Economic Impact of Metro Parks Tacoma Ecosystem Services

Economic Impact Study Phase II

EARTH ECONOMICS

December 2011

Citation:
Christin, Z., Batker, D., Harrison-Cox, J., 2011. Economic Impact of Metro Parks Tacoma Ecosystem Services: Economic Impact Study Phase II Earth Economics, Tacoma WA.

Authors: Zachary Christin, David Batker, Jennifer Harrison-Cox

V1.7

Acknowledgments

Project team members included David Batker, Jennifer Harrison-Cox, Zachary Christin, and Tedi Dickinson. Editing support was provided by David Seago and Allyson Schrier. Report layout and design by Maya Kocian. Joshua Kruszynski provided factsheet design support.

The project team thanks Metro Parks Tacoma for its Phase II grant supporting this research study. Special thanks to Kathy Sutalo, Brett Freshwaters, Wayne Williams, Nancy Johnson, and John Garner for their help with the completion of this report.

Through its innovative organization in Tacoma, Washington, Metro Parks strives to conserve and steward the precious resources that are entrusted to its care and provide leadership in inspiring an ethic of sustainability throughout the Northwest.

Cover Photo: Wapato Park in Tacoma. Photo by Maya Kocian

Table of Contents

Executive Summary 5

Study Findings 5

Next Steps 6

Introduction 7

About MPT 7

MPT Economic Impact Phase I Study 8

Phase II Study Objectives 9

Report Organization 9

Part I: Characterization of Metro Parks Tacoma 11

Geography 11

Land Cover and Land Use 11

Recreational Facilities and Gardens 12

Community Vitality 12

Stewardship Activities 13

Renovation Activities 13

Restoration Activities 14

Part II: Key Ecological and Economic Concepts 15

Introduction to Ecosystem Goods and Services 15

Ecosystem Goods 17

Ecosystem Services 17

Ecosystem Service Valuation 17

Benefits of Parks in Urban Settings 17

Part III: Ecosystem Services provided by MPT Natural Capital 19

Categories of Ecosystem Services 19

Ecosystem Service Descriptions 21

Disturbance Prevention 21

Recreation 22

Science and Education 23

Water Supply 24

Nutrient Regulation 25

Water Regulation 26

Spiritual and Religious Experience 28

Soil Formation 29

Soil Retention 30

Water Quality and Waste Treatment 31

Biological Control 32

Habitat and Biodiversity 33

Primary Productivity 34

Climate Regulation 35

Pollination 36

Food and Other Products 37

Aesthetic Information 38

Impact of Stewardship Activities on Ecosystem Services 39

Part IV: Impact of MPT Natural Capital on Human Well Being 41

Health: Categories of Health Benefits from Parks 41

Exercise 41

Mental Health 43

Air Pollution Removal 44

Community Benefits 45

Education 46

Social Capital 47

Part V: Economic Value of MPT Natural Capital **49**
Ecosystem Service Valuation **49**
Overview 49
Quantification of Land Cover Classes 49
Annual Flow of Ecosystem Service Value 56
Economic Contributions of Health and Education **56**
Overview 56
Reduced Health Cost Value 58
Value of Air Purification 59
Educational Value 60
Social Capital Value 60
Total Value **61**
Part VI: Value of MPT's Stewardship and Sustainability Practices **63**
Current Status of MPT Park Lands **63**
Restoration Prioritization 63
Ecosystem Services and Ecosystem Health 64
Value of Park Restoration 65
Total Ecosystem Service Value 68
Present Value **68**
Part VII: Applications of Study Findings **71**
Investing in the Future **71**
Decision Support **71**
Urban Park Characterization 71
Cost-Benefit Analysis 72
Project Prioritization 72
Environmental Impact Statements 72
Internal Policy and Procedure Revamp 73
Green Jobs Analysis 73
Conclusion **74**
Summary of findings **74**
Next Steps **74**
Photo Credits **76**
Appendix A: Report References **77**
Appendix B: Additional Ecological and Economic Concepts **82**
Appendix C: Value Transfer Studies Used - Full References **87**
Appendix D: Value Transfer Studies Used by Land Cover Class **93**
Appendix E: Additioanl Tables and Charts **98**
Appendix F: Study Limitations **101**
Appendix G: The Economic Value of Metro Parks Tacoma's Natural Capital **105**

Executive Summary

Created in 1907 by a vote of the people, the Metropolitan Park District of Tacoma, or Metro Parks Tacoma, strives to be a leader among its governmental peers and to set an example with regard to stewardship and sustainability of park lands and facilities, efficient use of public dollars, excellence in educational programming and conservation of resources. As a separate entity from the City of Tacoma and Pierce County, Metro Parks operates a comprehensive, award-winning system of parks, zoological and recreation facilities for the City of Tacoma and the Browns Point/Dash Point area of Pierce County, Washington. Metro Parks oversees 2,960 acres of park and open space; the majority of the park land in Tacoma.

Currently Metro Parks is evaluating innovative and timely methods for assessing the value of the parks in its jurisdiction so it can effectively maintain and restore its park lands and facilities and better serve the growing community of park users. This study, the first of its kind in the nation, attempts to provide a more complete assessment of park value than has traditionally been used, and is a complement to the Metro Parks Tacoma Economic Impact Study completed in January of 2010. Here, dollar values are assigned to the ecosystem services provided by the Park District's natural capital as well as to the social capital associated with these parks, and to the health and education benefits these parks provide to local community members and a broad spectrum of visitors.

Natural capital is defined as the greenspace, forests, bodies of water and coastline that exist in Metro Parks Tacoma parks. Ecosystem services are the benefits these natural systems provide free of charge which would be enormously expensive to recreate with manmade solutions. Forests, for example, provide air purification, carbon sequestration and rainwater retention, which helps prevent flooding events. Social capital is the inventory of organizations, institutions, laws, informal social networks, and relationships of trust that make up or provide for the productive organization of the economy. In a parks context, the quantifiable social capital is the hours and money donated by volunteers. These concepts and the valuation methods used are explained in detail in the body of the report. The report makes a strong case that social capital and health and education benefits are linked to natural capital. If park systems are allowed to deteriorate, people are less likely to volunteer time and money and are less likely to use parks, thereby reaping fewer health and education benefits.

Study Findings

This report identifies 23 ecosystem services provided by the natural capital present in Metro Parks Tacoma (MPT) parks. Of these, 10 ecosystem services have been assigned value using eight valuation techniques including market value and cost avoidance. The results are compelling: By assigning value to ecosystem services like reducing the frequency and severity of urban floods, supporting fisheries and food production, maintaining critical habitat, enhancing recreation and providing waste treatment, **MPT park ecosystems provide between $3.6 million and $13.0 million in benefits to the regional economy every year. The social capital and education and health benefits provided by MPT parks are worth approximately $18.2 million per year.**

The wide range in ecosystem services values represents an "appraisal" of the MPT's natural capital, similar to a house or business appraisal. As new studies are published and added to the Earth Economics database, and as spatial ecosystem service mapping of the parks and watersheds containing them is completed, this range in values will narrow. As it was not possible to value all 23 ecosystem services in this study, the low end of the range can be considered a "below the basement" baseline value.

This is tremendous economic value by any measure. Recognizing this value presents an opportunity for advancing the importance of all MPT parks and demonstrates the fact that allowing ecosystems to be further degraded will create real and potentially significant negative economic impacts both within the parks and within the communities and watersheds they support. To ensure a healthy, resilient Tacoma economy, a sustainable future and a high quality of life for citizens, the flow of benefits from MPT's natural capital should be incorporated into decision-making - including development of agency goals, metrics, indicators, assessment and general operations. This report provides guidance for achieving these objectives.

Further, ecosystem service values should be considered when developing budgets, program plans and grant applications; examining policies and accounting practices; reporting and aligning to Puget Sound health indicators; and developing review and permitting processes. This will enable decision-makers at Metro Parks Tacoma to develop an even more integrated approach with greater cost-efficient, sustainable and beneficial results.

Next Steps

While this report provides a valuation of ecosystem services in MPT parks and a whole view of the economy, it is only a first step in the process of developing policies, measures and indicators that support discussions about the tradeoffs in investments of public and private money that ultimately shape the long-term regional economy.

