely on costlier and often less effective built infrastructure substitutes.

Ecosystem services may be included in decision-making using a variety of economic tools, including benefit-cost analysis, full-cost accounting, environmental impact statements, asset management plans, and return on investment calculations. Accounting for ecosystem service contributions aids both public and private sectors by supporting the most cost-effective means to provide goods and services in perpetuity. By reporting the value of MBSNF ecosystem services in dollars, this analysis sheds light on the broadly-shared returns that result from responsible stewardship of these public assets.

Over the past half century, scholars specializing in environmental and natural resource economics have developed a diverse toolkit of primary valuation techniques to assess the economic contribution of ecosystem goods and services. In some instances, this value is partially captured by markets; consumers buy products directly provided by nature, such as water or salmon. For these goods and services, formal markets can reflect their contribution to human wellbeing. Yet there are also benefits for which markets do not exist. To estimate the value of these "non-market" benefits (e.g., clean air, aesthetic appreciation), economists must apply other techniques. Table 1 describes the most common techniques in the primary valuation literature and provides examples of their use.

Table 1: Ecosystem Service Valuation Methodologies

Valuation Method	Description	Value
Measures		
Market Prices	Assigns value equal to the total market revenue of goods/services.	Total revenue
Replacement Cost	Services can be replaced with man-made systems; for example water quality treatment provided by wetlands can be replaced with costly built treatment systems.	Value larger than the current cost of supply
Avoided Cost	Services allow society to avoid costs that would have been incurred in the absence of those services; for example storm protection provided by barrier islands avoids property damages along the coast.	Value larger than the current cost of supply
Production Approaches	Services provide for the enhancement of incomes; for example water quality improvements increase commercial fisheries catch and therefore fishing incomes.	Consumer surplus, producer surplus
Revealed Preference Approaches		
Travel Cost	Service demands may require travel, which have costs that can reflect the implied value of the service; recreation areas can be valued at least by what visitors are willing to pay to travel to it, including the imputed value of their time.	Consumer surplus
Hedonic Pricing	Service demand may be reflected in the prices people will pay for associated goods, for example housing prices along the coastline tend to exceed the prices of inland homes.	Consumer surplus
Stated Preference Approaches		
Contingent Valuation	Service demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives; for instance, people generally state that they are willing to pay for increased preservation of beaches and shoreline.	Consumer surplus

Introduction to Economic Contributions

The MBSNF directly drives economic activity within the region through employment, income, and spending, all of which may be measured through what is known as an “economic contribution analysis,” which assesses the aggregate economic activity “associated with an industry, event, or policy in an existing regional economy.”[15] Every industry is embedded in an economic network that sustains a variety of intermediate industries and associated employment. Understanding the structure and extent of a given sector is important to economic decision-making and maximizing social welfare.

Historically, timber cutting and other forms of natural resource extraction were among the largest employers in the region. The western slope of the Cascades was a large part of this economy, even before the National Forest System was established. Though timber extraction has declined drastically in recent years, MBSNF still contributes to economies both timber and non-timber resources (e.g., foraging for mushrooms, decorative materials, Christmas trees).

In recent decades, growing spending on outdoor recreation—hiking, overnight backpacking, hunting, rafting, and birdwatching—has injected growing sums of money into regional and local economies along the perimeter of the MBSNF. Since many of those enjoying these activities travel from the region’s urban cores, money cycles from urban to rural areas. These expenditures and their associated economic effects can be analyzed using *input-output* modeling to demonstrate how both rural and urban economies benefit from the natural capital present within the MBSNF. Trip-related expenditures on gas, lodging, restaurants, groceries, and guide services directly support local jobs, income, and public revenues (*direct* effects). These expenditures also generate secondary effects, as employees of the above establishments spend their income on things like rent and food (*induced* effects), and business-to-business purchases (*indirect* effects). Economic activity ripples out from each purchase, leading to other transactions, over and over. In this way, outdoor recreation has become a vital economic engine for many communities surrounding the MBSNF.

Chapter 3: Ecosystem Services

Water begins the journey to our faucets as precipitation, a familiar feature of life in the Pacific Northwest. Snow and rain fall in large quantities along the western slopes of the Cascades, becoming snowpack, groundwater, and surface water. These waters are gradually released throughout the year, as snow melts and groundwater recharges rivers and reservoirs. Forests aid this process by capturing, conveying, and supplying water, acts that collectively represent one of the many vital ecosystem services that flow from the MBSNF to nearby communities and the Puget Sound. How do we quantify these benefits? Using a land cover approach, we first characterize and determine the extent of each ecosystem type, based on ecological attributes (see Fig. 5). We then identify the specific ecosystem services provided by each land cover type, quantifying those outputs as per acre, per year averages. For example, "disaster risk reduction" may be quantified by the reduction in flood damages to downstream communities that

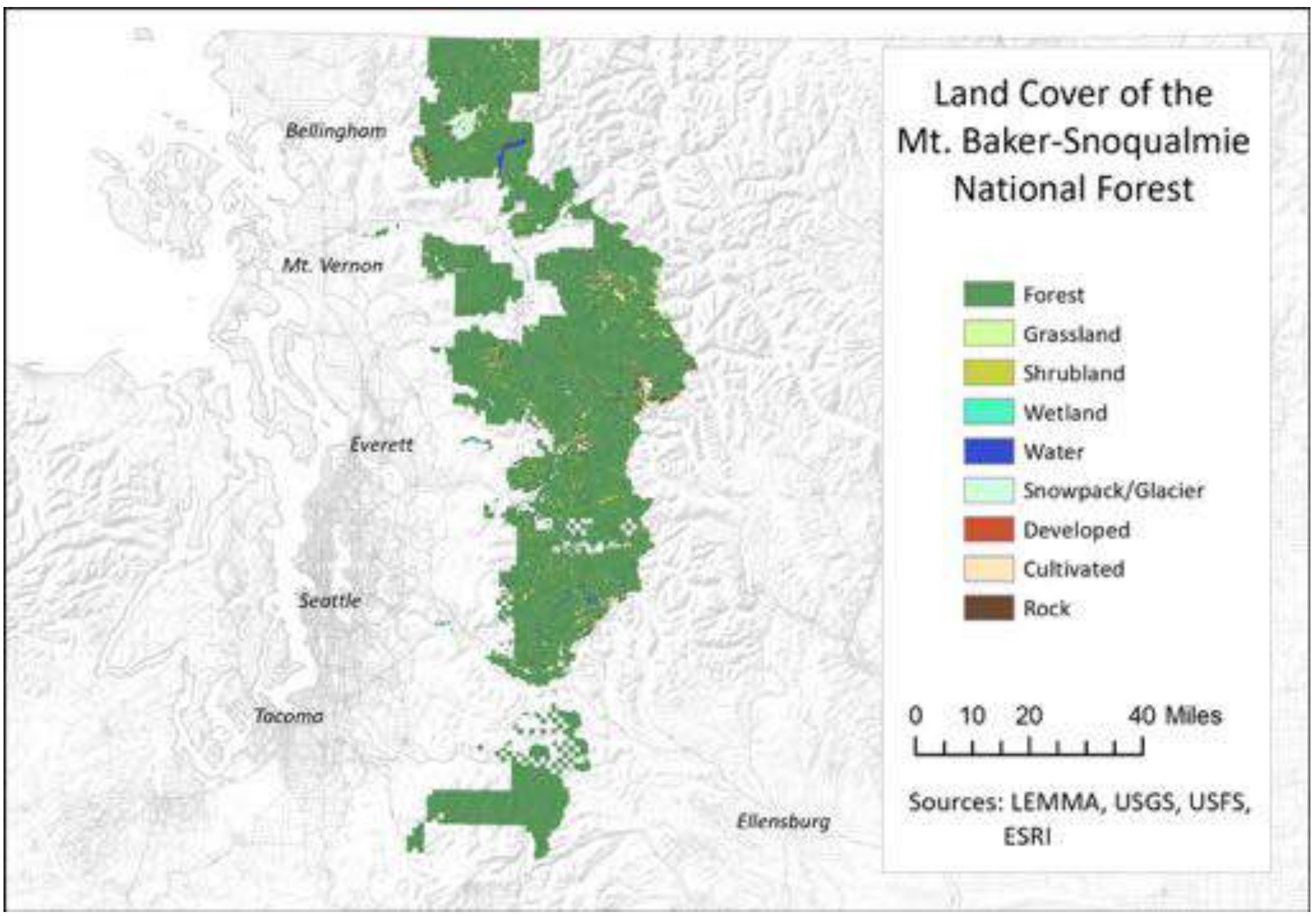

Figure 5. Land Cover Types in the Mt. Baker-Snoqualmie National Forest

each acre of wetlands provides by moderating the effects of heavy rain events. We then calculate the economic benefits of different types of land cover based on estimates from scholarly economics literature and scaled to the extent of each land cover type. Summing the ecosystem services provided in all land covers leads to an annual value of the MBSNF.

Because forest-management decisions are often made by Forest Rangers at the Ranger District level, this analysis values ecosystem services in each of the four Mt. Baker-Snoqualmie National Forest Ranger Districts both separately and together.

Identification and Quantification of Land Cover

An understanding of the variety and extent of the ecosystem types within the MBSNF is essential to ascribing value to the services produced by those living systems. However, it is not practical to perform an on-the-ground ecosystem assessment of the 1.75 million-acre MBSNF. Instead, this analysis relies on the use of Geographic Information System (GIS) technologies to assess remotely-derived land cover data. We aggregated geospatial data (e.g., land cover, riparian zones, distribution of tree age classes) to develop a comprehensive understanding of the natural characteristics of the forest (See Appendix C).

Table 2. Acreage by Land Cover Type and Ranger District in the Mt. Baker-Snoqualmie National Forest

Land Cover	Ranger District (Acres)				Total (Acres)	% Total
	Mt. Baker	Darrington	Skykomish	Snoqualmie		
Forests						
Second Growth	215,302	229,912	165,859	148,564	**759,637**	**43%**
Riparian	88,189	145,108	98,533	90,771	**422,601**	**24%**
Old-Growth, Owl Habitat	119,727	75,049	22,257	48,085	**265,118**	**15%**
Old-Growth, Riparian	50,348	53,836	13,117	32,665	**149,966**	**9%**
Grassland and Shrubland						
Grassland	8,681	7,084	3,108	1,619	**20,492**	**1%**
Grassland Riparian	3,612	1,861	1,001	665	**7,139**	**0%**
Shrubland	7,102	8,363	6,497	2,366	**24,328**	**1%**
Shrubland, Riparian	4,625	7,088	7,110	2,858	**21,681**	**1%**
Snowpack/Glaciers	14,995	6,776	1,080	169	**23,020**	**1%**
Rivers and Lakes	4,919	1,706	2,467	1,964	**11,056**	**1%**
Wetlands	619	368	265	396	**1,648**	**0%**
Developed	737	356	553	523	**2,169**	**0%**
Rock/Barren	17,065	18,898	6,108	3,125	**45,196**	**3%**
Total	**535,921**	**556,405**	**327,955**	**333,770**	**1,754,051**	**100%**

This process resulted in six primary land cover categories (forests, grasslands, shrublands, snowpack/glaciers, rivers/lakes, and wetlands) within the MBSNF, as well as two subsets, riparian and old-growth forests (see Table 2). We then used empirical data on ecosystem characteristics and scholarly literature to identify the services provided by each land cover type. Ninety-one percent of the MBSNF's land cover is classified as forest, but not all forests provide the same ecosystem services at the same levels. We used attributes such as species distribution and age class to more precisely estimate services such as carbon sequestration. Riparian and old-growth forests provide greater value than other forest types in terms of water quality and supply, flood-risk reduction, habitat, as well as carbon sequestration and storage.

Identification of Ecosystem Services

To value ecosystem goods and services, we employed the benefit transfer method (BTM), in which estimates of economic value are based on primary valuation studies of similar goods or services produced in comparable conditions (e.g., climate, terrain, soils, species). BTM is often the only practical, cost-effective option for producing reasonable estimates of the wide range of services provided by ecosystems, especially for regions as large and diverse as the MBSNF.[16]

The application of BTM begins by identifying critical attributes of a landscape that determine ecological productivity and expected benefits. Primary valuations of similar ecosystems, geographies, and communities are then identified, and assessed for their comparability with land cover types within the MBSNF. Estimates from primary studies are then standardized (i.e., adjusted to common units, correcting for any inflation between the period of research and the present) to ensure "apples-to-apples" comparisons. In this sense, BTM is similar to a property appraisal, in which the features and pricing of similar properties nearby are used to estimate value prior to a sale. While each process has its limitations, they are rapid and efficient approaches to generating reasonable values for making investment and policy decisions.

Interest in certain ecosystem services and land cover types has generated a substantial body of research, therefore multiple estimates can be found for given combinations of land cover and ecosystem services. In these instances, we report both low and high per acre value estimates. Other ecosystem services and land cover types are less well-researched. For cases where we have been unable to identify a study suitable for transfer to the MBSNF, we have not provided a value. It is important to understand that this decision simply reflects the limitations of valuation research, not that those natural assets provide no value.

To apply BTM for a full set of ecosystem service/land cover combinations, this analysis used Earth Economics' Ecosystem Service Valuation Toolkit (EVT). Studies within EVT have gone through multiple reviews and are standardized for use in BTM.

Our analysts used several criteria to select appropriate primary studies for the MBSNF, including geographic location and the ecological and demographic characteristics of the original primary study sites. Accordingly, all values included in this report are from studies conducted in temperate ecosystems. Where available, ecosystem valuation studies based in Washington

State were given preference. Where local studies are not available, valuations conducted within British Columbia and Oregon have been prioritized, followed by other studies in the United States. Finally, in a few instances studies from Canada and one global value were used to fill in key data gaps.

Carbon Sequestration and Storage

The methods for calculating carbon sequestration and storage differ slightly from those described above. Carbon sequestration involves the processes by which carbon dioxide and other forms of carbon are stored within plants, roots, and soil. These processes continuously draw carbon from the atmosphere and are critical to maintaining climate stability. To estimate annual sequestration, we draw from the scholarly literature on the ability of different vegetation types and age classes to store carbon each year, now and in the future. In this way, we account for variations in tree stand age and local climates on annual vegetative growth.

Stored carbon refers to the carbon stock, or carbon previously sequestered and currently held within organic matter. Stored carbon is akin to the value of capital in a bank account while sequestration would be the interest earned each year. We calculate carbon storage using the USFS EVALIDator tool, which uses Forest Inventory Analysis (FIA) data to generate forest-wide estimates for carbon stored above and below-ground in trees (living and dead), soils, and forest floor litter. Stored carbon can be released in disturbances such as forest fires, making the economic costs of these events even greater than the property destruction they cause.

The USFS estimates that there are currently 243 million tons of carbon stored in the MBSNF.[17] Multiplying this by the social cost of carbon ($142/ton) results in a value of nearly $34 billion. The social cost of carbon is an estimate of the increased risks to human health and property for each ton of carbon released into the atmosphere.[18] Because this carbon is currently stored within wetlands, forests, and other land covers, we have added the additional ecosystem service value of carbon storage to the asset calculation described below.

Identification of Ecosystem Services by Land Cover Type

For the land cover analysis, 13 ecosystem services are valued over six land cover types. At least one ecosystem service is valued for every land cover type (see Table 3). As discussed above, gaps exist where no peer-reviewed primary valuation literature is available for a given combination of land cover and ecosystem service. In particular, value estimates for lake and river ecosystem services are sparse, yet we know these

Table 3: Ecosystem Services Valued by Land Cover in the Mt. Baker-Snoqualmie National Forest

	Forests	Grasslands	Shrublands	Snowpack/ Glaciers	Rivers & Lakes	Wetlands
Aesthetic Information	●	●			●	●
Air Quality	●	●	●			
Biological Control	●	●	●			
Climate Stability	●	●	●	●		●
Disaster Risk Reduction	●	●				●
Food	●	●				●
Habitat	●	●			●	●
Pollination & Seed Dispersal	●	●	●			
Soil Formation	●	●	●			
Soil Retention	●	●	●			●
Water Capture, Conveyance, & Supply	●	●				●
Water Quality	●	●			●	●
Water Storage	●				●	●

ecosystems provide important benefits. Similarly, we know that snowpack/glaciers (23,000 acres within the MBSNF) provide many ecosystem services (e.g., water supply,[i] aesthetic value), yet only one suitable study was found on the climate-regulating benefits of glaciers. A data gap does not represent lack of value, but a lack of transferrable data.

Valuation of Ecosystem Services

One of the original purposes of the National Forest System was the protection and provision of drinking water, a service that remains essential.[19] The importance of this service is illustrated in the Forest to Faucets program,[20] a program that identifies land that maintains surface drinking water as well as the beneficiaries of this water. By pointing to key drinking water areas, this program helps to prioritize funding to protect those areas.

Pacific Northwesterners also view water as a critical aspect of Forest Service planning. According to a recent survey by The Wilderness Society, 78 percent of voters surveyed prioritized the restoration and stewardship of rivers, lakes, and streams.[21] Not coincidentally, the values of the ecosystem services associated with water tend to be larger than other values. For example, the ability of wetlands to remove pollutants from water is valued at over $11,000 per acre, per year.

The Wilderness Society survey also found that Pacific Northwest voters prioritize the protection of wildlife habitat; 65 percent of voters felt that protecting old-growth forests, which is important wildlife habitat,[ii] was a "very important" priority for public land management. This echoes an earlier analysis on the value of spotted owl habitat

[i] The snowpack, ice, and glaciers of the MBSNF act as natural reservoirs for the Puget Sound, storing water in the winter and slowly releasing it throughout the dryer summer months. Snowmelt provides over 70 percent of the water supply in the western portion of the United States. Without this important ecosystem service, we would be forced to increase groundwater extraction and build and maintain more surface water reservoirs.

[ii] More than 1,000 terrestrial species and 7,000 unique species of arthropods are considered to be closely

in Northwest forests. We normalized this study for use in the MBSNF and found that the value of old-growth Northern Spotted Owl habitat is $28,354 per acre, per year.[22]

Unlike forms of built capital that often provide focused benefits (e.g., levees to reduce flood risk), natural capital usually provides multiple, overlapping benefits. For example, each acre of wetlands reduces flood risk at a value up to $4,514 per year while also providing aesthetic beauty, a benefit less associated with levees. Wetlands also provide climate stability, food, habitat, and other valuable services. Additionally, as living systems, natural assets are often more resilient and less expensive to maintain than built infrastructure, which tends to degrade over time.

Valuation of Ecosystem Services by Land Cover Type

The summary of the ecosystem service values identified in Table 4 reflects the available data for ecosystem services across MBSNF land cover types. Because we were unable to value some ecosystem services due to a lack of supporting research, the services valued underestimate the MBSNF's annual economic value. As benefits from other ecosystem goods and services are studied and understood, we expect the value estimate of the MBSNF to increase. A complete list of studies used for the benefit transfer is available in Appendix H.

However incomplete, these estimates give a value to ecosystem services that markets currently ignore. As such, these estimates provide the best available information to decision-makers on the value that the natural capital of the MBSNF contributes each year.

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associated with old-growth forests in the Pacific Northwest.[4] Many threatened and endangered species rely on old-growth forest ecosystems such as the northern spotted owl, marbled murrelet and several species of salmon. Among many other species reliant on old-growth forest, the Northern Spotted Owl is considered an indicator species. Indicator species such as the Northern Spotted Owl can demonstrate the health of forests. A decline in these species indicates a decline in the health of habitat. Northern Spotted Owls are essential components of the ecological web, meaning population declines in these keystone species can result in significant ecosystem consequences. This analysis uses the value the public places on the protection of spotted owl habitat as a proxy for the value of habitat in the MBSNF. The loss of Northern Spotted Owl habitat indicates loss of habitat for thousands of other species closely associated with old-growth forest.

Table 4: Value of Ecosystem Services across Land Cover Types (2016$)

Ecosystem Service/ Land cover	Ecosystem Service Value (USD/acre/year)			
	Non-Riparian		Riparian	
	Low	High	Low	High
Aesthetic Information				
Forests	$57.20	$5,106	$57.20	$5,594
Grasslands	$57.06	$3,037	$57.06	$3,037
Rivers and Lakes	$1.60	$1.60	Not Applicable	
Wetlands	Not Applicable		$11.11	$9,580
Air Quality				
Forests	$31.18	$1,078	$31.18	$1,078
Grasslands	$0.58	$1.75	$0.58	$1.75
Shrublands	$1.13	$1.13	$1.13	$1.13
Biological Control				
Forests	$1.71	$11.85	$1.71	$11.85
Grasslands	$14.81	$14.81	$23.38	$23.38
Shrublands	$38.03	$38.03	$38.03	$38.03
Climate Stability				
Forests	$320	$320	$320	$320
Grasslands	$124	$124	$124	$124
Shrublands	$11.53	$11.53	$11.53	$11.53
Snowpack/Glaciers	$7	$365	No data	
Wetlands	Not Applicable		$5,478	$5,478
Disaster Risk Reduction				
Forests	$578	$578	$578	$578
Grasslands	$0.91	$3.27	$3,936	$3,936
Shrublands	No data		$45.16	$62.45
Wetlands	Not Applicable		$1.23	$4,514
Food				
Forests	$0.14	$1.01	$0.14	$1.01
Grasslands	$14.84	$104	$14.84	$104
Wetlands	Not Applicable		$37.30	$37.30
Habitat				
Forests (Non-Old-Growth)	$30.80	$276	$174	$3,788
Forest (Old-Growth)	$462	$28,631	$605	$32,142
Grasslands	$35.47	$35.47	$35.47	$35.47
Rivers and Lakes	$3.32	$4,218	Not Applicable	
Wetlands	Not Applicable		$353	$21,734

Ecosystem Service/ Land cover	Ecosystem Service Value (USD/acre/year)			
	Non-Riparian		Riparian	
	Low	High	Low	High
Pollination & Seed Dispersal				
Forests	$200	$642	$200	$642
Grasslands	$16.05	$427	$16.05	$427
Shrublands	$427	$427	$427	$427
Soil Formation				
Forests	$6.17	$6.17	$6.17	$6.17
Grasslands	$1.23	$7.41	$1.23	$7.41
Shrublands	$2.31	$2.31	$2.31	$2.31
Soil Retention				
Forests	$0.01	$127	$0.01	$127
Grasslands	$0.10	$21.10	$0.10	$21.10
Shrublands	$2.31	$10.26	$2.31	$10.26
Wetlands	Not Applicable		$0.26	$1.00
Water Capture, Conveyance, & Supply				
Forests	$146	$146	$1,901	$1,901
Grasslands	$2.47	$2.47	$2.47	$2.47
Wetlands	Not Applicable		$9.88	$7,353
Water Quality				
Forests	$22.32	$727	$49.77	$727
Grasslands	$1.09	$54.31	$6,382	$6,382
Rivers and Lakes	$2.03	$296	Not Applicable	
Wetlands	Not Applicable		$182	$11,067
Water Storage				
Forests	$11.11	$390	$11.11	$390
Shrublands	No data		$33.52	$568
Rivers and Lakes	$0.57	$13,687	Not Applicable	
Wetlands	Not Applicable		$24.46	$12,331

Annual Value of the Mt. Baker-Snoqualmie National Forest

To estimate the total annual value of ecosystem services from all land covers, the ecosystem service value estimates are summed for each land cover class and then multiplied by the extent of that land cover across the MBSNF. Because different studies of the same land cover have produced different value estimates—or sometimes a single study produces multiple value estimates—we present results as a range of the lowest and highest numbers found in the literature for each ecosystem type.[iii] Using this method, the land cover based ecosystem services identified in Table 4 contribute from $3.6 billion to $30.6 billion in economic value each year.

Annual Value of the MBSNF by Landcover Type

The per acre value of ecosystem services varies widely by land cover type, reflecting the subset of services that each land cover type produces (see Table 5). For instance, old-growth forests contribute over half of the high value of the MBSNF, $16 billion per year, even though old-growth forests represent just over a quarter of the total land cover. Riparian areas also contribute significantly to the overall value. For example, riparian forests (second growth) produce $6.4 billion of value each year. As was shown in Table 3, some ecosystems have large data gaps, complicating direct comparisons of land cover types. Despite these gaps, our analysis emphasizes the economic importance of critical ecosystems such as old-growth forests and riparian areas. The range in ecosystem value reflects the literature for ecosystem service studies available for benefit transfer. The low ESV values can be considered conservative, as they are the lowest values found in the literature. Even the high ESV estimate is likely conservative; only 55 of 126 possible combinations between land cover type and ecosystem service are valued (21 ecosystem services across six land covers). This large gap in transferable studies also underpins our reluctance to perform any kind of trade-off analyses with ecosystem services at this scale. The current approach for valuing ecosystem services is not

[iii] High and low values are provided in this report. This approach provides values that reflect the inherent uncertainty involved in valuation. The authors felt it better to provide the range of values rather than choose a single mean or average.

precise enough to use results for decisions regarding trade-offs between one ecosystem type and another based on monetary value alone. More detailed, site-specific models are needed.

Ecosystem service values in this report represent estimates of known, monetized values provided by ecosystem type and are useful in demonstrating the benefits provided by ecosystems. Using annual, per acre values can be useful in gaining an initial understanding of how ecosystem disruptions affect downstream beneficiaries. Major disruptions and changes in the environmental health of upstream ecosystems impact downstream recipients of ecosystem services. For example: decommissioning forest roads may improve downstream water quality and reduce treatment costs; protecting upland forests can regulate water flows and reduce downstream flood risk following storms; reducing fuel loads to mitigate wildfire risk can lead to broad benefits for nearby ecosystems and residents. Linking providers of ecosystem services, like the MBSNF, with downstream beneficiaries can build common interest in the management of upstream areas. Understanding the flow of value from the forest to people can inform land management decisions and the development of appropriate funding mechanisms.

Table 5: Total Annual Ecosystem Service Value by Land Cover (2016$)

Mt. Baker-Snoqualmie NF	Acres	USD/acre/year		Million USD/year	
		Low	High	Low	High
Forests	**1,597,322**	**$10,330**	**$105,852**	**$3,523**	**$30,093**
Second Growth	759,637	$1,404	$9,408	**$1,066**	**$7,147**
Second Growth, Riparian	422,601	$3,330	$15,163	**$1,407**	**$6,408**
Old-Growth	265,118	$1,835	$37,763	**$486**	**$10,012**
Old -Growth, Riparian	149,966	$3,761	$43,518	**$564**	**$6,526**
Grasslands and Shrubland	**73,640**	**$11,905**	**$19,545**	**$106**	**$216**
Grassland	20,492	$269	$3,833	**$6**	**$79**
Grassland, Riparian	7,139	$10,593	$14,102	**$76**	**$101**
Shrubland	24,328	$482	$490	**$12**	**$12**
Shrubland, Riparian	21,681	$561	$1,120	**$12**	**$24**
Snowpack/Glaciers	23,020	$7	$365	**$.2**	**$8**
Rivers and Lakes	11,056	$8	$18,203	**$.1**	**$201**
Wetlands	1,648	$6,098	$72,095	**$10**	**$119**
Totals	**1,706,686***			**$3,639**	**$30,636**

*Land covers not valued: 45,196 acres of rock/barren land and 2,169 acres of developed land.

Annual Value of the MBSNF by Ecosystem Service

Each ecosystem service provides a different annual value. Assessing these values allows a picture of the proportional impact that each ecosystem service has on the total value of services provided by MBSNF. For example, based on the high estimate of habitat value, the Forest's wildlife habitat accounts for over $14 billion of the $32.6 billion total annual value. But many other ecosystem services contribute significantly, as shown in Table 6.

Water-related ecosystem services contribute between $2.4 and $3.3 billion annually. Healthy, unpolluted watersheds provide reliable supplies of clean water for people as well as for fish and wildlife. Degraded or polluted watersheds deliver water that requires treatment, often at great cost, before downstream communities and industries can use it. Based on our analysis, healthy watersheds provide multiple services – storage, treatment (or quality), conveyance and groundwater recharge – all of which would be very costly or impossible to replace with built infrastructure. The value estimate for water-related services can help to justify the investments that the Forest Service and other agencies make to protect surface and groundwater supplies.

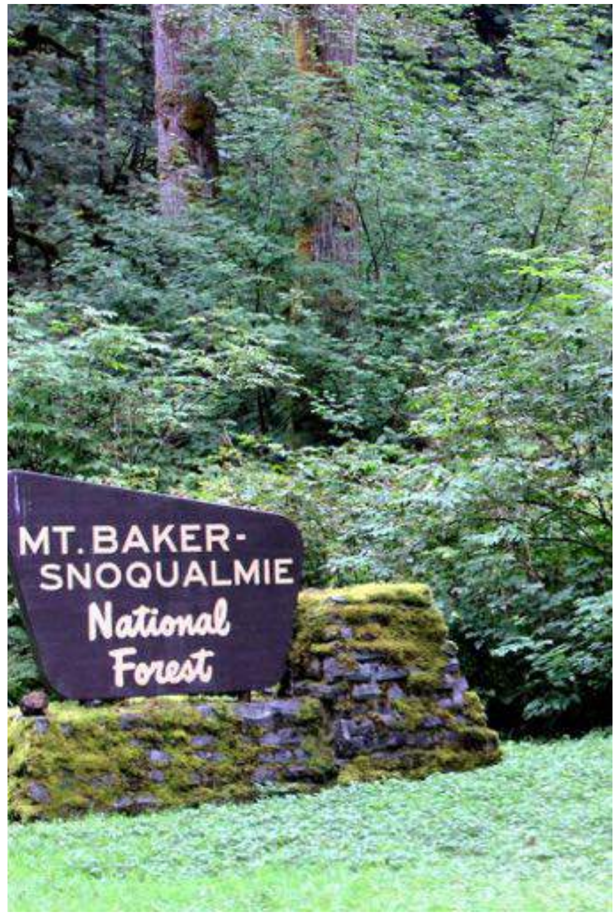
Table 6: Annual Value of the MBSNF by Ecosystem Service (2016$)

Ecosystem Service/ Landcover	**Ecosystem Service Value (USD/year)**	
	Low	**High**
Aesthetic Information		
Forests	$91,366,818	$8,435,689,622
Grasslands	$1,576,625	$83,928,886
Rivers and Lakes	$17,690	$17,690
Wetlands	$18,309	$15,787,477
Sub Total	**$92,979,442**	**$8,535,423,675**
Air Quality		
Forests	$49,804,500	$1,721,849,223
Grasslands	$16,026	$48,354
Shrublands	$51,990	$51,990
Sub Total	**$49,872,516**	**$1,721,949,568**
Biological Control		
Forests	$2,731,421	$18,928,266
Grasslands	$470,396	$470,396
Shrublands	$1,749,722	$1,749,722
Sub Total	**$4,951,539**	**$21,148,384**
Climate Stability		
Forests	$510,424,245	$510,424,245
Grasslands	$3,436,467	$3,436,467
Shrublands	$530,484	$530,484

Ecosystem Service/ Landcover	Ecosystem Service Value (USD/year)	
	Low	High
Snowpack/Glaciers	$161,140	$8,395,624
Wetlands	$9,028,387	$9,028,387
Sub Total	**$523,580,723**	**$531,815,207**
Disaster Risk Reduction		
Forests	$923,220,170	$923,240,665
Grasslands	$28,115,539	$28,163,900
Shrublands	$979,114	$1,353,978
Wetlands	$2,027	$7,438,644
Sub Total	**$952,316,849**	**$960,197,186**
Food		
Forests	$223,625	$1,613,295
Grasslands	$410,044	$2,869,479
Wetlands	$61,470	$61,470
Sub Total	**$695,140**	**$4,544,245**
Habitat		
Forests (Non-Old Growth)	$96,988,558	$1,810,561,042
Forest (Old Growth)	$213,219,275	$12,410,757,461
Grasslands	$980,072	$980,072
Rivers and Lakes	$36,706	$46,630,891
Wetlands	$582,469	$35,818,044
Sub Total	**$311,807,080**	**$14,304,747,510**
Pollination & Seed Dispersal		
Forests	$319,384,534	$1,025,257,099
Grasslands	$443,478	$11,791,529
Shrublands	$19,631,120	$19,631,120
Sub Total	**$339,459,132**	**$1,056,679,748**
Soil Formation		
Forests	$9,855,477	$9,855,477
Grasslands	$33,986	$204,746
Shrublands	$106,281	$106,281
Sub Total	**$9,995,744**	**$10,166,503**
Soil Retention		
Forests	$15,973	$202,556,403
Grasslands	$2,763	$583,014
Shrublands	$106,281	$472,052
Wetlands	$428	$1,648
Sub Total	**$125,446**	**$203,613,117**

Ecosystem Service/ Landcover	Ecosystem Service Value (USD/year)	
	Low	High
Water Capture, Conveyance, & Supply		
Forests	$1,237,655,723	$1,237,655,723
Grasslands	$68,249	$68,249
Wetlands	$16,282	$12,117,035
Sub Total	**$1,237,740,254**	**$1,249,841,007**
Water Quality		
Forests	$51,369,191	$1,161,093,362
Grasslands	$45,582,292	$46,672,876
Rivers and Lakes	$22,444	$3,277,551
Wetlands	$300,101	$18,238,169
Sub Total	**$97,274,028**	**$1,229,281,958**
Water Storage		
Forests	$17,746,247	$623,003,500
Shrublands	$726,747	$12,308,737
Rivers and Lakes	$6,302	$151,322,035
Wetlands	$40,310	$20,321,092
Sub Total	**$18,519,607**	**$806,955,364**
Total Ecosystem Service Value	**$3,639,317,497**	**$30,636,363,473**

Annual Value of MBSNF by Ranger District



Using land cover acreages and respective ecosystem service values, annual value estimates are provided for the four MBSNF ranger districts (Table 7). Estimates differ between Ranger Districts based on the size of the district and distribution of land cover types, but not the per acre ecosystem services values.