Next steps recommended in this study include:

1. **Jobs creation analysis on the results from restorations activities and expenditure in parks.** The Phase I report of MPT parks, showed that over $22 million is spent annually by visitors to 18 of MPT's parks. This spending supports local store owners, vendors and other businesses that rely on these park attendees for sales of their goods and services. Using expenditure models, this economic activity can be shown to support thousands of jobs in Tacoma's local economy.

2. **Ecosystem service mapping of service beneficiaries and provisioners.** Using hydrological models and GIS data, sophisticated maps can show geospatially where specific ecosystem services, such as flood risk reduction or salmon habitat, are provisioned on the landscape, and who benefits from those services. Mapping can also show impairments to ecosystem services, such as features on the landscape that impact salmon habitat.

3. **Funding mechanism review.** After modeling the flow of ecosystem service benefits and impairments across the landscape, funding mechanisms can be designed for green infrastructure investments. These investments typically reduce tax spending on solutions designed to address a single problem, such as flood risk reduction, and instead invest in a suite of ecosystem services that provide many benefits and produce far higher economic and quality of life returns.

   In 2011, Washington State Parks was facing budget cuts and potential closure of most state parks. Earth Economics had a study of the jobs provided by state parks to rural communities underway. After state legislators were provided with data on the jobs supported by state parks, they agreed that funding parks was economically important (Earth Economics does not lobby or promote legislation). The Legislature subsequently passed a $70 million funding mechanism called the "Discover Pass."[1]

Residents and decision-makers in the Metropolitan Park District have an excellent opportunity to begin developing policies, measures and indicators that can provide the data and information needed to support discussions about the tradeoffs among many potential investments of public and private money – investments that ultimately affect human well-being. Seizing the opportunity and rising to the challenge will ensure a sustainable and desirable future for all Tacoma parks.

Introduction

According to the United Nations Population Division, over 50% of people worldwide live in towns and cities, and by 2030, 70% of the world's population will be city dwellers.[2] People in large cities will have smaller living quarters, busier roads and generally less access to open space and nature. As more people live in cities, the importance and value of parks increases. We are at a pivotal moment as our society is becoming predominantly urbanized. Without significant vegetation, communities surrounded by concrete experience an increase in peak temperatures. In developed countries, extreme heat in urban areas resulting from climate change has taken the lives of hundreds of people. In the summer of 2011 alone dozens of heat related deaths were reported in the U.S. and over 35 in Japan.[3] Urban development has also contributed to increased water runoff, resulting in more frequent flooding. Flooding in the U.S. costs roughly $6 billion annually, excluding Hurricane Katrina, which cost over $200 billion alone.[4]

While there seems to be no immediate solution to increasing global temperatures and catastrophic floods, local action can help communities adapt and reduce negative impacts. Providing developed areas with urban vegetation and park forests helps alleviate excessive heat and reduces floods resulting from stormwater runoff. Further, more parks are needed to support the large populations, especially in downtown residential districts, that flock to parks on the hottest days of the year. Instead of building higher levees for flood protection, investments should be made to preserve and improve the ecosystems that provide flood protection naturally, not only in native forests but also in forested landscapes and greenspace built into urban areas.

With a weaker economy, new city developments that incorporate urban greenspace have slowed, as have incentives to add or enhance green infrastructure. Budget cuts in natural resource and parks funding have resulted in parks being closed around the country. In May of 2011, the California Department of Parks and Recreation announced that it would be closing 70 of its 278 parks due to budget cuts that required a $33 million reduction by 2012-13.[5] But recent studies reveal that parks actually contribute significant quantifiable value. In 2009 and 2010 the Trust for Public Land released studies in Seattle, Washington, D.C., and New York quantifying that parks provide significant benefits to health, tourism, property and community cohesion. Benefits that were previously ignored are now estimated to be worth hundreds of millions of dollars.[6]

Parks will continue to become larger components of city capital in the 21st century economy. When these lands are highly prioritized and adequate steps are taken to ensure ecological sustainability and biodiversity, the links between parkland and economic prosperity will become evident in the forms of improved ecosystem services, increased social capital, improved health and education, a stronger local economy and a higher quality of life for residents across many decades.

About MPT

Created by a vote of the people in 1907, Metro Parks Tacoma strives to be a leader among its governmental peers with regard to stewardship and sustainability of park lands and facilities. It seeks efficient use of public dollars, excellence in educational programming and conservation of resources. MPT works to deliver the quality programs and products district taxpayers have come to expect.

METRO PARKS
TACOMA

MPT operates a comprehensive, award-winning system of parks, zoological and recreation facilities for the City of Tacoma and the Browns Point/Dash Point area of Pierce County, Washington, as a separate entity from the City of Tacoma and Pierce County. MPT consists of 2,960 acres of parks and open space; the majority of the park land in Tacoma. Included are these major facilities:

- Point Defiance Park (702 acres)
- Point Defiance Zoo & Aquarium
- Point Defiance Marina Complex
- Northwest Trek Wildlife Park (715 acres)
- Meadow Park Golf Course (27 holes)
- Four Community Centers
- Ruston Way Parks on Commencement Bay
- Family outdoor leisure pool/waterslide complex at Stewart Heights Park

Through sound management and best practices, Metro Parks is creating a legacy for future generations. The intent to create a sustainable park system is embedded in the District's strategic plan, operating policies, recreational programming and leadership practices.

Metro Parks' long-term strategic plan calls for protecting and restoring the natural environment for conservation and learning. Guiding principles and strategic goals include reducing adverse impacts to the environment, protecting the ecological function of natural areas, promoting conservation ethics and environmental sustainability by adopting green practices throughout the park system; and providing for the health, safety and comfort of park visitors. MPT considers itself a charter agency responsible for both direct and indirect contributions to environmental health and sustainability.

MPT Economic Impact Phase I Study

Hebert and Associates completed a study in January 2010 for Metro Parks that measured the economic value and impact of MPT parks and recreation facilities, focusing on the economic value of spending by visitors within the park system, the value of MPT spending and the positive impact of parks on property values.[7] The Phase I study concluded that approximately $22.2 million annually was attributed to spending by park users and the increased value to homes located near parks.

Phase II Study Objectives

The value presented in the Phase I report, while substantial, is not a complete valuation of the benefits that Tacoma receives from its parks. A more complete analysis would consider the dollar value associated with other park benefits residents receive from their parks. These include the ecosystem services provided by natural capital, social capital, and health and education benefits. Even in an iconic park like Point Defiance, which serves over 100,000 visitors per year (not including zoo attendance), there has been no attempt to measure these values.[7]