Across all Ranger Districts, forests make up 91 percent of MBSNF land cover, and accordingly the largest share of value comes from forests. Across forest types, old-growth contributes the most value—$37,762 per acre, per year, largely due to its value as habitat for thousands of species. This land type has considerable impact on the total National Forest value: Nearly half of the Mt. Baker Ranger District's forests are characterized as old-growth, 31 percent of Darrington's, 18 percent of Snoqualmie's, and 11 percent of Skykomish's. The Darrington Ranger District also includes a large percentage of riparian forests, which provide significant value—$4.5 billion (high estimate).

Table 7: Total Annual Ecosystem Service Value by Ranger District

Ranger District	Ecosystem Services Value (Billion USD/year)	
	Low	High
Darrington	$1.2	$9.7
Mt. Baker	$1.1	$10.3
Snoqualmie	$0.7	$6.1
Skykomish	$0.7	$4.6
MBSNF Total	**$3.6 B**	**$30.6 B**

Recreation as an Ecosystem Service

Recreational users of the MBSNF receive non-market benefits from their direct-use of the forest. These benefits are provided to consumers free of charge. Economists use non-market benefits to measure the economic value provided, beyond what people may already be paying for access to the resource. Although recreation is an ecosystem service, its value is not directly tied to land cover type. The economic benefit of recreation is calculated through visitation and willingness to pay surveys. The spending effects associated with outdoor recreation are measured through an economic contribution analysis, covered in Chapter 5. The economic benefit of recreation is based on visitation data from the National Visitor Use Monitoring (NVUM) database, which estimates the volume of visitors to national forests and grasslands.[iv] Economic values (non-market benefits) were reported in Rosenberger et al (2017)[23] and are commonly used by federal agencies to measure the net economic value of recreation.

Table 8 shows the annual visits to the MBSNF, as well as average, per-visit economic value (or non-market benefit), and total economic value of outdoor recreation. Using this methodology, the total annual economic benefit of outdoor recreation is $191 million dollars. This estimate represents the value that recreationists place on outdoor recreation in the MBSNF. Activity specific economic values are presented in Appendix D. The MBSNF's designation as public land allows for the surrounding population to take advantage of these benefits. Understanding the value that society places on outdoor recreation in the MBSNF is critical to ensuring that land-use policy maximizes social welfare. Recreational non-market benefits are over $191 million each year.

Table 8. Economic Value for Outdoor Recreational Activities

Recreation Type	National Forest Visits	Economic Value per Visit	Economic Value (Millions USD)
General	1,871,496	$88	$165
Downhill Ski	272,080	$90	$25
Wildlife Related	20,056	$88	$2
MBSNF Total	**2,163,631**		**$191**

[iv] Improvements to the accuracy and frequency of NVUM is discussed in the *Next Steps* section of Chapter 6.

Asset Value of the Mt. Baker-Snoqualmie National Forest

Overall, this study finds that the non-market value of ecosystem services provided by the MBSNF, including ecological functions performed by the land and use values like recreation, amounts to between $3.8 billion and $30.8 billion per year.

Table 9. Annual Value Ecosystem Services in the Mt. Baker-Snoqualmie National Forest

Ecosystem Service Type	**Value (Million USD/year)**	
	Low	**High**
Land cover Ecosystem Services	$3,639	$30,636
Outdoor Recreation Benefits	$191	$191
Total Ecosystem Service Value	**$3,831**	**$30,828**

Just as the valuation of a built capital asset is valued based on future expectations of revenue, natural capital assets can be valued based on the future flow of goods and services. Unlike built capital, the natural capital of the MBSNF is capable of producing a flow of goods and services in perpetuity.

Treating natural capital as an asset better informs decision-makers about land-use and planning decisions. By calculating the asset value (also known as Net Present Value, or NPV), ecosystem services can be incorporated into economic tools such as benefit-cost analysis, asset accounting, environmental impact statements, asset management plans, and return on investment calculations.

In calculating the NPV, future income is often *discounted* to reflect the value of that expected income in today's dollars. Discounting is intended to account for factors such as time preference and opportunity costs, such as how investing a dollar today would, over time, yield more than investing a dollar in the future. Higher discount rates represent a higher preference for the present, and vice-versa. Here we calculate NPV using a three percent discount rate over a 100-year timespan.[v]

This analysis estimates the NPV of MBSNF somewhere between $159 billion and $1 trillion. Natural assets clearly provide enormous value to society, both in the short and long term. Wildlife habitat, carbon sequestration and storage, and supplying clean drinking water make up a fraction of the National Forest's full ecosystem service value. Limits in the relevant valuation research make our value estimates conservative. Moreover, while the timeline for these estimates has been limited to 100 years, with effective stewardship these ecosystems should continue to provide benefits in perpetuity.

In contrast, all built capital, such as the Howard Hanson Dam in the Green-Duwamish Watershed, will eventually reach its end of life. The dam provides important flood-risk reduction benefits for the economically thriving region in the floodplain, but raises serious ecological concerns (habitat blockage, lack of flooding in historic floodplain, sediment buildup). Understanding the asset value of both built and natural capital is a useful tool in a land-use planner's tool box.

[v] A three percent discount rate is often used by economists for valuation of natural capital.

Different decisions (e.g., build a dam versus not developing in the floodplain, decommissioning versus repairs) should take into account the asset values of built and natural capital so that one can understand the tradeoffs between economic, social, and environmental benefits.

Discussion

This section reviews our appraisal of the value of ecosystem services in the MBSNF, quantifying the economic value supplied by nature in the forest every year. MBSNF ecosystems provide between \$3.8 billion to \$30.8 billion in economic value every year by providing flood-risk reduction, clean water, critical habitat, climate regulation, recreation opportunities, and other critical services. If we treat MBSNF ecosystems as capital assets (over a 100-year time horizon), their value is between \$159 billion and \$1 trillion at a three percent discount rate.

Water-related services (i.e., water quality, capture, conveyance, supply, and storage) are among the MBSNF's most valuable contributions, estimated to be valued between \$1.4 billion to \$3.3 billion per year. Nationally, one in five people in the United States rely on USFS lands to provide clean drinking water. In 2000, Forest Service economists estimated the minimum value of water from USFS lands was \$7.2 billion per year.[19] Given that water supports every economic, social, and environmental activity, this estimate seems a gross underestimate of the value that forests provide to regional communities.

The USFS has an annual budget of \$5.5 billion for the nation and reported (conventional infrastructure) assets of \$7.7 billion.[24] The MBSNF has an annual budget of \$9.7 million. The USFS's annual budget is slightly higher than the low annual ecosystem service value estimated for the MBSNF (\$3.6 billion per year), and the MBSNF's budget is only 0.3 percent of the low ecosystem service value. If ecosystem service values were to be estimated for all USFS lands, the benefits would be substantially greater than the annual budget. Much of the MBSNF's budget goes towards fire suppression. In above average fire seasons, borrowing can occur from budgets typically allocated to other purposes. Given the scale of public benefits that national forests provide, investment in these lands should be a priority for federal budgets, local government, public and private utilities, and other stakeholders.

Given an increasingly carbonized atmosphere, forests will continue to play an important role in offsetting climate change. With longer growing seasons, carbon sequestration rates by forests will increase. However, climate change will also likely increase droughts and shift the timing of hydrological processes in ways that increase the severity, intensity, and frequency of fires.[25] Because fires release carbon stored in trees, they may offset increased sequestration rates. One thing is clear: managing our forests will become more complicated as a result of climate change.

Chapter 4: Physical, Social, and Cultural Benefits

In addition to the ecosystem service benefits detailed in Chapter 3, humans also gain value from our public lands and national forests directly, through non-consumptive uses such as physical and mental health benefits, community cohesion and volunteerism, and cultural benefits. People visit public lands for a wide variety of reasons: exercise, relaxation, climbing, skiing, or fishing, to name a few. Many indigenous peoples also use national forest land for cultural and traditional practices. The MBSNF helps millions of people to reconnect with nature, themselves, and their heritage.

Physical and Mental Health Benefits

Outdoor activities have important physical and mental health benefits.[26] By reconnecting with nature, we reduce stress levels, sleep better, lower blood pressure, improve immune function, reduce obesity, and even improve eyesight.[27] Yet, despite the strong link between physical activity and human health, over half of Washington adults fail to achieve recommended levels of physical activity. According to a 2012 state health profile by the Center for Disease Control, nearly one-fifth of residents reported no exercise at all within the past month.[28] In 2011, the Washington Department of Health reported that 27 percent of state residents were obese, which has been linked to chronic diseases such as heart disease, stroke, and type two diabetes. The economic impact of inactivity is staggering; it has been estimated that the national costs of obesity-related diseases range from $147 billion to $210 billion per year.[29] USFS research shows that “metro nature,” or nature in and nearby our cities, provides $6.7 billion in annual health savings.[30]

The MBSNF provides the opportunity for physical activity through a wide range of recreational activities, from relaxing walks or picnicking to more strenuous activities, such as backpacking and cross-country skiing. The intensity of these activities can be compared based on the Metabolic Equivalent of Task (MET), a measure of the average calories expended during each activity. These are then scaled by the average weights of adults and (pre-16) youth.[31,32] We used national average body weights for adults (82.6 kg) and youths (47.2 kg).[33]

These MET-activity profiles can then be scaled by NVUM visitation data[vi] for the MBSNF (2.2 million visits in 2015), paralleling earlier USFS research.[34] To calculate total calorie expenditures, profiles are multiplied by the weight of the participant and the time spent participating in the activity (MET x

[vi] Estimates for youth participation are based on previous USFS research.[34]

Table 10: Net Calorie Expenditures from Recreation in the Mt. Baker-Snoqualmie National Forest

Recreation Type	Visits			Net Calorie Expenditures (Millions kcal)		
	Adult	Youth	Total	Adult	Youth	Total
General	1,671,598	199,897	**1,871,495**	2,482	153	**2,635**
Downhill Ski	262,557	9,523	**272,080**	341	7	**349**
Wildlife Related	19,057	999	**20,056**	68	1	**69**
MBSNF Total	**1,953,212**	**210,419**	**2,163,631**	**2,892**	**161**	**3,053**

Weight x Hours). Table 10 shows annual visits, MET-activity values, and average net calorie expenditures for adults and youths. A full breakdown of the calories expended by each recreation type can be found in Appendix E.

Hiking and walking account for the greatest calories expended, followed by biking, skiing, and backpacking. Across the MBSNF's 1,500 miles of trails, [35] four mountain ski resorts, hundreds of alpine lakes, and countless backcountry camping opportunities, over three billion calories are burned each year, the equivalent of 872,000 pounds of fat. The average recreation visit burns nearly 1,500 calories for adults and 765 calories for youth.

To attribute economic value to the health benefits of physical activity, economists often look at the costs associated with inactivity. For instance, a report on the economic benefits of Seattle parks found that adults younger than 65 years who regularly exercised in parks had average annual medical savings of $351. Adults over 65 saved an average of $702 dollars each year.[36] Unfortunately, the number of people who achieve recommended physical activity levels while visiting the MBSNF is unknown; until this can be determined, we are unable to characterize such benefits in monetary terms.

Volunteerism and Community Cohesion

Public spaces—and the sustained effort necessary to maintain them—are known to increase social capital, or the formal and informal rules, responsibilities, and relationships critical to community resilience and productivity. Greater social capital in turn strengthens the shared sense of community, making communities safer.[37]

Though social capital can be difficult to measure, one way to estimate its value is to measure the effort of community members during activities

that sustain social capital, such as volunteerism. Volunteering in the forest can span a wide range of activities including citizen science, trail maintenance and restoration, trash cleanup, and visitor assistance and education. In 2015, volunteers clocked over 61,000 volunteer hours in support of the MBSNF.[38]

One of the largest organizers of volunteers in the region is the Washington Trails Association (WTA). In 2016, WTA completed 150,000 hours of volunteer trail work throughout the state,[39] nearly 40,000 of which were in the MBSNF. WTA volunteer shifts range from a few hours to week long volunteer vacations, where volunteers participate in a variety of projects, creating trails and shared experiences with other community members.

This effort can be monetized by multiplying the total number of volunteer hours by the prevailing wage in Washington State. According to Independent Sector, a leadership forum focused on charities, foundations, and corporate giving programs, the average estimated hourly rate for volunteers in Washington State is $30.04.[40] This equates to an investment of nearly $2 million in the MBSNF from volunteer effort annually.

Cultural Significance

Of the many cultural services the MBSNF provides,[41] cultural heritage and identity as well as spiritual value are vital to many in the Pacific Northwest, particularly Native American tribes. Since time immemorial, indigenous peoples have stewarded the land and its resources and had a deep spiritual and cultural connection to the sea, rivers, streams, forests, and mountains throughout the region. Although the region's once bountiful natural resources have been significantly diminished, the forests and foothills of the MBSNF still support many tribes, including the Lummi, Skagit, Nooksack, Sauk-Suiattle, Salish, Swinomish, Nisqually, Puyallup, Snoqualmie, Duwamish, Muckleshoot, Tulalip, Squaxin Island, and many more. Many of these tribes work collaboratively to protect and manage the natural resources and cultural heritage of the area. MBSNF lands are part of the past, present, and future for tribal nations of the region.

Traditional uses of MBSNF lands by Native American tribes include: hunting for mountain goat, elk, black-tailed deer, mule deer, hoary marmot, black and grizzly bear, and many bird species; and foraging for a wide range of berries, roots, and mushrooms. Western red cedar and Alaska cedar trees are stripped of bark for clothing, baskets, mats, and containers. For many tribes, waterways serve as the main arteries of life, as trade routes and as sources for salmon and other staple foods. Combined water and land routes facilitate trade between inland and coastal tribes.

The tribes of the region had various lifestyles. Some, like the Nooksack and Skagit, settled in permanent villages along rivers, while others lived in camps that moved with the seasons. Dart and arrow points, lithic debris, and other evidence of hunting and residential sites have been found throughout the region. Hundreds of archaeological sites, including rock shelters between 300 and 1,000 years old, indicate a long history of land use by native peoples in the North Cascades. Tribal stories and legends surround the natural resources of the region as well as the formations of iconic rivers and mountains, like Mount Rainier and Mount Baker.[42]

Today, tribal natural resources management is inextricably linked to cultural heritage, traditional uses, and spiritual values. Government-to-government consultation is required between the federal government and tribal nations (such as the Lummi Nation and Tulalip Tribes) for federal actions affecting national forests and other resources of concern. Treaties signed between several Pacific Northwest tribes and the federal government in the mid-1850s effectively removed native peoples from traditional lands but reserved the right for tribal members to fish, hunt, and gather in traditional places. Through the seminal Boldt decision in 1974 and subsequent legal challenges, tribes have affirmed their treaty rights and held the federal government accountable for habitat protection in Western Washington. Ultimately, the federal government has a responsibility to protect tribal trust resources and treaty rights.

Discussion

Though many benefits of public lands cannot be fully monetized, it is important to identify their value. As economists continue to find ways to value the countless benefits of public lands, the designation of these lands becomes more important.

The opportunities for physical activity provided by MBSNF can be partly accounted for by the number of calories burned within the forest, about three billion every year, or the equivalent of 872,000 pounds of fat. Maintaining access to the MBSNF helps to improve the health of nearby residents and potentially helps address obesity and mental health issues.

The MBSNF also generates social capital. Pacific Northwest communities expend a great deal of time and effort to care for trails and natural areas, preserving their value and appeal while building communities. In 2015, more than 61,000 volunteer hours were recorded in the MBSNF alone. These contributions are conservatively estimated at $2 million annually, reflecting not only public interest, but an active investment in the health of the MBSNF. Though we are currently able to monetize only a fraction of these benefits, recognizing that they contribute to human wellbeing is an important step in land-use planning.

Finally, and most importantly, cultural heritage and identity as well as spiritual value are vital to many in the Pacific Northwest, particularly Native American tribes. Land-management decisions must take into account the cultural significance of public lands. To fully understand the value of lands for indigenous communities, we need more than economic studies. Open communication with tribes must be of high priority.

Chapter 5: Economic Contributions

The MBSNF supports economic activity throughout the Emerald Corridor from urbanized areas to rural communities in a variety of ways. Recreation related expenditures such as lodging, food, and fuel generate employment. Special use permits for activities—including guide services, photography, and real estate leasing—bolster additional economic benefits such as small business development. The purpose of this section is to estimate the economic activity associated with these activities in the Emerald Corridor and the forest's larger region of influence, the eight counties surrounding the MBSNF.

The Economic Contribution of Outdoor Recreation

The Outdoor Industry Association estimates the outdoor recreation economy generates $887 billion in consumer spending throughout the U.S. annually.[43] A separate analysis by the BEA has placed a preliminary estimate on the amount that outdoor recreation contributes to the U.S. GDP - over $373 billion.[44] Between 2012 and 2017, this economic powerhouse in Washington State grew from $21.6 billion to $26.2 billion.[45] In Washington state alone recreation supported $7.1 billion in wages and salaries and brought in more than $1.5 billion in state and local taxes.[45] Expenditures on equipment drive recreation-related industries along the I-5 corridor and trip-related expenditures support economies throughout the state. The industry depends on public lands like the MBSNF, where urban recreationists pump millions of dollars into rural, recreation-centered communities close to public lands. Many such communities capitalize on their proximity with restaurants, gas stations, recreational equipment stores, breweries, and accommodations. Collectively, these retail businesses are major drivers of local economies.

As described in Chapter Two, trip-related expenditures directly support employment for local businesses (*direct* effects). These expenditures also generate additional spending as employees spend their paychecks (*induced* effects) and as businesses buy from other businesses (*indirect* effects). We tracked these expenditures through GIS modeling and estimated the subsequent economic effects using input-output modeling with an industry-standard platform, IMPLAN V3.0 (IMpacts for PLANing).[vii] Because forest management decisions are often made by Forest Service Rangers within unique Ranger Districts, we analyzed economic effects for

[vii] An economic contribution analysis differs from an economic impact analysis in that an impact analysis shows new economic activity within the region resulting from a new industry, event, or policy, while a contribution analysis shows how economic activity circulates within a region's existing economy.

each Ranger District as well as the MBSNF overall. We modeled these effects within the eight-county region surrounding MBSNF (Chelan, King, Kittitas, Pierce, Skagit, Snohomish, Whatcom, and Yakima) (see Figure 6).

Methodology and Data Sources

For our economic contribution analysis, we first collected data on visitation and per-trip expenditures. We used these to calculate total trip-related expenditures (multiplying visitation by per-trip expenditures), and then estimated where expenditures occurred within the study area. Finally, we modeled the estimated economic effects stemming from trip expenditures.

The USFS collects visitation data through the National Visitor Use Monitoring (NVUM) program. Among other trip characteristics, the NVUM details the primary activity, number of participants in each party, survey site location, and the home ZIP code of each respondent. The survey is conducted for the MBSNF every five years;[46] here we use MBSNF data for the 2015 fiscal year (October 1 –September 30).

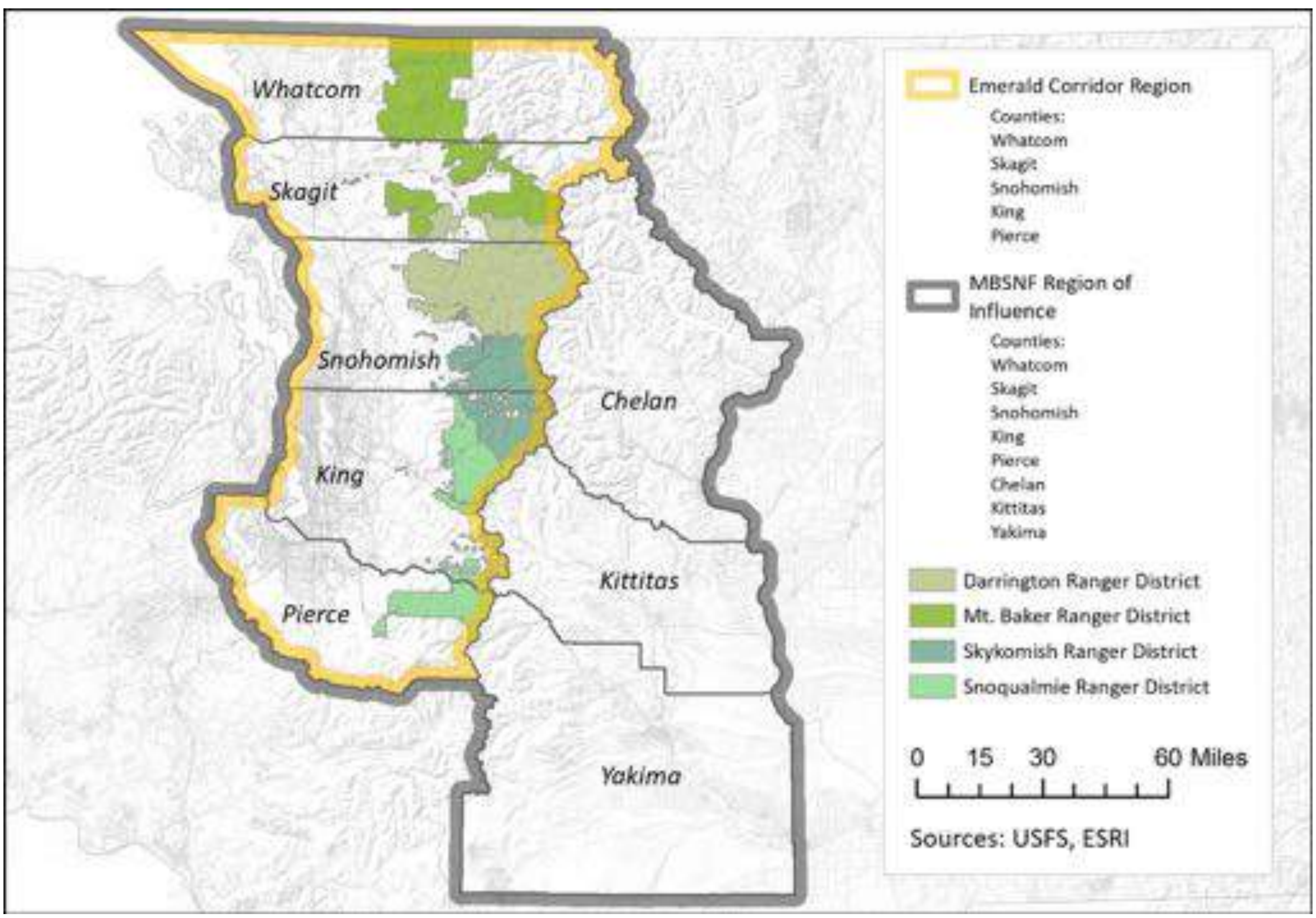


Figure 6. Mt. Baker-Snoqualmie National Forest, Associated Ranger Districts, and Surrounding Counties

We paired participation data with expenditure profiles[47] to estimate total expenditures.[viii] The literature used for calculating total expenditures grouped expenditure profiles into three categories: general recreation, downhill skiing and snowboarding, and wildlife-related recreation (hunting, fishing, and wildlife watching).[47] These are further divided into a matrix of local and non-local users, and day and overnight users (both on and off MBSNF lands). Local users are defined as those who traveled less than 60 miles to the recreation site. The NVUM reports spending across ten categories within 50 miles of each recreation destination. For the average respondent, most expenses went to restaurants, groceries, lodging, and gasoline.

Recreation-related spending is an important economic resource for communities located near public lands. However, at local levels, the effects can be unclear and have yet to be studied in detail. Previous analyses have focused on larger regional impacts of national forest visitation without focusing on individual Ranger Districts and gateway communities. Here, we used GIS tools to identify patterns of expenditures within the MBSNF's region of influence (eight-county region) for each Ranger District, as the location of spending often determines the economic beneficiaries.

Once travel expenditures were allocated, we were able to assign them to each county economy to model direct and indirect effects. In this way, we were able to estimate the economic contribution of outdoor recreation spending across the MBSNF and its four Ranger Districts.

Recreation Participation and Consumer Expenditures

There were 2.2 million total visits to the MBSNF in 2015, with an estimated $79 million in trip-related expenditures by visitors within 50 miles of the forest. These expenditures are estimated to occur between the time the recreationist leaves home until they return home. Expenditures on equipment are not included unless they occur on the trip (these are generally small expenditures).

While general recreational day visits by locals made up the largest share of National Forest visits, non-local overnight visits contributed the most, at 15.6 percent of all expenditures. General recreation local overnight visitors also contributed significantly, with 15 percent of total expenditures. A full breakdown of visits and expenditures by recreational type is found in Table 10.

The MBSNF's four ski resorts account for a significant portion of National Forest visits and expenditures, though these visits are susceptible to precipitation patterns. Fiscal Year 2015 was a down year for ski operators, with NVUM reporting visitation at just 20 percent of the 10-year average of 1.4 million lift ticket days, therefore the current

[viii] Expenditures documented in White 2017 are said to have occurred within 50 miles of the survey location. This analysis assumes that survey respondents reported expenditures made within 50 road miles, though some respondents may have interpreted this question as expenditures made within 50 linear miles of the survey location, potentially leading to higher expenditure rates than other respondents. Expenditures did not include equipment purchases.

estimates are very conservative. Because skiers have higher expenditure profiles than other recreation types, local economies reliant on this type of spending may also feel hardship.

NVUM zip code data reveals that the National Forest is heavily used by residents of the Emerald Corridor. Although users come from across the country, over 75 percent of visits come from the Emerald Corridor region—many of them from the urban cores. Participants from highly populated areas like Bellingham, Seattle, Everett, and Tacoma transfer wealth from the urban core to communities near the forest. Rural communities

Table 11: Mt. Baker-Snoqualmie National Forest Visitation by Recreation Type

Recreation Type	Per-party, Per-trip	Average Party Size	National Forest Visits	Total Expenditures
General Recreation				
Local day-use	$38	2.5	823,877	**$12,608,100**
Local overnight (National Forest)	$170	2.8	205,969	**$12,516,325**
Local overnight	$215	2.3	37,449	**$3,499,064**
Non-local day-use	$61	2.3	411,939	**$10,975,925**
Non-local overnight (National Forest)	$187	3.1	168,520	**$10,188,032**
Non-local overnight	$354	3	56,173	**$6,620,983**
Non-recreational use	$38	2.2	168,520	**$2,930,602**
Sub Total			**1,872,448**	**$59,339,032**
Skiing and Snowboarding				
Local day-use	$58	2.1	81,624	**$2,248,661**
Local overnight (National Forest)*	Not Applicable			**$0**
Local overnight	$310	2.4	5,442	**$702,563**
Non-local day-use	$95	2.7	138,761	**$4,889,467**
Non-local overnight (National Forest)*	Not Applicable			**$0**
Non-local overnight	$894	3	35,370	**$10,542,808**
Non-recreational use	$58	2.9	10,883	**$217,112**
Sub Total			**272,080**	**$18,600,611**
Wildlife Related Recreation				
Local day-use	$45	1.9	10,316	**$245,130**
Local overnight (National Forest)	$174	2.7	764	**$49,202**
Local overnight	$189	2	382	**$36,184**
Non-local day-use	$70	2.1	2,101	**$70,132**
Non-local overnight (National Forest)	$315	2.3	2,101	**$287,477**
Non-local overnight	$592	2.5	1,719	**$407,120**
Non-recreational use	$45	2.3	1,719	**$33,750**
Sub Total			**19,103**	**$1,128,994**
		Total	**2,163,631**	**$79,068,637**

Expenditures gleaned from White (2017), using below-average expenditure profiles. Forest visitation data comes from 2015 NVUM surveys.

* Although ski lodging occurs on MBSNF lands, lodges are privately operated and therefore not considered "Overnight National Forest."

benefit significantly from the 2.2 million annual visits that inject dollars into the local economy.

Participation and Expenditures by Ranger District

While forest-wide participation and expenditures are useful when modeling economic contributions to the larger region, we further refined these results by allocating participation and expenditures to individual Ranger Districts within the MBSNF. Starting with forest-wide visitation data, we used GIS to determine the spatial distribution of visitation within each Ranger District (see Table 12). Appendix F provides additional details on allocation methods.

On a per-person basis, skiers contribute the most to the regional economy. Ski resorts can be found in the Mt. Baker Ranger District (the Mt. Baker Ski Area), Snoqualmie Ranger District (Crystal Mountain Resort, the Summit at Snoqualmie) and the Skykomish Ranger District (Stevens Pass). The Darrington Ranger District does not have a ski resort, but winter recreation (including skiing) occurs at sno-parks.

Table 12: National Forest Visits and Expenditures by Ranger District

Ranger District	Visits	Expenditures
Darrington	228,817	$7,277,672
Mt. Baker	439,120	$16,964,900
Snoqualmie	762,004	$29,269,564
Skykomish	733,690	$25,556,502
MBSNF Total	**2,163,631**	**$79,068,637**

Community-level Expenditures

Most visitors to the MBSNF bring money from urban centers and spend it along their route.[46] While these expenditures can be associated with visits to individual Ranger Districts, to model their full economic contribution we needed to assign this data to counties, the unit of analysis used in the contribution analysis. A simple approach would be to associate spending with counties that Ranger Districts overlap. But because most spending occurs outside of the MBSNF and visitors may pass through multiple counties before reaching the MBSNF, this would skew allocations of spending across counties. Moreover, most Ranger Districts span multiple counties. To more accurately reflect visitor spending, we used GIS to analyze probable visitor travel along the road network to MBSNF access points based on home ZIP codes and visitor survey locations within the MBSNF, as reported in NVUM survey results, see Appendix G for details.

Our models support the observation that most expenditures follow urbanites as they travel to the MBSNF through gateway communities. For example, the city of Monroe receives visitors from northwest, west, and southwest to access the Highway 2 corridor, which continues east to the Skykomish Ranger District. High traffic through Monroe combined with opportunities to spend leads the model to associate high expenditures with Monroe. Similar patterns are found across other Ranger Districts where recreationists are funneled to MBSNF access corridors.