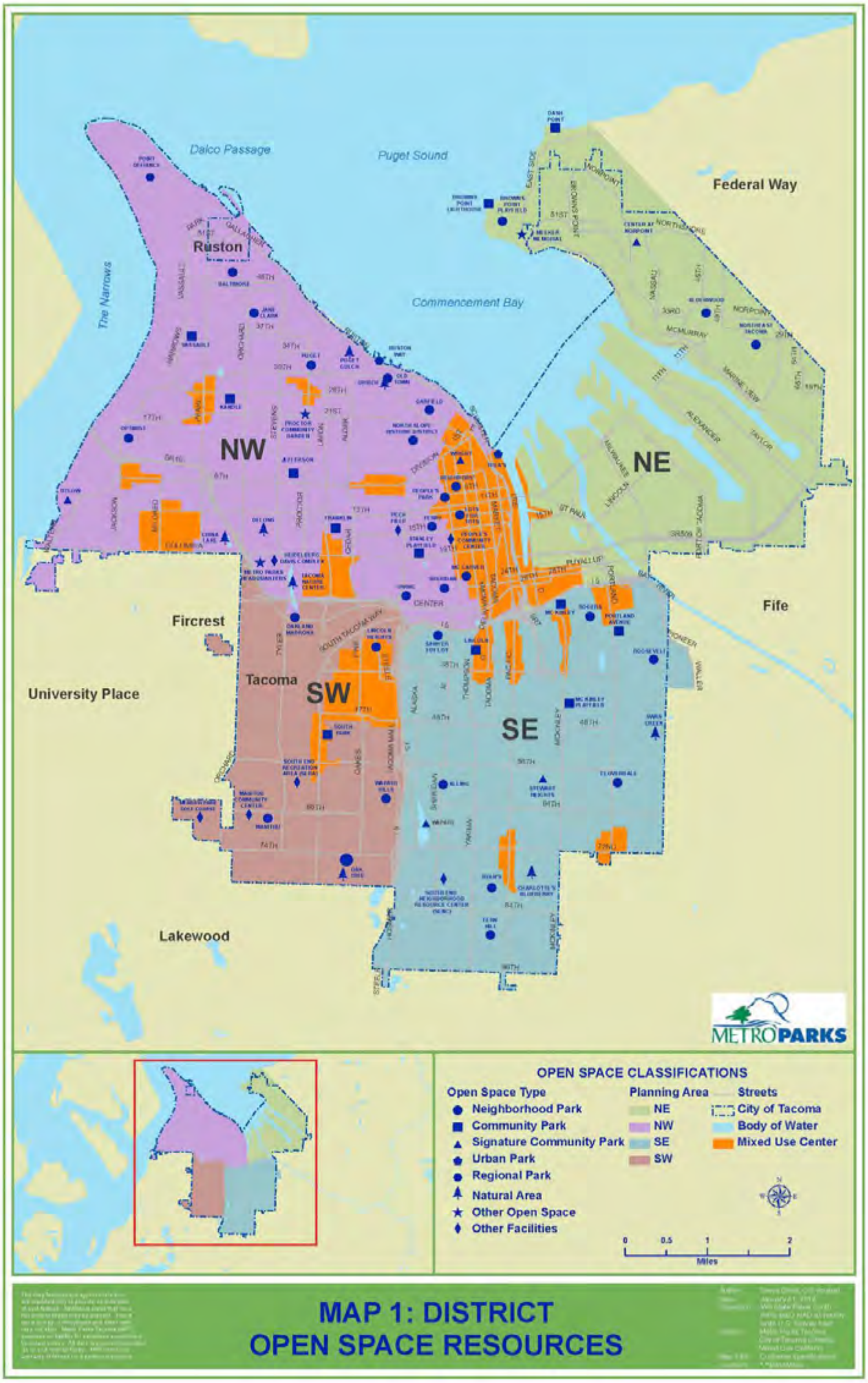
The purpose of this study is to illuminate the importance of maintaining a healthy and vibrant ecosystem within MPT parks. This paper introduces and applies the tools of ecological economics, including an ecosystem services valuation to MPT. This is accomplished by:

- Providing a conceptual model for aligning multiple investment goals
- Identifying and describing ecosystem goods and services present
- Identifying health benefits
- Calculating the dollar-value of natural capital
- Discussing applications of this approach in accounting and decision-making to improve prosperity for all

Report Organization

- **Part I: Characterization of Metro Parks Tacoma** introduces the geography, park facilities and local communities of MPT parks.
- **Part II: Key Ecological and Economic Concepts** provides the definitions and funding elements necessary to understand the economic benefits of MPT ecosystems.
- **Part III: Ecosystem Services Provided by MPT Natural Capital** describes the ecosystem services identified and valued in this report, with specific examples.
- **Part IV: Impact of MPT Natural Capital on Human Well Being** describes the value for some ecosystem goods and services**.**
- **Part V: Economic Value of MPT Natural Capital** estimates the educational, social and health values.
- **Part VI: Value of MPT's Stewardship and Sustainability Practices** uncovers the value associated with future and potential restoration projects that would increase the value of ecosystem services.
- **Part VII: Applications of Study Findings** discusses investing in green infrastructure and whole systems economic analysis, with specific recommendations for decision-makers.

Figure 1 – Map of Tacoma



Part I

Characterization of Metro Parks Tacoma

Section Summary: *The 70 parks and urban green spaces that MPT maintains provide a majority of the forest cover and public play fields (not counting public school fields) within the Tacoma city limits. While some of the smaller parks are comprised of limited greenspace, many contain forest, dense wetlands and lakes and ponds. Individuals and community organizations donate time and money to help care for this land. Continued restoration and maintenance efforts are needed to help these local ecosystems flourish.*

Geography

Most of the 2,960 acres of greenspace maintained by MPT are located in the Tacoma area, in the southern Puget Sound region of Washington State. Northwest Trek, the only exception, is located outside the city near Eatonville, Washington. Most of the parks range from one to 10 acres, but the largest, Point Defiance, stretches across 702 acres of the northwest tip of Tacoma.

This report follows the same geographic conventions as the Phase I report, which describes northwest, northeast, southwest and southeast regions shown in Figure 1.

Land Cover and Land Use

Along the coast of the southern Puget Sound, a majority of the shoreline in Tacoma is dedicated to heavy industrial, commercial and residential development. The Port of Tacoma, which shipped more than 700,000 containers of goods in 2010, encompasses over 20 miles of coastline.[8] The remainder of the Tacoma shoreline is developed residentially and commercially, with the exception of 10 waterfront miles occupied by five parks: Point Defiance Park, Titlow Park, Ruston Way, Browns Point Lighthouse Park and Dash Point Park.

In some of the shoreline parks, located in the northwest and northeast regions of Tacoma, the terrain becomes very steep with clay and glacial till ridges forming cliff sides along the Sound. Inland, six parks contain lakes and creeks. Especially environmentally significant are Swan Creek, which flows directly into the Puyallup River and then into Puget Sound, and Snake Lake, which consists of 70 acres of wetlands and forested watershed. These lakes and creeks act not only as habitat for native plant and animal species, but also as water reservoirs, nurseries, food sources and carbon banks.[9]

Nearly half of MPT's parks have some portion dedicated to the preservation of natural areas. These areas directly benefit surrounding communities during every season. The heavy rainfall in the autumn, winter and spring would pose a direct threat to local communities without the flood protection provided by nearby vegetation systems that can hold large amounts of stormwater. And in the summer, in the more developed regions of Tacoma, the forest cover provides welcome relief to residents seeking escape from the heat. Year-round, these parks provide premier recreation benefits.

Before Tacoma grew into a city of nearly 200,000 people,[10] economic growth was heavily dependent on the surrounding environment and its resources.

The parks and greenspaces that MPT owns and/or maintains are what remain after decades of development. The remaining natural capital, or green infrastructure, of MPT parks plays a critical role in the community by providing ecosystem services such as water regulation, aesthetic and recreational value and flood risk reduction in addition to providing health benefits and educational opportunities to both the local community and visitors.

Recreational Facilities and Gardens

In addition to the natural landscapes within MPT parks, many acres have been converted into baseball fields, soccer fields and grass open space for active recreation. Hundreds of thousands of people visit MPT parks each year to participate in sports events, to take advantage of miles of trails for walking, running and biking, to swim, or to enjoy more passive recreation like bird-watching or simply enjoying nature and taking in the breathtaking views that Tacoma offers.

Nearly all of MPT's parks have amenities such as play structures, swimming pools, spraygrounds, skate parks or ballfields, and some provide community buildings or picnic structures. Many of the sports fields were constructed to serve the general local community, and some of the parks, like McKinley Playfield, Stewart Heights and Vassault Field, serve educational institutions and organized teams by providing field space.

Thousands of people come to Tacoma each summer to visit the botanical gardens. Since 1938, Wapato Park has displayed rows of flowers including perennials, sunflowers, begonias, and more.[11] At Point Defiance, large sections of the park are dedicated to gardens featuring hundreds of plant species. Metro Parks dedicates space for these displays, partnering with the Tacoma Garden Club, Tacoma Rose Society, the American Dahlia Society, the Tahoma Fuchsia Society, the Pierce County Iris Society and the Tacoma Chapter of the American Rhododendron Society.[12]

Wright Park, located just a half-mile north of downtown Tacoma, is one of the city's most diverse parks, with an assortment of play structures and features in a relatively small space. Made up of nearly 30 acres, Wright Park sees more visitors per acre than any other park in the city.[a] The most distinctive feature is the W.W. Seymour Botanical Conservatory. Built in 1908, this conservatory offers exotic floral displays year round at no cost to visitors.[13] Outside the conservatory, 155 different species of trees, some more than 100 years old, cover nearly the entire park.

Community Vitality

Parks bring people together and create a sense of shared purpose, whether it is in the form of kids playing on a team, parents gathering with their children at a playground, or community members gathering to share in the use of community gardens.

Open space areas in Tacoma also provide communities with the opportunity to collectively organize, both for small group functions (i.e., family, social groups), or for major events like the Taste of Tacoma, held in Point Defiance Park. In 2010, that weekend event drew 235,000 visitors.[b] Several more large festivals take place each summer in Wright Park, Ruston Way parks, and in Peoples Park.