Economic Contribution Results

Outdoor recreation is a major industry in the Pacific Northwest.[48,49] The $79 million in trip-related expenditures from MBSNF recreation supports economic development, jobs, income, and taxes throughout the region, but may be especially important for rural gateway communities. We estimate the employment and labor income that result from expenditures estimated in the previous section.[ix]

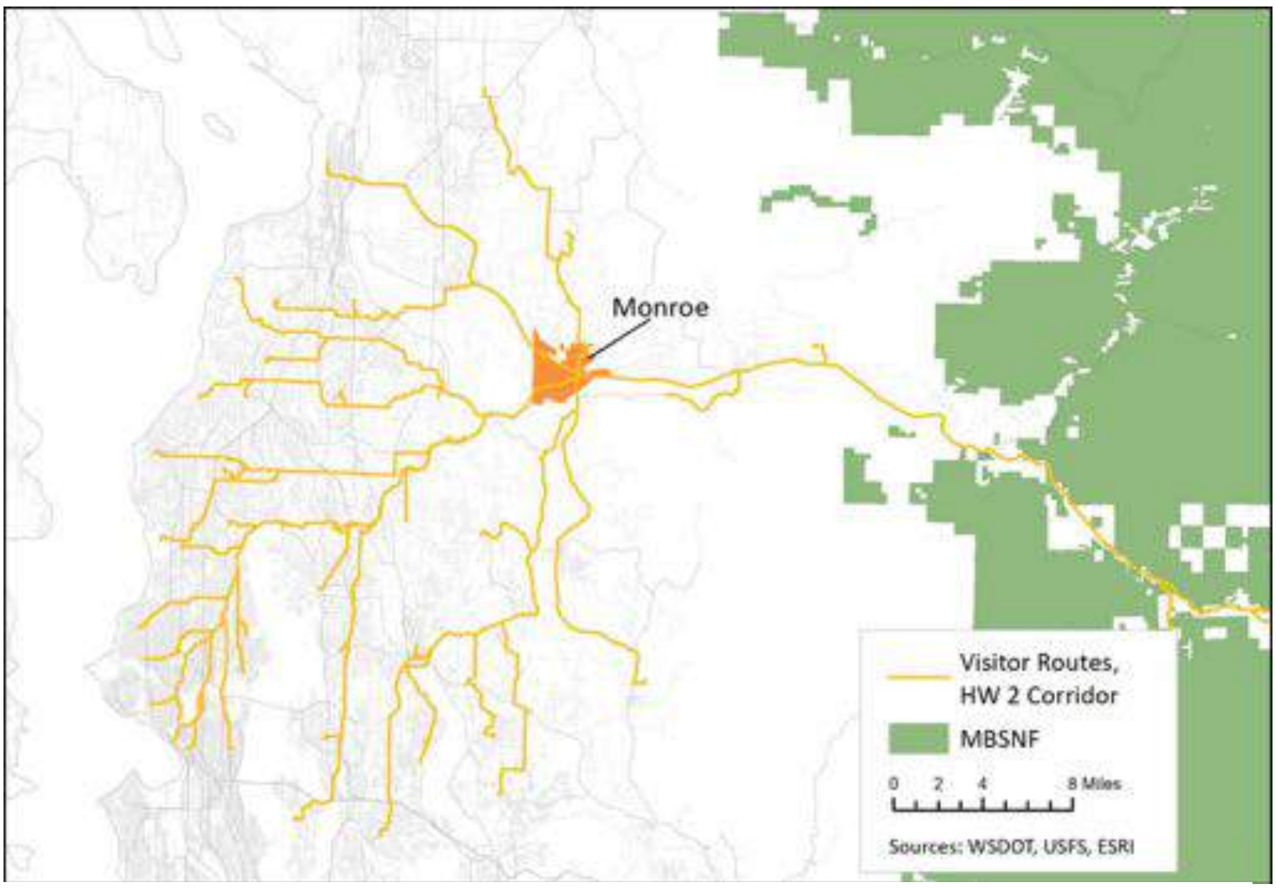


Figure 7. Routes Recreationists Follow to Access the Mt. Baker-Snoqualmie National Forest

[ix] Calculated in terms of "job years," or the total number of full and part time jobs annualized over the course of the project (e.g., one employee working twelve months, or two employees working six months each equals one job year). Labor income includes wages and benefits.

The input-output model estimates that the $79 million in annual trip spending supports 504 jobs in the National Forest's region of influence. Spending directly supports 382 annual jobs and $13.7 million in labor income and secondary effects (indirect and induced) support an additional 121.3 annual jobs and $6.9 million in labor income. Because most MBSNF visitors originate from Puget Sound urban centers, the majority of expenditures occur within the Emerald Corridor. The remainder of expenditures occur along the Forest's eastern gateways. Additionally, two of the four National Forest ski resorts can only be accessed from the west—areas with high expenditure profiles—resulting in more spending associated with the Emerald Corridor. Through our road network analysis, we estimate that 97 percent of trip spending occurs in the Emerald Corridor region, with the remainder along the MBSNF's eastern gateways. As such, most of the economic effects occur within the Emerald Corridor Region.

We conducted similar analyses for each MBSNF Ranger District. As one might expect, those Districts with higher visitation and trip spending benefit from a greater number of recreation-related employment. The Snoqualmie Ranger District is associated with over $29 million in trip-related expenditures of over 765,000 visitors. This spending directly supports 155 jobs, and secondary spending results in an additional 51 jobs for a total of 206 jobs annually.

To better understand the impact that outdoor recreation can have on gateway communities that surround the MBSNF we calculated the number of visits per job to reveal the number of visitors needed to support one annual job. According to our models, shifts in overall visitation to the Snoqualmie Ranger District would have the biggest impact on regional employment, while the Darrington Ranger District is least sensitive to variation. Note that the number of visits per annual job is not related to how Ranger Districts are managed, but rather the economies surrounding each Ranger District.

Table 13: Ranger District Expenditures and Employment Supported by Outdoor Recreation

Ranger Districts	Expenditures	Annual Jobs Supported by Outdoor Recreation Spending				Visits per Job
		Direct	Indirect	Induced	Total	
Darrington	$7,277,672	26	3	4	34	6,815
Mt Baker	$16,964,900	101	15	19	136	3,241
Snoqualmie	$29,269,564	155	24	27	206	3,715
Skykomish	$25,556,502	100	14	16	130	5,678
MBSNF Total	**$79,068,637**	**382**	**56**	**66**	**504**	**4,298**

Economic Contribution of Forest Products

The MBSNF also benefits the regional economy through the sale of both timber and non-timber forest products (e.g., mushrooms, ornamental plants). In addition to cultural importance, these industries provide employment opportunities and income, especially to nearby rural communities. In 2016, timber sales in the MBSNF totaled $454,396. [50] The vast majority of this comes from the sale of saw timber, however firewood and Christmas trees make up about 7 percent of sales. According to a 2016 USFS analysis, timber and non-timber forest products supported 280 annual jobs, providing $13.7 million in wages within the MBSNF's economic area of influence, or the eight-county region.[51] Because timber extraction is both labor and resource intensive, the rural jobs it supports tend to offer higher-wages than other rural jobs.

Special Use Permits in the Mt. Baker-Snoqualmie National Forest

The MBSNF allows for non-extractive commercial use of the forest through the issuance of Special Use Permits (SUPs). SUPs are required for many non-extractive activities in the MBSNF, including outfitting and guide services, recreation events, commercial photography and filmography, and concessionaires. Guide services, commercial photography, research, apiary, and other permit holders all rely on healthy ecosystems. The permit fees help to support both a healthy forest and permit program.

Compared to the revenue earned by SUP holders, the fees collected by the USFS are rather small. The fees collected by the USFS are typically just three to five percent of the permit holder's annual revenue. For instance, outfitters and guides paid a total of just $13,801 in SUP fees to the MBSNF between 2011 and 2016. Assuming this number represents only four percent of annual revenue,

Table 14: Special Use Permit Fees, 2011-2016 Average

Permit Category	Fees Paid to USFS*	Estimated Total Revenue
Apiaries	$286	$7,150
Campground Concessions	$75,093**	$750,930
Commercial Still Photography	$21,752	$543,800
Organizational Camping (e.g., Boy Scouts)	$65,017	$1,625,425
Outfitting and Guide Services	$13,801	$345,025
Private Lodging (e.g., condos, cabins)	$27,708	$692,700
Private Residences (land leases)	$246,573	$6,164,325
Recreation Event	$27,142	$678,550
Research Studies	$909	$22,725
Resorts	$47,976	$1,199,400
Winter Recreation Resorts***	$2,485,073	$62,126,825
Total	**$3,011,330**	**$74,156,855**

*Obtained via FOIA request for Special Use Permit Activities from the USFS

**Concessionaires pay fees of 10% of gross revenue

***Fees collected from Winter Recreation Resorts go directly to the U.S. Treasury, and are not retained by the MBSNF

we estimate that the gross annual revenue earned by outfitters and guide services was about $345,025. A large portion of this revenue goes on to support jobs within the forest's region of influence, though these job impacts are not estimated here. Some of the economic effects from this revenue are captured in our recreation analysis, while revenue related to SUPs such as apiary, photography, and private residency is not. In total, over $3 million is paid in fees to the USFS. From this, we estimate that revenue earned (or the gross average annual income) related to SUPs is $74 million (Table 13). This revenue supports small businesses whose secondary economic effects generate additional local jobs. This estimate reinforces that the MBSNF is an important multiple-use forest providing for many beneficiaries.

It is also important to note the unique role that guide services play in local economies because of the higher-spending recreationists they attract. Those who use guide services spend significantly more in local economies than their non-guided counterparts. A recent study of guided trips in Montana found that guided trip-goers have expenditures nearly five times that of the average vacationer.[52] A similar study in Wyoming showed that guided hunters spent over five times more per hunter than unguided hunters.[53]

Fees paid to the USFS will increase in the near future due to a large expansion of outfitting opportunities and reissuance of concession permits for campground operations in the MBSNF. This expansion, paired with the decrease in fees paid by extractive programs, reveals how recreation is becoming more important to USFS planning and practices.

Other Forest Service Contributions

Additional jobs and income result from management of the MBSNF and payments made to local governments. Investments made by the Forest Service in the management of roads, forest health, ecosystem restoration projects, and salaries all support jobs throughout the region. Payments to states and counties from USFS program revenues and royalties support schools, road maintenance, stewardship projects, and county government operations. According to a 2016 USFS analysis, management of the MBSNF supported 350 jobs. Payments to counties and state governments supported an additional 160 jobs.

Discussion

Recreation, forest products, forest management, and payments made to local government support an estimated 1,294 jobs in the MBSNF's economic region of influence. Many of these jobs are in rural communities that depend on the Forest's healthy lands.

Table 15: Jobs Supported by the MBSNF

Program	Jobs
Outdoor Recreation	504
Forest Products	280
Resource Management	350
Payments to Local Government	160
Total	**1,294**

The recreation economy in the United States generates $887 billion in consumer spending.[49] Approximately 80 percent of these expenditures are trip-related, with the remainder associated with equipment purchases. These trip-related and equipment expenditures support an estimated 7.6 million jobs, and generate nearly $125 billion in federal, state, and local tax revenue.[49] As the recreation economy continues to grow, economic information will be increasingly used to make resource allocation and planning decisions.

Nationally, more than 240 million Americans live within 100 miles of a national forest or grassland and many take advantage of the recreational opportunities public lands offer. These lands are an important amenity and asset for residents and visitors alike, driving the growth of the outdoor recreation economy. In 2016, recreational opportunities provided by National Forests generated more than $9.3 billion in annual spending in nearby communities.

Within Washington, the MBSNF is associated with large amounts of consumer spending. Although the MBSNF is one of the most visited national forests in the country, the NVUM sampling year for the MBSNF was one of the lowest snow years in recent history, leading to a misrepresentation of average annual forest visitation. As a result, our estimate of the economic contribution of recreation is conservative. Improvements to the accuracy and frequency of NVUM is discussed in the *Next Steps* section of Chapter 6.

Recreation-related spending in the MBSNF ($79 million in annual trip-related spending) contributes significantly to both urban and rural economies throughout the region. Though the effects are not modeled in this analysis, the business activity and spending effects associated with Special Use Permits contribute significantly to the regional economy as well. The considerable movement of people and money from urban areas to gateway communities highlights the importance of well-informed land management decisions in the MBSNF.

Consumers can influence the economic development within the region through their choices of when and where to spend disposable incomes. Spending that goes to franchised industries with lower regional economic connectivity (e.g., chain movie theaters and restaurants) generates less activity and economic benefit to local and regional economies than does spending going to locally-owned businesses.[54] Spending related to outdoor recreation tends to have a high degree of regional connectivity, resulting in higher secondary spending and employment effects. Because recreational opportunities provided by the MBSNF attract significant visitors and spending from urban centers, the Forest contributes significantly to rural economic development.

From a land-management perspective, land-use decisions have the potential to influence MBSNF visitation. Understanding how outdoor recreation, forest products, and other USFS programs contribute to local economies can aid effective and long-term decision-making at all management levels.

Chapter 6. Conclusion and Next Steps

Conclusion

Nature provides water, clean air, food, timber, and much more. It is fundamental to a functioning economy. Yet in our economic development plans, conservation efforts, and legislative decisions, we often fail to account for the value nature provides. Knowing where to develop or invest—identifying cost-effective and resilient means of managing natural capital and protecting built infrastructure—requires the most-complete economic information available. By taking nature into account, we can make better informed and more strategic decisions that lead to long-term prosperity.

Overall, this study finds that the non-market value of ecosystem services provided by the MNSNF, including ecological functions performed by the land and passive uses like recreation, amount to between $3.8 and $30.8 billion per year. In addition, the MBSNF fuels local economies through recreation expenditures, forest product sales, forest management efforts, and other payments from forest activities. These transactions translate into about 1,300 jobs supported by the Forest.

While this valuation monetized only some of the ecosystem services present in the MBSNF, the estimates made suggest that the MBSNF provides significant benefits. Each year, land cover based ecosystem services alone contribute between $3.6 billion to $30.6 billion in economic benefits. Of most economic value to this region are critical habitat provided by old-growth forest, water quality provided by riparian forests, and flood-risk reduction from wetlands. This does not include the benefits from recreation.

There are many benefits provided by recreational opportunities in the MBSNF, which are calculated separately to unpack the benefits of these services. Ski resorts, backpacking, hiking, and camping provide about $191 million of non-market benefits, or quality of life benefits that visitors get for free.

Ecosystem services provide an annual flow of value and will do so well into the foreseeable future. The asset value of the MBSNF is conservatively estimated at $159 billion to $1 trillion (assuming a 3 percent discount rate). This means that the cumulative values provided by the Forest over the next 100 years accrue to this expected value.

The MBSNF provides health benefits via ample opportunities for physical activity. These health benefits can be partially accounted for by the number of calories burned by exercising within the forest: about three billion calories every year, or the equivalent of 872,000 pounds of fat. The Forest also supports social capital. Pacific Northwest communities expend a great deal of time and effort caring for trails and natural areas, preserving their value and appeal while building communities. In 2015, more than 61,000 volunteer hours were recorded in the MBSNF alone. These contributions have been conservatively estimated at $2 million annually, reflecting not only interest, but an active investment in the health of the MBSNF. The cultural significance of the Forest cannot be monetized, but remains a vital part of the past, present, and future for regional tribal nations. Better understanding of cultural values requires further inquiry.

Finally, visitation to the MBSNF is an important economic engine for gateway communities surrounding the MBSNF and the Emerald Corridor region as a whole. Our analysis estimates that about $79 million in annual expenditures occur within 50 miles of the forest, resulting from about 2.2 million visits (as recorded in FY2015). This analysis shows how expenditures vary by type of recreation and visitor. For example, non-local skiers who stayed overnight spend an average of $300 per-person per visit within 50 miles of the forest, while local day-use visitors spend an average of $15 per-person per visit to hike and sightsee. Gateway communities such as Monroe and Enumclaw are estimated to capture a significant amount of this spending, based partly on their location along forest access corridors, as well as their greater economic scale and diversity.

The MBSNF is a multi-use forest that fuels local economies through recreation expenditures, forest product sales, forest management efforts, and payments to local government from forest activities. These translate into about 1,300 jobs supported by the forest.

The values presented in this report reveal the breadth and magnitude of the economic benefits the MBSNF provides to the Emerald Corridor. Despite constraints due to data gaps and the granularity and precision of the analysis, the obtained results provide a broad sense of the economic importance of these lands. Understanding the value of MBSNF ecosystem services and economic contributions to downstream beneficiaries and surrounding communities can help to build shared goals and sustainable funding mechanisms for upstream land management.

Key Findings:

- The MBSNF provides between $3.8 and $30.8 billion in ecosystem services per year.

- Treated as an asset that will continue to deliver benefits well into the future, the asset value of the MBSNF is conservatively estimated at $159 billion to $1 trillion.

- Outdoor recreation participants spend $79 million annually on trip-related expenditures within 50 miles of the forest. This does not include equipment purchases used on National Forest land (mountain bikes, hiking shoes, etc.).