The business community is also well-served by MPT parks. Employees from Mary Bridge Children's Hospital, MultiCare and Group Health enjoy the benefit of using Wright Park, which is conveniently located within a city block. More than 25 additional businesses are located within a quarter mile of the park. Point Defiance, Puget Creek, Wapato Park, and

a Not including Point Defiance Zoo.

b Information provided by MPT.

several other Tacoma parks are all located within two to three blocks of shopping centers or business districts, providing hundreds of employees with a break from the working environment.

As much as people depend on their parks, the park system depends on the people who visit them to donate their time to youth programs and park restoration efforts. The success of Tacoma parks is increasingly dependent on the involvement of these volunteers. In 2010 more than 52,000 volunteer hours were donated by Tacoma organizations, societies and groups of volunteers.[c]

Stewardship Activities

Long-term investment in city parks, both in the form of financial investment and volunteerism, is crucial for maintaining the health and vitality of the parks and the entire community. Active stewardship is essential to prevent greenspace from being overrun with invasive species, and to maintain trails and ornamental landscapes. When stewardship is abandoned and parks are allowed to decay, people are less likely to make use of them and are less enthusiastic about putting energy into their upkeep.

Renovation and construction projects raise longer-term stewardship issues. While the addition of parking lots may improve accessibility to park visitors in the short run, the conversion of landscape may result in increased flooding, toxic runoff, and degraded aesthetics in the longer run, thus rendering the parking lot project a bad investment.

Renovation Activities

MPT is currently in the midst of reconstructing and renovating many of its parks. In 2005, Park District voters passed an $84.3 million bond measure that allowed MPT to implement projects

c Information provided by MPT.

in environmental categories, in addition to specific site improvements: Environment, Greenspace, and Natural Area Enhancements; Reforestation Program; Off-Leash Park Development, and Trail Improvement Program.[14] In addition to the bond program, other renovation projects recently included converting turf areas to habitat plantings that use less water and motorized equipment. As of the end of 2010, MPT had completed about 75% of its bond projects.

2,960

Number of acres maintained by Metro Parks Tacoma

Restoration Activities

Substantial restoration projects are in place to improve near-shore habitat to support salmon. In light of statewide issues regarding depleting salmon populations, restoration of salmon spawning areas is generating tremendous value. According to a 2008 study, salmon populations are still on the decline in the Western U.S., resulting in the need for more salmon hatcheries at high costs.[15] In Tacoma, the completion of the Swan Creek Master Plan marks the beginning of the first phase of restoration in the 383-acre park, the only park in Tacoma supporting an annual salmon run.[16] Puget Creek has also documented sporadic use by coho salmon.

52,000

Number of hours volunteered in 2010

The removal of invasive plant species has become a priority in MPT parks facing the greatest threat. The proliferation of non-native species directly interferes with natural ecological processes, challenging the survival of native flora and fauna. Projects in Puget Creek, Swan Creek, Oak Tree Park, Snake Lake, Garfield Gulch, McKinley Park and Titlow Park are restoring native vegetation in an effort to preserve the ecosystems and the services that they provide.

75%

Proportion of bond projects completed to date

In Part VI of this report, the potential restoration goals are detailed and the organizational restoration plans analyzed in order to provide MPT with a guide to manage those projects so as to return the highest long-term value.

Part II

Key Ecological and Economic Concepts

Section Summary: *The "ecosystem services" framework is an operational way of including natural capital in economic analysis. It is a means to understanding and embracing an integrated approach to managing undeveloped land. Appendix B provides more information on the relationship between human well-being and the supply of nature's goods and services, as well as built, financial and human capital (labor), and the scarcity of natural resources.*

Introduction to Ecosystem Goods and Services

Ecosystems provide economically valuable goods and services. Ecosystem services were recently given higher prominence in the Millennium Ecosystem Assessment, a project initiated in 2000 by then-United Nations Secretary-General Kofi Annan and completed in 2005. The Millennium Ecosystem Assessment examined worldwide changes in ecosystems, their impacts on human well-being, and options for enhancing the conservation of ecosystems and their contribution to human well-being. The project, involving more than 1,360 experts worldwide and a multi-stakeholder board representing governments, businesses, NGOs, indigenous peoples and international institutions, utilized the concept of "ecosystem services" to best understand the linkages between ecosystems and human well-being. Today, a number of federal agencies in the United States, including the Environmental Protection Agency, the United States Forest Service, the United States Geological Service and the United States Department of Agriculture house dedicated ecosystem services departments to advance understanding of how ecosystem services can be promoted to improve long-term economic prosperity for the nation.[d]

The natural environment provides many of the things humans need for survival, including breathable air, drinkable water, food for nourishment, and stable atmospheric conditions, to name a few. These "ecosystem goods and services" are derived from ecosystems and provide benefit to humans. Ecosystems perform many functions, but only functions that provide human benefits are considered ecosystem goods or services. Every ecosystem produces a suite of ecosystem services.

d The agencies' websites contain more detailed information on these departments. For example: http://www.fs.fed.us/ecosystemservices/ (USFS); http://www.fs.fed.us/ecosystemservices/OEM/index.shtml (USDA).

Healthy, resilient, natural infrastructure, referred to as "natural capital," is critical to the production of ecosystem goods and services. The natural capital of an ecosystem consists of its individual structural components (trees, forests, soil, hill slopes, etc.) that produce dynamic processes (water flows, nutrient cycling, animal life cycles, etc.) which in turn create functions (water catchment, soil accumulation, habitat creation, etc.) that generate ecological goods and services (salmon, timber, flood risk reduction, recreation, etc.). It might be likened to the production of cars in a factory. Building a car (a "built" good) requires high-quality built capital (e.g. the factory, machines and connection to a power plant), natural capital (e.g. the extracted metal, rubber, food for the workers), human capital (the workers), and financial capital (equity to buy the raw materials) and social capital (labor laws and agreements, etc.). This relationship is summarized in the following figure.

The benefits of ecosystem goods and services are similar to the economic benefits provided by labor and capital that are typically valued in the economy, yet they are less often noticed or measured. For example, ecosystems (through ecological processes) provide the majority of flood risk reduction in watersheds. If the flood protection function is valued as an economic asset (as measured by the flood risk reduction) but the value of flood risk reduction provided by forests, wetlands and lakes is not included, then the economic analysis is deeply flawed. Losing the natural (unvalued) flood protection services may well increase overall flooding despite vast expenditures in new levees. These natural assets provide as much, or often more, flood risk reduction than built structures and can frequently be enhanced with little or no capital cost and low maintenance costs. Many built structures that people rely on for flood risk reduction, such as levees and dams, were installed decades ago, when understanding of land use practices was less refined. This has led to expensive cycles of loss and repair in many Washington watersheds, most often funded by taxpayers. Once lost, ecosystem goods and services are expensive to recover or may not be recoverable at all. If ecosystems are valued as assets, better decisions about investments in built and natural capital can be achieved.

Figure 2 – The Link Between Natural Infrastructure and Ecosystem Goods & Services

Ecosystem Goods

Ecosystem goods are typically tangible, quantifiable items or flows, such as drinking water, timber, fish and food. Most goods are excludable, which means that if one individual owns or uses a particular good, that individual excludes others from owning or using the same good. For example, if one person eats an apple, another person cannot eat that same apple. Excludable goods can be traded and valued in markets. The quantity of water produced per second or the amount of timber board feet produced in a 40-year rotation can be measured by the physical quantity an ecosystem produces over time. The current production of goods can be valued relatively easily, by multiplying the quantity produced by the current market price.

Ecosystem Services

Ecosystem services are defined as “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life.” [17] Unlike ecosystem goods, ecosystem services are generally not tangible items that one can see or hold. Flood risk reduction, recreational value, aesthetic value, and storm-damage prevention are a few of the services that ecosystems may provide. Though often more difficult to value because market values rarely exist, ecosystem services have tremendous economic value and are critical both for our quality of life and economic production [17; 18].

Water filtration is an example of a critical ecosystem service. A standing forest may be cut down once every few decades to provide an ecosystem good (timber) with revenue generated from the harvest and sale of the wood. However, if left standing, the same forest might purify the drinking water for a nearby city for centuries, saving the cost of constructing a filtration plant and the additional costs of maintaining the plant each year. In addition, the forest may provide flood risk reduction, soil erosion control, and many other services.

Public utilities for many North American cities, including Seattle, Everett, Tacoma, Portland, San Francisco, Vancouver (B.C.), New York and Boston, have decided that natural water purification is far more cost-effective than other alternatives. Each has purchased all or portions of forests within their water supply areas to purify drinking water. Seattle Public Utilities, for example, purchased most of the Cedar River Watershed more than 100 years ago. Through careful management of its forests, the utility has avoided constructing a water filtration plant and upfront costs of $200 million.[19; 20] In addition, other ecosystem services such as carbon sequestration, wildlife habitat, soil erosion control and many more will benefit from this management approach.

Ecosystem Service Valuation

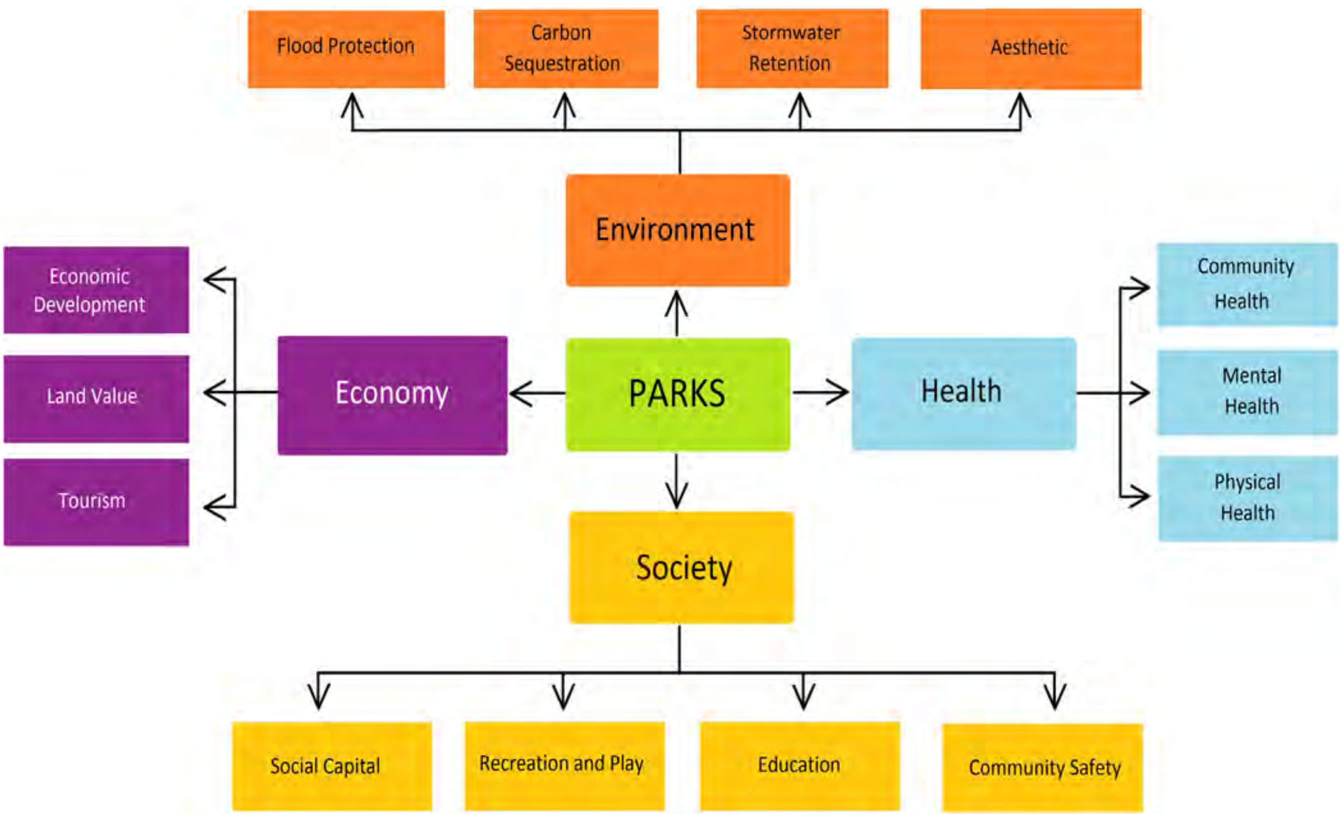
Ecosystem service valuation assigns a dollar value to goods and services provided by a given ecosystem. This allows for proposed management policies to be considered in terms of their ability to improve ecological processes that produce valuable ecosystem goods and services. Ten of 23 ecosystem goods and services produced in MPT parks are valued in Part IV of this report.

Benefits of Parks in Urban Settings

Parks benefit both the urban environment and the people who live there. In urban environments ecosystems become even more valuable due to the limited space allocated to natural settings. Limited vegetation amid concrete infrastructure does not store sufficient water; without careful planning, heavy rains and flooding can inflict catastrophic damage to cities.

People derive substantial health and educational benefits from natural environments, and the limited exposure to green space imposed on urban dwellers can be costly to their mental and physical health. In dense areas clean air and opportunities for outdoor exercise are limited and further the negative impact on human health. Even tree cover on city streets provides enormous benefits to urban residents. Urban parks and forests provide even more substantial benefits to health and additional educational benefits.

Figure 3 – Model of Parks Benefits provided to People



Part III

Ecosystem Services provided by MPT Natural Capital

Section Summary: *Ecosystem services can be divided into four categories: Regulating, Supporting, Provisioning and Cultural services. In this section, we provide examples of ecosystem services provided by MPT's park systems and consider the impact of stewardship activities on ecosystem services.*

Categories of Ecosystem Services

Ecosystem services can be categorized in different ways. This study follows an approach that categorizes ecosystem services into functional areas.[21] This approach is consistent with the Millennium Ecosystem Assessment completed in 2005, as well as much of the ecosystem service valuation literature. Economists have generally accepted these categories.

- **Regulating services** are benefits obtained from the natural control of ecosystem processes. Intact ecosystems provide regulation of climate, water, soil, floods and storms and keep disease organisms in check.
- **Supporting services** provide refuge and reproduction habitat to wild plants and animals and thereby contribute to the conservation of biological and genetic diversity and evolutionary processes.
- **Provisioning services** provide basic goods including food, water and materials. Forests grow trees that can be used for lumber and paper, wild and cultivated crops provide food, and other plants may be used for medicinal purposes. Rivers provide fresh water for drinking, and fish for food. Coastal waters provide fish, shellfish and seaweed.
- **Cultural services** provide humans with meaningful interaction with nature. These services include recreation, spiritual, aesthetic, historic, educational, scientific and other cultural values.

Specific ecosystem services exist within each category, as identified in Table 1.

Table 1 – Ecosystem Services by Function - Adapted from de Groot et al., 2002

	Good/Service	Economic Benefit to People
Provisioning	Water Supply	Water for human consumption, irrigation, and industrial use.
	Food	Food for human consumption.
	Raw Materials	Biological materials used for clothes, fuel, art, and building. Geological materials used for energy, construction, or other purposes.
	Genetic Resources	Genetic material and evolution in wild plants and animals.
	Medicinal Resources	Biological materials used for medicines.
	Ornamental Resources	Ornamental and companion uses (flowers, plants, pets, and other).
Regulating	Gas Regulation	Generation of atmospheric oxygen, regulation of sulfur dioxide, nitrogen,carbon dioxide, and other gaseous atmospheric components.
	Climate Regulation	Regulation of global and local temperature, climate, and weather, including evapotranspiration, cloud formation, and rainfall.
	Disturbance Prevention	Protection from floods, storms, and drought.
	Soil Retention	Erosion protection provided by plant roots and tree cover.
	Water Regulation	Water absorption during rains and release in dry times, temperature and flow regulation for people, plants, and animals.
	Biological Control	Natural control of diseases and pest species.
	Waste Treatment	Absorption of organic waste, natural water filtration, pollution reduction.
	Soil Formation	Formation of sand and soil from decaying vegetation and erosion.
	Pollination	Fertilization of plants and crops through natural systems.
	Nutrient Regulation	Transfer of nutrients from one place to another; transformation of critical nutrients from unusable to usable forms.
Habitat	Habitat Refugium	Providing habitat for plants and animals and their full diversity.
	Nursery	Growth by plants provides basis for all terrestrial and most marine food chains.
Information	Aesthetic Information	The role which natural beauty plays in attracting people to live, work, and recreate in an area.
	Recreation and Tourism	The contribution of ecosystems and environments in attracting people to engage in recreational activities.
	Scientific and Educational Value	The value of natural systems for scientific research and education.
	Spiritual and Religious Experience	The use of nature for religious and spiritual purposes.
	Cultural and Artistic Information	The value of nature for cultural purposes.