- The MBSNF supports about 1,300 jobs within the region.

- The number of calories estimated to be burn within the forest through physical activity in MBSNF, amounts to about three billion calories every year, or the equivalent of 872,000 pounds of fat, and reduces the health risks and related economic tolls associated with inactivity.

Next Steps and Study Improvements

The natural lands of the MBSNF are critical to the health and resilience of the regional economy. Without these healthy and productive lands, our economy and our communities would suffer and be less resilient in the face of future challenges.

Building awareness about the value of goods and services provided by natural capital helps to build understanding about the synergy between our environment, our communities, and our economy. Education also helps to garner public support for financing public land preservation and stewardship. This report should be used to make the connection between the MBSNF and the beneficiaries that receive value from the forest, both directly and indirectly. However, this is only a beginning of analysis. This study should not be taken as a comprehensive analysis of the value provided by the MBSNF. This is merely a step towards understanding the significant contributions that functioning ecosystems make to the economic well-being of the region. The process of identifying and monetizing benefits provided by the MBSNF has revealed a number of data gaps and next steps that will improve study resolution and comprehensiveness.

Improve Tracking of National Forest Use

The Mt. Baker-Snoqualmie is one of the most visited national forests in the country, yet NVUM survey data does not properly account for these visitors. Other sources state visitation may be as high as 5 million visitors per year, 3 million more annual visits than reported in by the 2015 NVUM Survey. Though NVUM is a strong tool at the national level, its practicality at the site, ranger district, and forest level could be improved.

For instance, the 2015 NVUM survey for the MBSNF reports that 272,080 skiers visited the forest's four ski resorts. 2015 was a low-snow year which resulted in unusually low skier visits for the National Forest. Between the 2006/2007 and 2016/2016 ski seasons, the Pacific Northwest Ski Areas Association reported an average of 1.4 million ski days to the four ski areas in the MBSNF–over a million more visitors than NVUM suggests. Additionally, with the low snow year visitors to the forest benefited from an extended shoulder season. Much of this visitation was not captured due to standardized NVUM sampling practices, e.g., surveys not conducted at sites that are normally closed due to snow conditions.

With skiers having some of the highest trip-related expenditures, and general recreationists not being sampled in the shoulder season, the economic effects associated with these visitors are not accounted for properly, painting an inaccurate picture of actual economic contribution by the forest. Additionally, economic benefits such as recreation and health benefits are not properly accounted for under the current NVUM estimate.

Efforts are currently being made to improve the spatial tracking of USFS visitors, which will prove useful in community level analysis and could more accurately estimate the Forest's annual number of visitors. Increasing the frequency of surveys (currently once every five years) will provide decision-makers with more complete and accurate economic information necessary for more informed land-use decisions.

Conduct More Detailed Assessment of Cultural Ecosystem Services

The natural lands of the MBSNF have been used by the native peoples of the Pacific Northwest since time immemorial. Pride, identity, sustenance, community, traditional practices and so much more are fostered by native lands. Many of these significant benefits cannot be measured in monetary terms, and are therefore overlooked. Gaining a better understanding of the benefits that the natural capital of the MBSNF provides to native peoples is a necessary part of improving land-management decisions.

The cultural value provided to residents of the Pacific Northwest is also substantial. The many benefits associated with sense of place—a love of wild places, science and education, and happiness, among many others—present gaps in economic knowledge and space for future study.

Bring Ecosystem Service Valuation into Standard Accounting and Decision-Making Tools

Ecosystem services should be integrated into accounting frameworks. Accounting rules currently recognize timber and fossil fuel natural capital values, but need to be improved to include water provisioning. Ecosystem service valuation can provide governments, utilities, businesses, and private landowners with a way to calculate the rate of return on conservation and restoration investments. Benefit-cost analysis is a widely used economic decision support tool. Strengthening benefit-cost analyses with ecosystem services will shift investment of public and private funds toward more productive and sustainable projects.

For instance, Tacoma Public Utilities receives immense value from the services provided by the headwaters in the MBSNF. Without the services provided by these lands, the utility would need to pay for a water filtration plant, costing ratepayers. Consideration of the value of ecosystem services can improve economic analysis, as natural capital strategies often prove to be the cost-effective and robust solutions to our most challenging infrastructure problems.

Conduct a More Detailed Valuation, Mapping, and Modelling of Site-Specific Analyses

This study provides a baseline valuation of ecosystem services and identifies key benefits. It does not necessarily lend itself to trade-off analysis which is useful in USFS planning processes. Conducting site-specific analyses that combine the values in this report with more robust models will allow for a greater understanding of the complex issues that land managers face.

Appendix A: Case Study: The Green-Duwamish and White-Puyallup Watersheds

Watersheds represent areas of land where water drains to a common outlet – river, bay, or ocean. Elevation, or the height of land above sea level, decreases from watershed headwaters to low-lying outflows enabling unidirectional flow of water and sediment. Over geologic time, water draining from high elevations formed the fertile valleys and wide floodplains attractive to modern development and cultivation. Today, water flowing from forested headwaters provides a valuable flow of resources to growing downstream populations.

From alpine lakes, old-growth forests, and glaciated mountains to skyscrapers, manufacturing plants, and condominiums, many western Washington watersheds encompass a vast diversity of landscapes. As opposed to administrative boundaries, watershed boundaries represent connected systems – particularly the capture and transport of precipitation. Changes in upper watershed land use that impact water quality, water regulation, recreation opportunities, and aesthetic beauty all have direct economic implications for downstream beneficiaries.

The watersheds of the Mt. Baker-Snoqualmie National Forest are managed differently based on congressional forest designations and

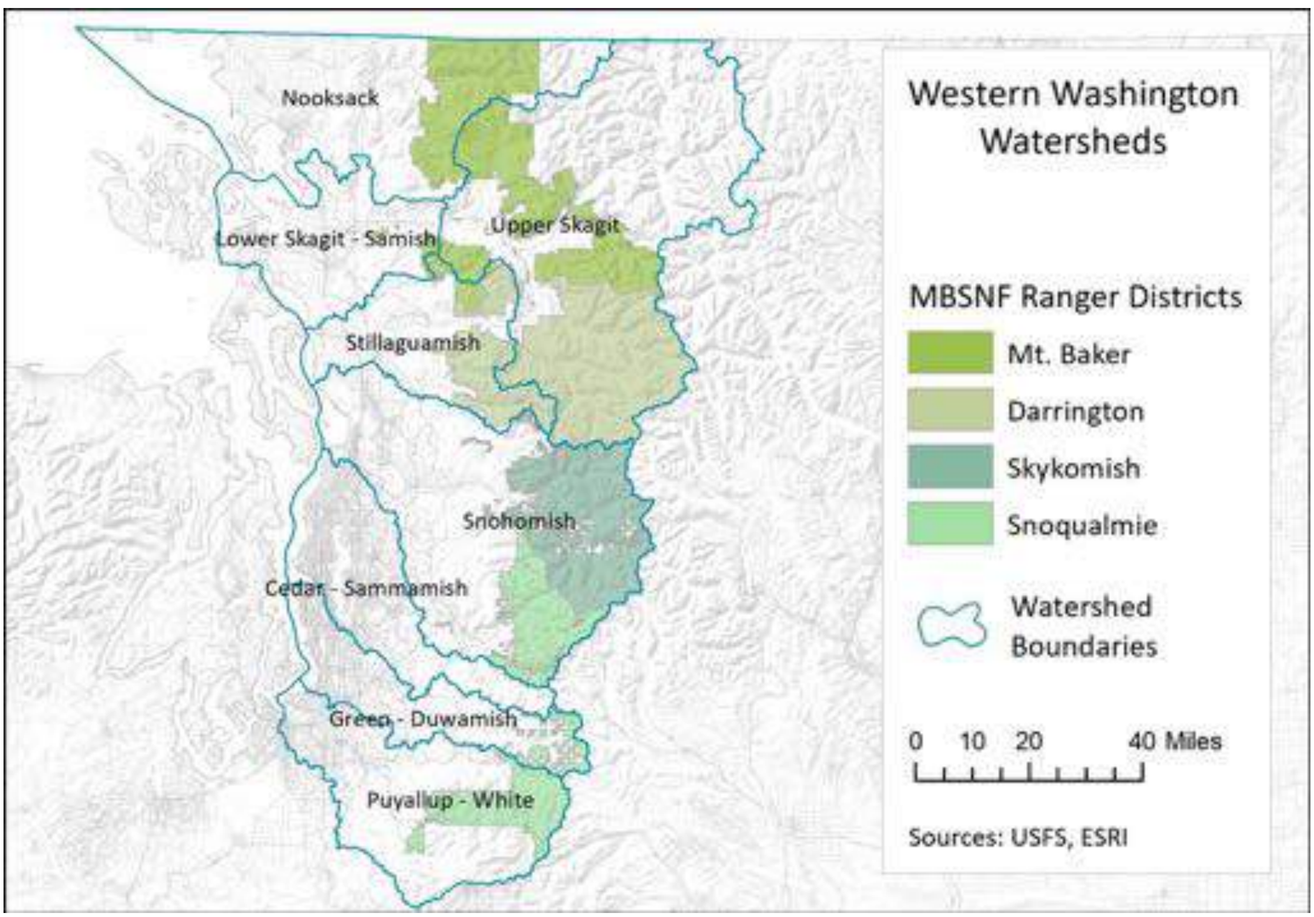


Figure 8. Western Washington Watersheds and the Mt. Baker--Snoqualmie National Forest

management priorities. The USFS is in the early stages of a landscape analysis encompassing the Upper Green and Upper White Watersheds – the Snoquera Landscape Analysis. The focus is to assess current needs in the area to promote old-growth forest characteristics and aquatic values and mitigate future large-scale disturbances, such as fire and non-native insects and diseases. The Upper Green and Upper White watersheds form the headwaters of two major Puget Sound watersheds, the Green-Duwamish and White-Puyallup. This case study examines these watersheds to highlight connections between the forest and downstream beneficiaries that may be impacted through forest management decisions. The MBSNF is a critical link in a resilient Puget Sound landscape, which we will highlight here.

The Green-Duwamish Watershed stretches from the Southeast portion of King County to Elliott Bay in the Puget Sound. The Watershed covers nearly 570 square miles, 10 percent of which is in the MBSNF. The upper watershed is forested, the middle offers recreational opportunities and farmlands, and the lower Green-Duwamish is home to the industrial centers of the South Seattle region. The Upper Green River Watershed also serves as the primary drinking water source for the City of Tacoma.

The White-Puyallup Watershed is located south of and adjacent to the Green Duwamish Watershed, in Pierce County. The watershed headwaters span across the Mt. Baker-Snoqualmie National Forest and Mt. Rainier

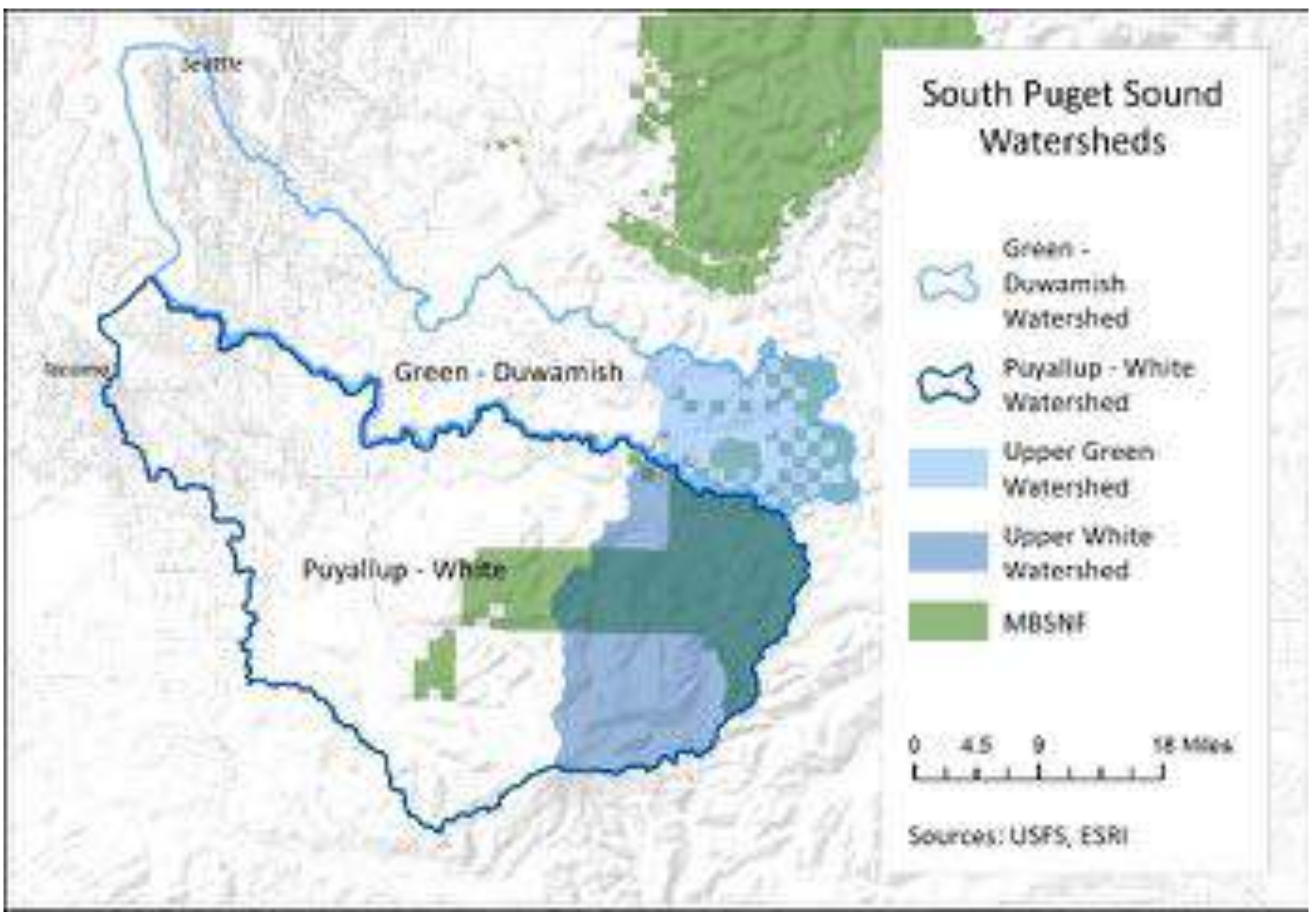


Figure 9. The Green-Duwamish and Puyallup-White Watersheds

National Park. The watershed drains 1,050 square miles from southeast to northeast through Buckley, Bonney Lake, and Puyallup into Tacoma's Commencement Bay. The MBSNF covers 20 percent of the watershed. Historically, the White River joined the Green River and discharged into Elliot Bay, but in 1906 a debris jam rerouted the river into the Puyallup River. The debris jam was later replaced with a permanent diversion.

Ecosystem Services in the Green-Duwamish and White-Puyallup Watersheds

Each of the ecosystem services found in the MBSNF are also present in the Green-Duwamish and White River watersheds. The forests of these watersheds contribute important services such as flood risk-reduction, maintaining water quality and supply, and important fish and wildlife habitat. This section looks at how the MBSNF supplies ecosystem services to downstream beneficiaries.

Disaster Risk Reduction

Large-scale urban and industrial development is found throughout the floodplains of the White and Green-Duwamish watersheds – nearly 1,000 businesses are located in the 100-year floodplain of the latter. In response to repeated flooding of the lower Green-Duwamish Watershed, the Army Corps of Engineers built Howard Hanson Dam, a project costing approximately $360 million (2017 USD).[55] With flooding under control, development in the floodplain became more attractive. Although the Howard Hanson dam reduces flood risk, the forests and wetlands of the headwaters also regulate flows and limit flood potential, holding water after heavy rains and slowing the waters entering the reservoir. The degradation or loss of these ecosystem services would increase flood risk downstream, leading to expensive upgrades to the dam and other infrastructure (and ongoing maintenance and operational costs). Wetlands alone provide up to $3,500 per acre per year in flood-risk reduction.

While built capital is necessary to sustain the economic vitality of the downstream region, it is important to remember that all built assets deteriorate over their lifespan. In 2010, the Army Corps of Engineers estimated that it would cost $450 million to permanently fix damages to the wall of the Howard Hanson Dam.[56] Ongoing maintenance and upkeep of the dam is clearly in the economic interest of the region, and therefore some scale of investment can be justified. To follow suit, land managers must demonstrate that upkeep of our natural assets is in the best economic interest of the region and should be a priority for funding.