Ecosystem Service Descriptions

Disturbance Prevention

Healthy ecosystems often reduce the impact of natural disturbances on humans. Natural disturbances can include floods, storms, tsunamis and fires. Flood and storm protection, in particular, are critical to maintaining economic security for communities, states and nations, as Hurricane Katrina demonstrated in New Orleans. The Mississippi Delta has lost 1.2 million acres of wetlands that once buffered against hurricane impacts.[19] Floodplains, watersheds, estuaries and bays, coastal wetlands, headlands, intertidal mudflats, seagrass beds, rock reefs and kelp forests all provide storm protection along marine shorelines. These areas are able to absorb and store large amounts of water from coastal waves, storm surges or floodwater runoff.[19; 22] Wetlands and floodplains are particularly important for absorbing waters during river flooding.

One of the most significant factors in an ecosystem's ability to attenuate flooding is the absorption capacity of the land. This is a factor of land cover type (forest vs. pavement, for example), soil structure and quality, and other hydrological and geological dynamics within freshwater systems and coastline. In the Puget Sound region, impermeable surface area, such as parking lots, roads and roofs, has increased by more than 10% in the past 15 years. The U.S. Geological Survey estimates that in some rivers, urban development may lead to increases in flood-peak discharge flows of 100% to 600% for two-year storm events, 20% to 300% for 10-year events, and 10% to 250% for 100-year events.[23] Record flooding in the U.S. Midwest in 2011 was partially caused by the loss of natural water absorption and peak flow delay that natural systems once provided.

Retention of forest cover and restoration of floodplains and wetlands provide tangible and valuable ecosystem services: reduced damage from floods to property, lost work time, injury, and loss of life. Today, changes in land use (such as urban development), combined with the potential for more frequent storm events due to climate change, make disturbance regulation highly important for the future of economic development in the MPT urban park spaces.

Local Example:

Wapato Park contains one of the largest lake systems in the city. Stretching over half a mile, Wapato Lake empties into forested wetlands that stay wet for nearly the entire year. This large area acts as a natural sponge and drainage area, protecting homes and businesses downstream from flooding during periods of heavy rainfall.

Recreation

Recreation provides joy, health and happiness to people. Citizens travel to beautiful places local or distant to engage in activities they enjoy. These include hiking, organized sports, biking, fishing, diving, surfing, kayaking, whale and bird watching, and along with the park experience, enjoying local foods and communities.

A substantial number of recreational activities, such as wildlife-watching and fishing, depend upon healthy ecosystems. Many other recreational activities would be less enjoyable and attract fewer participants without healthy ecosystems. Storm protection, shoreline stabilization and waste treatment are also important ecological services associated with recreation and tourism because they help keep tourists safe and protect both private and public infrastructure needed for the tourist industry.

Local Example:

- More than half of MPT parks contain acres of forest that provide beautiful trails for the public. Quite often these trails lead to picnic areas and lookout points that attract many recreational walkers. These forests also provide habitats for deer, raccoons and a wide assortment of native birds, drawing even more wildlife watchers.
- Metro Parks has committed many of its parks to providing a wide variety of recreational activities to the surrounding community. Within Stewart Heights' 22 acres, for example, there are sports fields, tennis courts, a basketball court, a playground and a community swimming pool.
- Point Defiance Park, Titlow Park and Dash Point Park offer recreational opportunities limited only by the energy and creativity of park-goers. Each park offers opportunities for outdoor sports, beach access for fishing, wading and kayaking. During the spring, visitors to Dash Point Park can even dig for razor clams. In addition, heritage sites offer a link to the past and help make these and other parks popular destinations for both locals and out-of-towners year-round.

Science and Education

Everything in the built economy was harvested from nature: plant, animal or mineral. Scientific knowledge gained from studying the gifts of nature has enabled humanity to utilize natural resources to build the economy we enjoy today. A growing number of educational and research institutions are devoted to studying marine and terrestrial environments to understand the scientific and educational importance of ecosystems. Government, academic and private resources are devoted to formal study of ecosystems in the Puget Sound Basin. Study of the natural environment produces human, social and economic benefits. Scientific and educational institutions devoted to both marine and terrestrial environments also provide local employment. Parks are a critical link in providing areas for study, learning and scientific knowledge.

Local Example:

- In 2008, Foss High School and Bellarmine Preparatory School came together in an effort to restore sections of Snake Lake by planting native vegetation.[24] They received a $9,650 grant from the Pierce Conservation District to fill the park area between the two schools with native plants. This work has contributed to the students' senior project requirements in addition to enhancing the community.

Water Supply

As water moves through a watershed, it can be extracted as surface water or groundwater for the use of large metropolitan areas, industry and agriculture. The hydrologic cycle is affected by the structural elements of a watershed, such as forests, wetlands and geology, as well as by processes such as evapotranspiration and climate. More than 60% of the world's population gets its drinking water from forested watersheds.[22] Increasing loss of forest cover around the world has decreased water supply, due to lower ground water recharge and lower flow reliability.[25]

Local Example:

- The wetlands and lakes within MPT parks serve as a drinking water source for animals in addition to providing habitat for nesting and breeding. Potable water drawn from the aquifer at NW Trek provides drinking water to the park visitors.

Nutrient Regulation

The transfer of nutrients from one place to another and transformation of critical nutrients from unusable to usable forms is an essential ecosystem service. All living things depend on the nutrient cycles of carbon, oxygen, nitrogen, phosphorous and sulfur in relatively large quantities. These are also the nutrient cycles that humans have most affected through the burning of fossil fuels, deforestation, heavy use of agricultural fertilizers and other activities. Silicon and iron are important elements in oceanic nutrient cycles because they affect phytoplankton community composition and productivity. Natural processes facilitate the movement of nutrients and turn them from biologically unavailable forms, such as rocks or gases in the atmosphere, into forms that can be used by other living things. Nutrient cycling is a fundamental precursor to ecosystem and economic productivity; without functioning nutrient cycles, life on the planet would cease to exist.

Living organisms mediate nutrient regulation. On land, plants depend on biologically mediated breakdown of organic matter to make the nutrients they need for growth available. As plants and plant parts decompose, they contribute to the pool of organic matter that feeds the microbial, fungal and micro-invertebrate communities in soils. Underground fungal structures can also provide support to living plants. For example, young trees may not receive enough light (and therefore nutrients) because mature trees block sunlight, but they can draw nutrients from fungal structures hundreds of yards away.[26] Such communities facilitate the transformation of nutrients from one form to another. Larger animals play a crucial role in nutrient cycles by moving nutrients from one place to another in the form of excrement, and through the decomposition of their bodies after they die. Animals also play a role in transporting nutrients between terrestrial and aquatic environments. Salmon and marine birds bring marine nutrients into terrestrial and freshwater ecosystems, enhancing the productivity of these systems throughout several layers of the food web.[27]

Local Example:

- Swan Creek Park is one of two parks within Tacoma that contribute to the salmon populations in the Puget Sound. In the 383-acre park, natural ecosystem processes deposit essential nutrients to the limited areas where salmon spawn in the park's creeks. Minor restoration efforts were completed in 2008 to increase spawning opportunities for salmon.