Water Supply

The Green River Watershed is the primary source of water for Tacoma Public Utilities (TPU), which provides 59 million gallons of drinking water to 300,000 people in Pierce and South King counties.[57] The water filtration provided by the

144,480 acres of upland forest in the Green River watershed, means that TPU's drinking water requires minimal filtration. 37,000 acres of that upland forest is found within the MBSNF boundary, and the USFS maintains a cooperative agreement with the utility.

We estimate that riparian (flood plain) forests contribute between $1,961 and $3,018 per acre per year, and that non-riparian forests contribute between $180 and $1,262 per acre in water-related ecosystem services. Of the protected upland forest of the MBSNF, nearly 10,000 acres (close to 50 percent) are considered riparian. Based on these estimates, the headwater forest ecosystems of the Green-Duwamish within the MBSNF contribute between $84 million and $712 million each year, with an asset value of $2.7 to $23 billion, based on a 3 percent discount rate.

Habitat

The public tends to value areas without roads, apart from any other factor, at $6.72 per acre per year.[58] Part of this likely comes from our understanding of the impact of roads on fish and wildlife habitat, which can be improved, in part, through road reclassification and decommissioning. Roadless areas improve water quality, reduce sediment loads to streams, reconnect fish and wildlife habitat, and provide unique recreational experiences.

Approximately 27 percent of the forests of the upper Green-Duwamish and 32 percent of the upper White watersheds are classified as Old-Growth, respectively, within the MBSNF. These forests are estimated to provide up to $43,518 per acre per year in habitat benefits, $28,354 of which are associated with habitat protection.

Salmon are central to the culture of Puget Sound (and the Pacific Northwest, broadly) and this is reflected in public concern. The headwater forests of the Green-Duwamish and White River watersheds provide cool, clean water necessary for chinook salmon, coho salmon, steelhead, bull, rainbow, and cutthroat trout to thrive. Yet blockages to habitat (Howard Hanson dam, impassable salmon culverts), and pollutants from industrial and non-point sources (e.g., roads) have negatively impacted both water quality and overall habitat availability. USFS restoration efforts to increase quality habitat have included in-stream placement of large woody debris, road decommissioning, culvert replacement, and improvements to tributary streams.

The USFS manages 40 river miles of salmon habitat in the Upper White River watershed. The value of their stewardship can be understood as the *avoided costs* associated with stream restoration, which have been found to average about $129,000 per river mile.[59] Subtracting ongoing maintenance costs ($11,000 per river mile) results in an estimated avoided cost of $118,000 per river mile. Annualized at a 3 percent discount rate over 100 years, the USFS avoids $3,735 per river mile per. Based on this analysis, the annual value of forest and stream stewardship in the Upper White River is estimated at $137,400; this translates to an asset value of $4.7 million.

Cultural Services

The Muckleshoot Indian tribe is a federally recognized tribe whose membership is composed of descendants of the Duwamish and Upper Puyallup people who inhabited Central Puget Sound for thousands of years before non-Indian settlement. The Tribe's name is derived from the native name for the prairie on which the Muckleshoot Reservation was established. Following the reservation's establishment in 1857, the Tribe and its members came to be known as Muckleshoot, rather than by the historic tribal names of their Duwamish and Upper Puyallup ancestors. The Muckleshoot Reservation is located on a six-square mile reservation between Auburn and Enumclaw. The tribe numbers in the thousands and employs most of its members through fisheries, gaming, small business, and tribal government.

In the last two decades, the Muckleshoot Tribe has diversified and expanded its tribal economy and become one of the largest employers in south King County and an economic force in the region. In 2013, the tribe acquired 86,500 acres of land in King and Pierce counties for more than $300 million, now managed with sustainable practices as the Tomanamus Forest. The Muckleshoots manage land for the primary purpose of long-term sustainable timber harvest, while preserving natural values, including fish and wildlife habitat, plant resources, and areas of cultural importance. Acquisition of the property will permanently protect access to traditional hunting and gathering areas. The area is an important part of the tribe's homeland and tribal ownership is the realization of a long-held goal of the Muckleshoot people. [60] The Muckleshoot works with Hancock Timber Management and the Sustainable Forestry Initiative to manage the forestland with sustainable standards. The tribe intends to build an educational facility and interpretative trail in the Tomanus Forest to support tribal forestry education. Interpretative forest management, ecological processes, and plant identification signs with traditional plant uses will be posted along the trails.

Economic Contribution of Outdoor Recreation along the 410 Corridor

Highway 410 provides access to the southern part of the MBSNF. To access Highway 410 from the Puget Sound, commuters must pass through the gateway community of Enumclaw. Whether stopping for gas, groceries, or an after-hike meal, the city of Enumclaw captures a large share of MBSNF recreation related expenditures. According to the literature, average recreation participants spend $32 per person per visit, though skier visits may spend between $58 for day visits and $900 for non-local overnight visits within the local community.

One of the most popular destinations is Crystal Mountain Ski Resort, which is associated with high visitor expenditures. Currently, Crystal Mountain Ski resort is planning $5 million in upgrades to the resort. Improvements include an expanded snow-making system, additional lights to extend skiing hours, and five additional gondola cabins that will increase the capacity for both winter and summer visitation. Improvements to the resort will likely lead to an increase in use, which will lead to a larger number of travelers on the 410 corridor.

If the assumption is made that NVUM survey results accurately represents visitation along the 410 corridor, 254,000 national forest visitors gained access to the national forest via the 410 corridor in 2015. These visits led to an estimated $13 million in spending within the local community. It is estimated that Enumclaw receives over half of all MBSNF recreation related expenditures along the 410 corridor. These expenditures ripple through the local economy and support jobs, income, and taxes. Gateway communities stand to benefit greatly from improvements to the resort.

Conclusion

This brief case study identifies how downstream beneficiaries are tied to upstream providers of ecosystem goods and services. Ecosystem services such as flood risk-reduction benefit those in the lower watershed, while the service of water supply benefits both those inside and outside of the watershed. Investment by the Muckleshoot Tribe has furthered the stewardship of natural lands within the watershed, ensuring the delivery of important ecosystem services and cultural benefits.

Additionally, healthy watersheds bring recreation expenditures to gateway communities. Therefore gateway communities stand to benefit from long-term forest planning that prioritizes recreation. By continuing to study and reveal linkages between gateway communities and the MBSNF, support can be gathered to prioritize funding for and management of valuable public assets.

Key Findings:

- The forests and wetlands of the headwaters regulate flows and limit flood potential in the lower Green-Duwamish, with wetlands providing up to $3,500 per acre per year in flood-risk reduction.
- When regarded as an asset, the provisioning of water-related ecosystem services in the headwater forest ecosystems of the Green-Duwamish are valued at $2.7 to $23 billion.
- The annual value of the 40 miles of stream stewardship in the Upper White River is estimated at $137,400.
- Along the 410 corridor, an estimated $13 million in spending occurs within the local community from MBSNF recreation.

Appendix B: Study Limitations

Appreciation of the significant economic value produced by natural capital should not be diminished by acknowledgement of the limits inherent in estimating that value. As with any form of analysis, the methodologies applied in this report have strengths, weaknesses, and limitations. With this in mind, we have highlighted both the range and distribution of our value estimates, which necessarily reveals varying levels of imprecision. To a large degree, this is inescapable when estimating the value of non-market benefits, but the resulting lack of specificity must be placed within the proper context – even imprecise estimates are likely better than assuming that ecosystem services have zero (or infinite) value. In pragmatic terms, it is often better to be "roughly right than precisely wrong."

Some of the limitations to this analysis include:

Ecosystem Service Valuation

- **Every ecosystem is unique.** Value estimates derived from another location may not accurately map to the ecosystems studied here. Although every ecosystem is unique in some way, ecosystems of a given type have many traits in common. The use of average values in ecosystem valuation is no more or less justified than their use in other macroeconomic contexts (e.g., Gross Domestic Product).

- **Incomplete Coverage**. The fact that not all ecosystems and ecosystem services have been well-studied or valued is perhaps the most serious issue, because it significantly underestimates the value of ecosystem services. More complete coverage would almost certainly increase the estimates in this report. Table 3 identifies the ecosystem services valued for each land cover type within the MBSNF.

- **Increased Scarcity.** Valuations such as ours likely underestimate shifts in demand curves when the landscapes producing a given ecosystem service become relatively scarce, as many ecosystem service benefits are more highly valued as they become scarcer.[61] As natural lands are transformed to developed landscapes, ecosystem service provisioning can be expected to diminish, and thus the per unit value is likely to be underestimated.

- **GIS Data.** Since this valuation approach relies heavily on benefit transfer methods to assign values to land cover types, geospatial data quality assurance is paramount, in terms of the validity of land cover designation, as well as the accuracy and precision of the spatial extent of land cover types.

- **Ecosystem Health.** The ecosystems identified in the geospatial analysis may produce varying functions depending on their health. They could deliver values higher than those reported in the primary studies, which would result in an underestimate of current value. On the other hand, if ecosystems are less healthy than those in primary studies, this valuation will overestimate current value.

Economic Contribution Analysis

- **IMPLAN.** IMPLAN is a static, linear input-output model, based on empirical economic data that is periodically updated. This means that the models within IMPLAN reflect the economy at a given time, and does not account for price elasticities or changes in consumer behavior. Moreover, final IMPLAN estimates are partly based on inputs (e.g., expenditure data) provided by the analyst.

- **NVUM.** Our economic contribution analysis is based on the 2015 National Visitor Use Monitoring (NVUM) sampling year, which is believed by many to drastically under-represent actual visitation. As NVUM becomes more refined, further analyses should better understand the economic effects associated with MBSNF recreation.

- **Ranger District Allocation.** NVUM provides estimates of forest visitation and use within USFS boundaries. Thus, estimating visitation at a site or Ranger District level may not accurately reflect the distribution of recreation participation across (or within) ranger districts. Research is currently being conducted to better understand recreation patterns within national forests.

Appendix C. Defining Land cover

Land cover data for forested areas was provided by the Northwest Forest Plan (NWFP) Monitoring Initiative, developed by the Landscape Ecology, Modeling, Mapping & Analysis (LEMMA) research team, a collaboration between the USFS PNW Research Station and Oregon State University.[62] This dataset applies Gradient Nearest Neighbor (GNN) models to characterize forest plots based on Landsat imagery and Forest Inventory and Analysis (FIA)[x,63] sampling plots. The resulting 30x30 meter resolution forest cover data is effective for this large-scale analysis but does not fully capture forest conditions. For non-forested portions of the MBSNF, we applied the Ecological Systems map from the US Geological Survey's GAP Analysis Program.[64] This nationwide, remotely-sensed land cover grid captures primary ecosystems present but as with forests, does not provide the accuracy of on-the-ground field data. We encountered inaccuracies in the classification of several gravels bars and alluvial fans (classified as cultivated land) and adjusted the land cover accordingly. To further distinguish riparian zones (transition areas between terrestrial and aquatic ecosystems), we relied on USFS data on the extent of riparian reserves.[65] To define old-growth forest, the USFS also supplied tree stand age data, which we combined with information on species type and dominance, consistent with the Northwest Forest Plan.[66] We overlaid these datasets to generate a single, comprehensive map of forest ecosystems.

[x] "The FIA Program collects, analyzes, and reports information on the status, trends, and condition of America's forests: how much forest exists, where it exists, who owns it, and how it is changing, as well as how the trees and other forest vegetation are growing and how much has died or has been removed in recent years."[62]

Table 16: Crosswalk for Land Cover Data

Raw Land Cover Data	Land Cover used for Benefit Transfer
LEMMA GNN Structure Map	
Forest, Conifer Dominant Forest, Hardwood Dominant Forest, Mixed Conifer/Hardwood	Forests
GAP Analysis Program Ecological Systems Map (ESLF)	
Open Water (Fresh)	Rivers and Lakes
North American Alpine Ice Field	Snowpack/Glaciers
Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland North Pacific Alpine and Subalpine Dry Grassland	Grasslands
North Pacific Montane Shrubland North Pacific Avalanche Chute Shrubland North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-field and Meadow	Shrublands
North Pacific Bog and Fen North Pacific Shrub Swamp Temperate Pacific Montane Wet Meadow Temperate Pacific Freshwater Aquatic Bed Temperate Pacific Freshwater Emergent Marsh	Wetlands
Developed, Open Space Developed, Low Intensity Developed, High Intensity Disturbed, Non-specific Temperate Pacific Intertidal Mudflat North Pacific Alpine and Subalpine Bedrock and Scree Rocky Mountain Cliff, Canyon and Massive Bedrock Unconsolidated Shore North Pacific Herbaceous Bald and Bluff North Pacific Montane Massive Bedrock, Cliff and Talus	Not Valued

Appendix D: Economic Value of MBSNF Recreation by Activity

Activity	Visits[46]	Economic Value Per Visit[23]	Total Economic Value (Millions USD)
Hiking and Walking	1,082,608	$93	$100.7
Downhill Skiing	272,080	$90	$24.5
Viewing Natural Features	176,696	$66	$11.7
Bicycling	174,193	$104	$18.1
Some Other Activity	97,739	$72	$7.0
Relaxing	95,482	$98	$9.4
Cross-country Skiing	77,224	$62	$4.8
Backpacking	36,650	$86	$3.2
Driving for Pleasure	34,112	$72	$2.5
Picnicking	25,204	$59	$1.5
Developed Camping	19,733	$100	$2.0
No Activity Reported	12,731	$65	$.8
Primitive Camping	11,894	$86	$1.0
Fishing	8,777	$93	$.8
Viewing Wildlife	8,424	$72	$.6
Resort Use	7,805	$150	$1.2
Motorized Trail Activity	4,466	$66	$.3
OHV Use	3,361	$66	$.2
Hunting	2,855	$116	$.3
Nature Study	2,689	$72	$.2
Other Non-motorized	2,378	$72	$.2
Gathering Forest Products	2,252	$72	$.2
Non-motorized Water	2,148	$142	$.3
Snowmobiling	1,426	$61	$.09
Nature Center Activities	334	$72	$.02
Motorized Water Activities	186	$82	$.02
Visiting Historic Sites	186	$66	$.01
Total	**2,163,631**	**x**	**$191**

Appendix E: Health Value of MBSNF Recreation by Activity

Activity	Visits[46]		MET[32]		Net Calorie Expenditures (millions Kcal)	
	Adult	Youth	Adult	Youth	Adult	Youth
Hiking and Walking	928,878	153,730	6	4.6	1,495,584,402	101,796,948
Biking	167,747	6,445	8	7.8	358,734,866	7,648,040
Downhill Skiing	262,557	9,523	5.5	5.5	341,446,234	7,073,809
Backpacking	31,372	5,278	6.5	4.2	205,156,290	11,469,676
Cross-Country Skiing	74,366	2,857	8	8	159,035,446	3,490,275
Relaxing	84,788	10,694	2	1.4	78,409,797	2,259,569
Camping (Developed)	13,418	6,314	2.5	2.5	53,180,486	14,294,983
Fishing	8,610	167	40	2.9	52,678,852	28,392
Viewing Nature	172,809	3,887	2.5	2.9	47,086,602	766,362
Camping (Primitive)	8,088	3,806	2.5	2.5	32,054,471	8,616,283
Non-Motorized Boating	1,585	563	4	3	10,288,481	1,390,898
Hunting	2,512	343	5	5	9,957,444	775,598
Other	95,296	2,443	1.5	1.4	9,835,599	115,244
Resort Use	6,674	1,132	2	1.4	7,990,006	309,599
Driving For Pleasure	33,293	819	2	1.4	6,597,524	37,067
Viewing Wildlife	7,935	489	2.5	2.5	5,700,413	200,481
Off-Highway Vehicle Use	3,126	235	4	2.5	5,419,544	116,503
Motorized Trail Riding	4,256	210	4	2.5	4,955,056	69,793
Picnicking	24,247	958	1.5	1.5	3,803,846	85,827
No Activity Reported	12,413	318	1.5	1.4	1,281,145	15,011
Other Non-Motorized	2,321	57	3	3	920,013	12,922
Gathering	2,207	45	3	3	728,875	8,497
Nature Study	2,640	48	2.5	2.9	588,664	7,807
Snowmobiling	1,397	29	3.5	2.5	576,944	4,035
Nature Centers	307	27	2	1.4	203,096	4,035
Motorized Boating	184	2	2.5	2.5	22,782	131
Historic Sites	186	-	2	1.4	-	-
Other Motorized Activities	-	-	2.5	2.5	-	-
Horseback	-	-	4	4	-	-
Total	**1,953,531**	**210,100**			**2,892,236,878**	**160,597,787**
				Grand Total	**3,052,834,665**	

Appendix F. Visitation to Ranger Districts

This analysis uses National Visitor Use Monitoring (NVUM) program FY2015 data to estimate visitation to Ranger Districts within the MBSNF, taking the All-Forest Information approach, as described in White 2007.[67] It is assumed that patterns of recreation within site types (e.g., day-use developed sites) and use levels (e.g., high, medium, low) do not differ across ranger districts, but follow identical use patterns throughout the MBSNF. Specific combinations of site types and use levels are called "strata" within the NVUM framework (e.g., day-use developed–medium).