Water Regulation

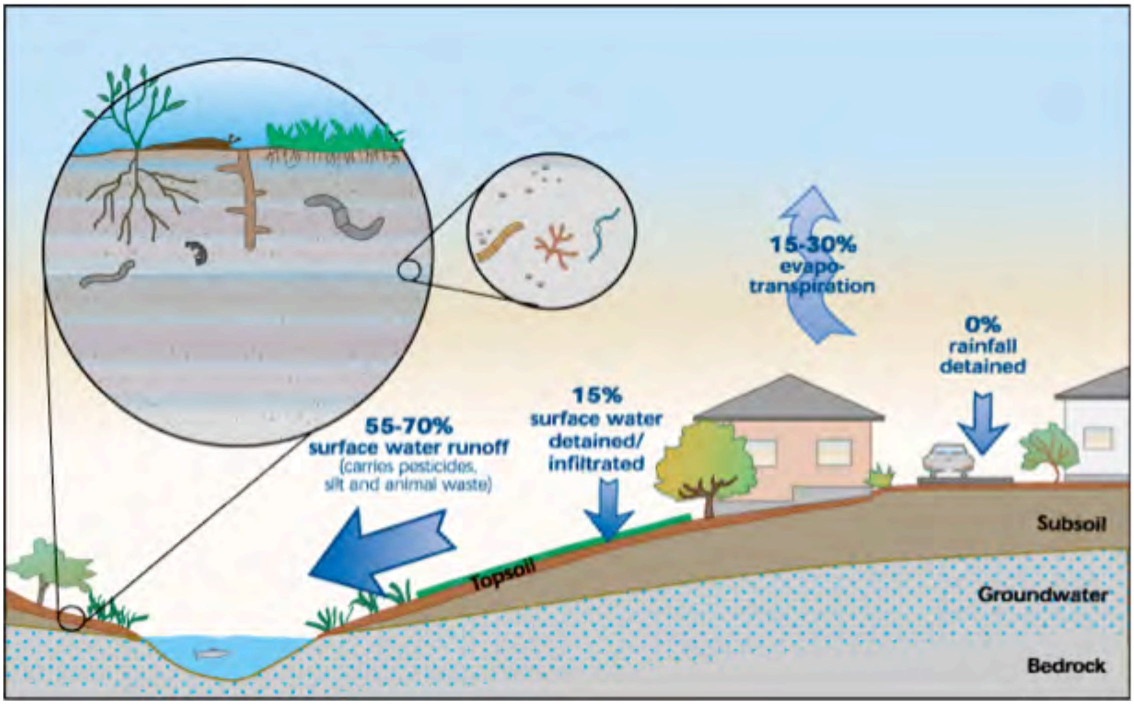
The amount and timing of water flow in MPT parks near rivers and lakes is important for many reasons. The supply of adequate amounts of cool water at critical times is important for salmon migration, and the filtration of water allows for clean drinking water. Also important in Washington State is the operation of reservoirs and dams for the production of hydroelectricity. This cycle is tuned to the seasonal timing and volume of stream flow. Recent analysis suggests that a lengthened summer low-flow period may increase competition over water use for hydroelectric generation, irrigation and in-stream flow protection for salmon.[28] Water regulation includes regulation of water flows through the ground and along terrestrial surfaces, and regulation of temperature, dissolved minerals and oxygen. Many ecosystems absorb water during rains and release it in dry times, and also regulate water temperature and flow for plant and animal species. Forest cover, riparian vegetation, and wetlands all contribute to modulating the flow of water from upper portions of the watershed to streams and rivers in the lower watershed. In undeveloped areas of a watershed, typically less than 15% of precipitation reaches streams or rivers as surface runoff, compared with 55 to 70% in a developed watershed. See Figures 9 and 10 for a graphic illustration.

When forested basins are heavily harvested, the ground's capacity to absorb water is reduced, and surface water runoff is increased and conveyed into streams and rivers, contributing to higher peak flows, more frequent flood events, erosion and landslide issues. Another result may be lower low flows in summer months, because the water is not retained in soils and aquifers.[29]

Local Example:

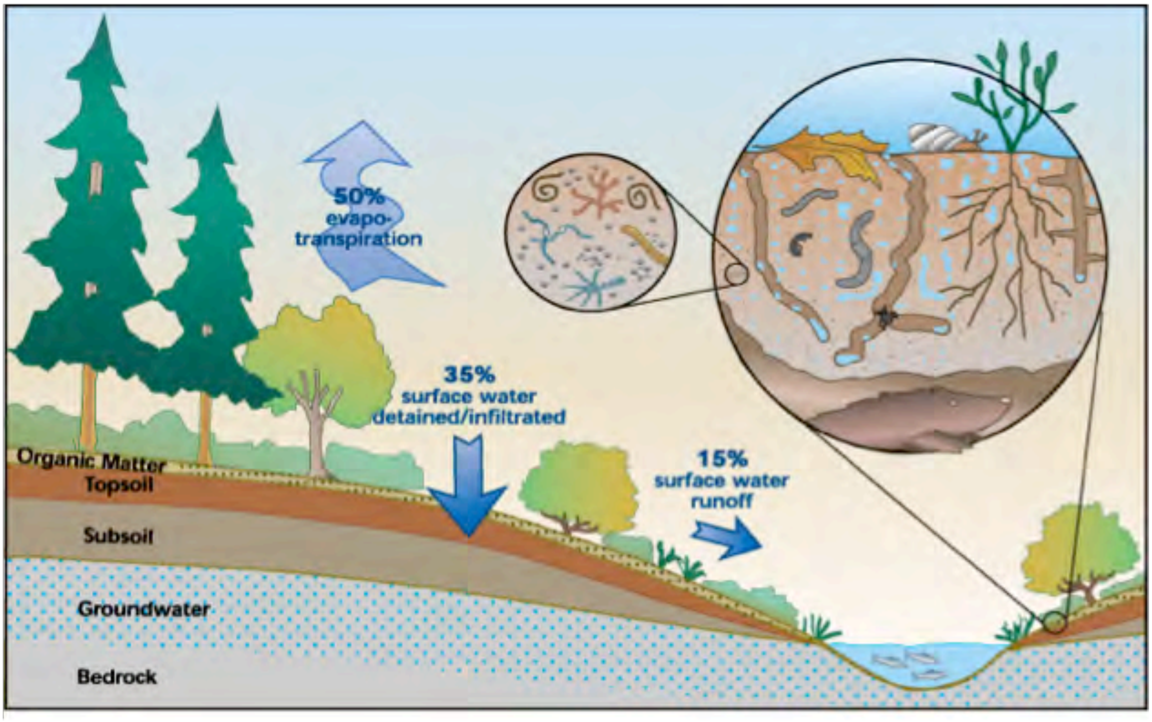
- Swan Creek Park's cool water temperatures contribute to the success of salmon populations that breed inside the park. The salmon that breed upstream of the Puyallup River also benefit from the cooled water of the creek as it empties into the river and out in to the Puget Sound.

Figure 4 - The Movement of Water in a Developed Watershed



Source: King County

Figure 5 - The Movement of Water in a Forested Watershed



Source: King County

Spiritual and Religious Experience

Many natural areas have special importance to tribes from a spiritual perspective, as evidenced by indigenous traditions, including stories and art depicting salmon, other marine organisms and community residents. Non-tribal people also tend to feel an emotional or spiritual connection to the landscape in which they live. Spiritual and religious experiences have not been valued monetarily, as there is no real way to measure their quantity or importance across individuals. In addition, existence value is hard to estimate. However, some studies have provided insight by asking people how much they would be willing to pay to protect a given species or area.

Soil Formation

Soil serves a vital function in nature, providing a medium for plant growth as well as nutrients for plants and habitat for millions of micro- and macro-organisms. Healthy soils store water and nutrients, regulate water flow and neutralize pollutants more efficiently than degraded soils.[30] Soil retention contributes to a number of other ecosystem services, including disturbance prevention, salmon habitat and provisioning of raw materials such as timber. Soil quality and abundance is critical for human survival. However, many human actions can negatively affect natural formation of high-quality soils. Soil is formed over thousands of years through a process that involves parent material, climate, topography, organisms and time.[31]

Soil Retention

The interplay between soil retention and natural rates of soil erosion is important to Pacific Northwest ecosystems, for example allowing fertile soils to be deposited on floodplains and providing the gravel required for salmon spawning. Coastal erosion is a natural process along Puget Sound's shorelines, building, maintaining and moving shorelines naturally with interactions of wave energy and sediment deposition.

The soil retention properties of ecosystems determine the soil's rate of erosion. The susceptibility of a given slope to erosion is determined by factors such as grain size, soil cohesion, slope gradient, rainfall frequency and intensity, surface composition and permeability and type of land cover. Soil retention is closely linked with prevention of disturbances such as landslides, which are often caused by excessive erosion and can frequently be attributed to human changes in land use. A healthy forest's organic layers act as a natural sponge, absorbing water during periods of heavy precipitation and preventing erosion. In areas where active forest harvesting occurs, the upper layers of soil are often removed or degraded.