We first generated site visits within Ranger Districts for both proxy and non-proxy sites. A proxy site requires users to obtain a permit or pay a fee prior to use – as such, establishing visitation rates for these is a relatively straightforward process of combining proxy counts, site days, and a forest-wide conversion factor for each stratum. Visitation to non-proxy sites is calculated based on forest-wide site averages for each stratum, as well as the number of site days for each stratum within each ranger district. Then forest visits for each Ranger District are estimated using the site visits and the forest-wide average number of national forest visits per stratum. Following this approach, we arrive at the distribution of visits depicted in Table 16.

The estimates presented here assume that NVUM site interviews accurately represent forest use across the MBSNF. Unfortunately, NVUM sampling pools are relatively small, and as such are not statistically significant at the site or ranger district level. Therefore, the allocation of visitation reported here may not be representative of actual use. However, these results provide context for understanding the importance of outdoor recreation to nearby communities.

Table 17: Visits by Ranger District

Ranger District	Visits	Expenditures
Darrington	228,817	$7,277,672
Mt. Baker	439,120	$16,964,900
Snoqualmie	762,004	$29,269,564
Skykomish	733,690	$25,556,502
MBSNF Total	**2,163,631**	**$79,068,637**

Appendix G. Mapping Visitor Spending

Visitors are likely to pass through multiple towns before reaching the MBSNF. Passing through each town, visitors have opportunities to spend money in restaurants, gas stations, and gear shops. Accordingly, modeling visitor pathways to the MBSNF can be useful in understanding relationships between the MBSNF and local communities.

Earlier analyses have estimated regional economic impacts of national forest visitation, but connections between specific Ranger Districts and gateway communities have not been studied. NVUM surveys indicate respondents’ home zip codes, primary activities, and trip-related spending within 50 miles of the survey location. We began our analysis with a subset of respondents who reported a home zip code within Washington State (78 percent of respondents). We excluded out-of-state visitors, as they are more likely take several modes of transportation to the survey location (e.g., planes, trains, automobiles).

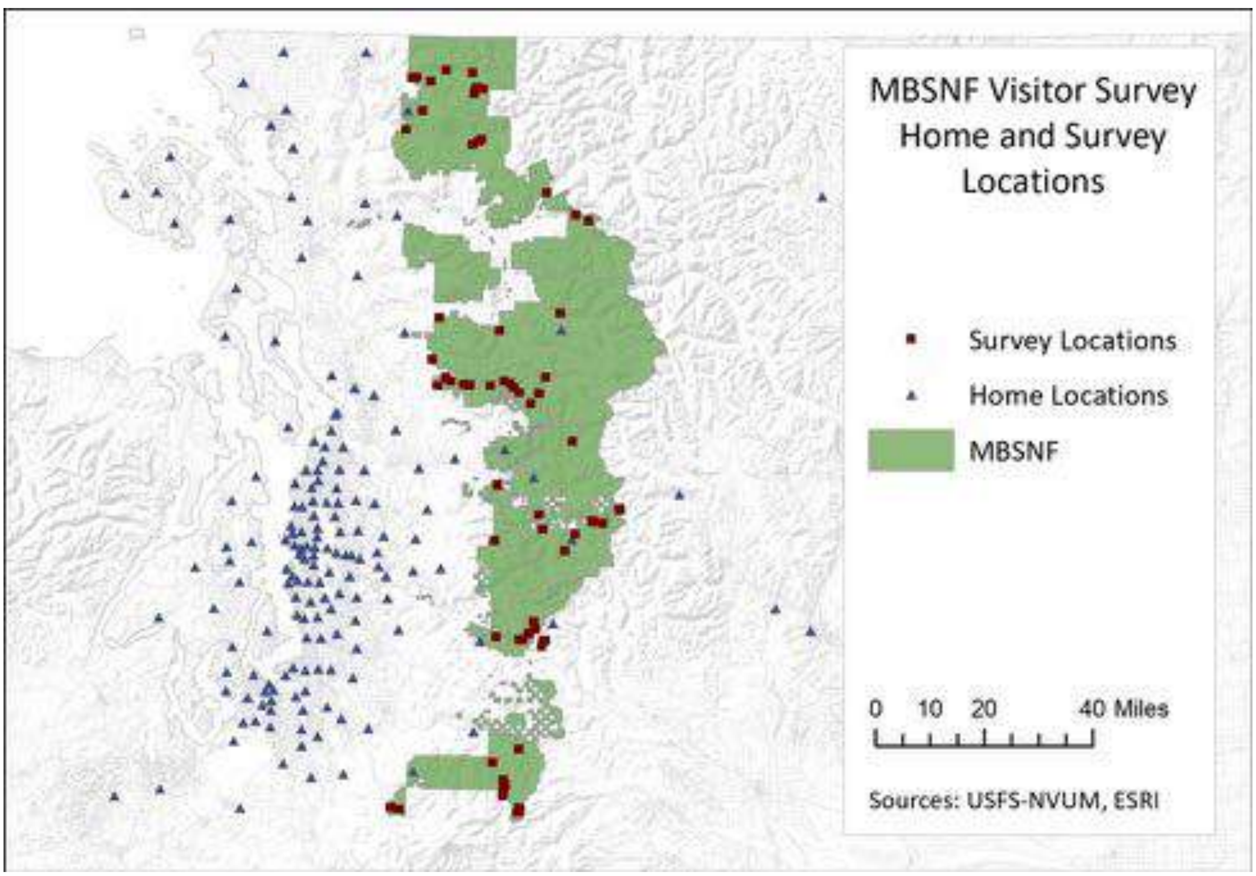


Figure 10. Survey locations and Respondents Home Zip Codes.

Combined with the survey site location, we then developed a geospatial model to estimate community-level spending. We made two key assumptions: one, that interview locations represent participants' primary recreation destination and are associated with most of their spending; and two, that recreationists' travel began in their home zip codes and they did not travel beyond the survey location before returning. While we do not know the individual travel patterns, the MBSNF restricts entry and exit points to the forest in such a way that travel between Ranger Districts is limited.

We then generated most-likely travel routes between survey site locations and respondent zip codes, based on the shortest travel time. Data included all Washington State public roads and speed limits for a subset of major roads and highways.[xi] This resulted in 820 unique routes (see Figure 4). Of course, this analysis could be improved by including traffic data and other impediments (e.g., stoplights).

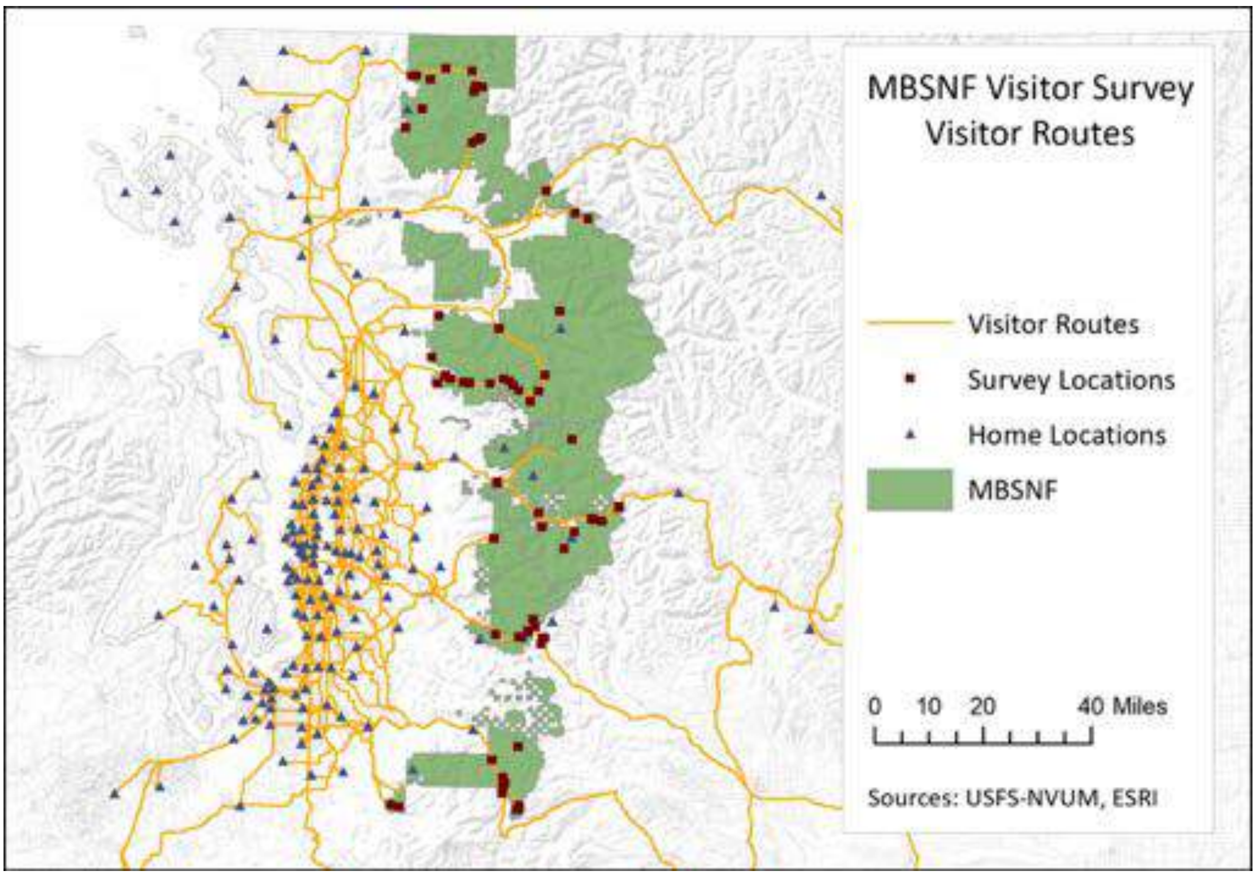


Figure 13. Approximated Routes Traveled to Reach the Mt. Baker--Snoqualmie National Forest

[xi] A speed limit of 25mph was assigned to remaining neighborhood roads.

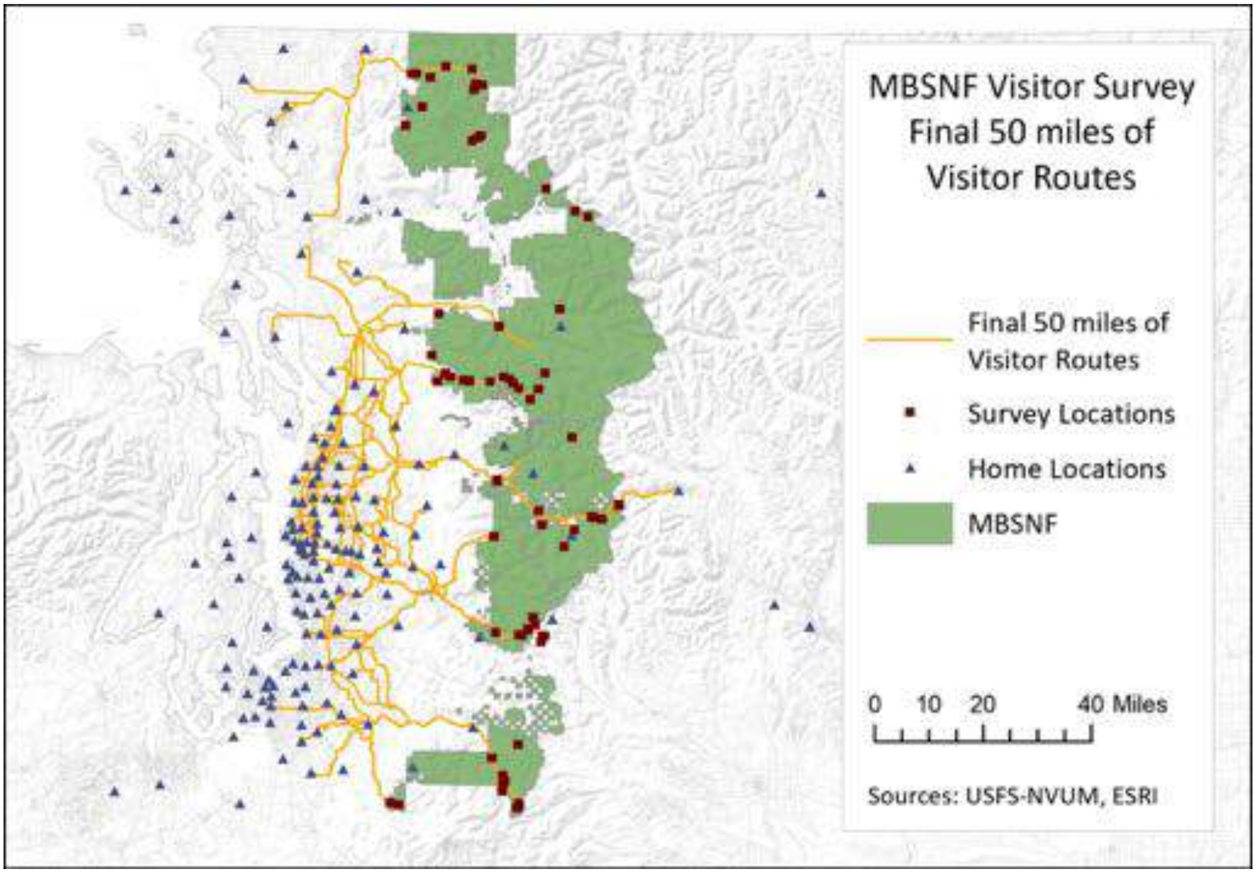


Figure 16. Final 50 Miles of Routes to the Mt. Baker--Snoqualmie National Forest (used to distribute trip-related spending)

Again, we limited trip spending to the last 50 miles of each route to the MBSNF. To estimate specific expenditure locations along the final leg of each route, we identified businesses associated with outdoor recreation travel based on 167 NAICS codes.[xii] Along each route, businesses were associated with specific communities (or census designated places). Businesses located within a half-mile of a route were assumed to be equally likely to capture recreation spending, regardless of community. Thus, we assumed that communities with more businesses would receive a larger proportion of expenditures and vice versa.[xiii] Secondary analysis could segment businesses by spending categories and community, allowing spending to

[xii] Based on the 10 categories identified in White (2017) (restaurants, sporting goods stores, gas stations, etc.).

[xiii] Attempts were made to generate likelihood to spend based on business revenue data, surrounding population, and concentration of businesses, but did not return significant results. Additional research should be conducted to disaggregate recreation and non-recreation related expenditures in gateway communities.

be further refined by community, based on specific recreationist types (e.g., skiers, backpackers) and their associated spending.

To scale individual survey trip expenditures to represent all national forest visitation, we used respondents’ primary activity and survey site characteristics (i.e., NVUM strata, see Appendix F). We used the number and type of visitors along each route to calculate total route expenditures, which we then distributed to communities based on their proportion of all spending opportunities, as described above. By overlaying all routes, we estimated total spending by community. Expenditures per community were then aggregated to the county level for an input-output economic contribution analysis. In addition to providing necessary inputs to model economic contributions, community-level spending estimates provide a better understanding of relationships between forest use and local spending, helping to connect gateway communities to the MBSNF.

Appendix H. Studies Used for Benefit Transfer

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