Local Example:

- Point Defiance Park and Titlow Park are located on and help stabilize the forested shoreline of Puget Sound. Should these parks lack necessary maintenance due to funding cuts, the threats of human disturbance and invasive species could interfere with this natural protection, resulting in degraded stabilization of the shoreline. Even though slides on steep slopes occur naturally, building activities and improper use contribute to surface erosion and increased frequency of slides.

Water Quality and Waste Treatment

Microorganisms in sediments and mudflats of estuaries, bays and near-shore submerged lands break down human and animal wastes.[32] They can also detoxify petroleum products and chemicals harmful to human health. The physical destruction of habitat, alteration of food webs or overload of nutrients or waste products disrupts disease regulation and waste processing services. Alteration of ecosystems can also create breeding sites for disease vectors where they were once nonexistent. People can be exposed to disease in coastal areas through direct contact with bacterial or viral agents while swimming or washing in fresh or saltwater, and by ingesting contaminated fish, seafood or water.

Water quality is extremely important to healthy native fish and wildlife populations. Because most aquatic biological processes are limited by nitrogen and phosphorous, changes in these nutrient levels may have significant effects on ecosystems. For example, increases in nutrient loading in Hood Canal due to failing septic systems have caused low dissolved oxygen, or "dead zones," where fish cannot survive. Land-use patterns also play an important role. Researchers have found that more agriculturally active and heavily urbanized watersheds contribute three times the nitrogen and phosphorous loads to Puget Sound waters than the forested watersheds in the Olympic Mountains.[33] Wetlands, estuarine macroalgae and nearshore sedimentary organisms play a crucial role in removing nitrogen and phosphorous from water.[32; 34]

Local Example:

- Many MPT parks serve this filtration function, helping to purify residential water runoff containing chemicals from lawn fertilization. Both Swan Creek and Puget Creek are deep canyons surrounded by homes and businesses. Water running through these canyons is naturally filtered before it enters Puget Sound.

Biological Control

Healthy ecosystems limit the population of invasive plant species, pests and diseases, protecting human health, crops and livestock. A number of natural predators help control pest species, limiting potential damage. For example, birds consume insects that at higher populations may infest trees and damage forests.

Many exotic species have, in modern times, been introduced to areas beyond their natural range. Some have caused significant damage to the sustainability of forest ecosystems and elevated carbon emissions from the increased decay of trees. Recent measurements of such increased carbon emissions are the most severe in British Columbia, a result of mountain pine beetle infestations. In a 2008 report, annual estimates of the cumulative damage caused by the beetle outbreak were believed to be close to the average annual damage caused by forest fires.[35] Chestnut blight, a fungus that penetrates the bark of chestnut trees, damaged more than 23 million cubic meters of American chestnut before the 1940s.

The evolving field of integrated pest management has shown that pests are best managed naturally and treated with pesticides only as a last resort. There are also ways to manage crops so as to enhance biological control services. These techniques include crop diversification and genetic diversity, crop rotation and promoting an abundance of smaller patches of fields.[36-38]

Local Example:

- Birds, bats, fungi and other bugs regulate populations of bugs and pests. In many places these natural controls have been depleted due to suburban development of wooded areas. In the moist environment of the Pacific Northwest, pest insects are able to thrive when the habitats of their natural predators have been destroyed. Fortunately, Tacoma's heavily wooded parks, including China Lake, Snake Lake, Wapato Park and Wapato Hills Park, provide the complex habitats needed to maintain a balance of species.

Habitat and Biodiversity

Biological diversity is defined as the number and types of species as well as the ecosystems they comprise. It is measured at gene, population, species, ecosystem and regional levels. Biodiversity must exist for the flow of ecosystem services, and it can also be considered an ecosystem service in itself.[22] Ecosystems with diverse complements of native species tend to be more productive and more resilient despite environmental conditions or external shocks.

Habitat is the biophysical space formed by (typically natural) processes in which species meet their needs. A healthy ecosystem provides physical structure, adequate food availability, appropriate chemical and temperature regimes and protection from predators. In addition to the physical structure provided to species, food web relationships are important components of habitats.

One recent meta-analysis of marine data and studies examining the effects of biodiversity on ecosystem services found strong evidence that loss of biodiversity leads to fisheries collapse, lower potential for species population and system recovery, loss of system stability, and decreased water quality. The relationship is one of an exponential loss of ecosystem services with declining diversity.[39] The study also found that restoration of biodiversity, through such mechanisms as the establishment of marine reserves protected from fishing pressures, may lead to a fourfold increase in system productivity and a 21% decrease in variability (i.e., an increase in resilience). This study provides the best evidence to date of the direct relationship between biological diversity and ecosystem services in the marine environment.

Local Example:

- Historically, the economy in Tacoma was primarily based on logging and lumber production. Although this activity helped Tacoma become a major city in Washington, the deforestation wiped out many native tree species in the surrounding areas. The Garry oak has become rare in Tacoma, with a very limited presence in South Park, Wapato Hills Park, Meadow Park Golf Course and Oak Tree Park. Providing a habitat for many wildlife species, the Garry oak's disappearance has resulted in the depletion of species including the western bluebird, the white-breasted nuthatch and the Taylor's checkerspot butterfly.[e] Urban parks and forests will only grow in importance by providing much-needed pockets of biodiversity within the region.

e Information provided by MPT.

Primary Productivity

Primary productivity is another supporting service upon which all other ecosystem services depend. It refers to the conversion of energy from sunlight into forms that living organisms use. Aquatic and upland plants perform this function in a variety of habitats. Human life depends on primary productivity through consumption of food such as crops, wild plants, seaweed, seafood and livestock, and on the use of photosynthesis-dependent materials such as wood, cotton, medicines and petroleum.

Humans appropriate over 40% of the planet's terrestrial primary productivity, and this share is increasing – with tremendous ecological implications for the rest of the planet's organisms and energy budget.[40] One likely outcome of greater consumption of primary productivity is the loss of biological diversity, which, as discussed in the previous page, would have severe consequences on the delivery of many other ecosystem services. Loss of forests to development also decreases primary productivity.

Marine primary productivity comes from wetland plants, macro-algae, and sea grasses in the coastal and nearshore environment, as well as from phytoplankton in the continental shelf and deep-sea waters. Most marine primary productivity occurs in the coastal zone out to the farthest extent of the continental shelf. About 8% of total primary productivity of ocean ecosystems supports fisheries. However, when the calculation is confined to parts of the ocean where most primary productivity and fish catches occur, the number approaches the productivity of terrestrial systems, or 25 to 30%.[41; 42]

When humans consume most ocean primary productivity, less productivity will be left to fuel the remainder of the food web and all the ecological processes that it drives.[42] Whereas fish harvests in the past were focused primarily on the top-level food-web species such as cod, as demand has grown and many fisheries have collapsed, fishing pressure has been increased on smaller species like mackerel, herring and anchovies. This shift in target species is often called "fishing down the food chain," and it places additional pressure on top predator fish by reducing their food supply. In addition, climate change has large implications for ocean productivity due to changes in currents, upwelling and changes in water chemistry.[43]

Climate Regulation

Climate regulation refers to the roles that ecosystems play in regulating the gaseous phase of organic and inorganic compounds that affect atmospheric composition and climate. Atmospheric oxygen is a product of photosynthesis from marine plankton and terrestrial plants. The regulation of climate is dependent on the composition of the atmosphere. "Greenhouse gases" such as CO_2 are transparent to light but trap heat, warming the planet like a greenhouse. Carbon dioxide is removed as plants absorb CO_2 to grow.

Pollination

Pollination is essential to agricultural crops, trees and flowers. Insects, birds, mammals and the wind transport pollen grains to fertilize plants. People depend on pollination directly for food and fiber (such as wood, paper and cloth), and indirectly as part of ecosystem productivity. Many plant species would go extinct without animal- and insect-mediated pollination. Pollination services by wild animals are also crucial for crop productivity for many types of cultivated foods, enhancing the basic productivity and economic value of agriculture. Notably, some plants have only a single species pollinator. The importance of wild pollinators to food crops means that wild habitats near croplands are necessary in order to provide sufficient habitat to keep populations of pollinators intact.

Food and Other Products

Providing food is one of the most important functions of ecosystems. Agricultural lands are the primary source of food for humans. Farms are considered modified ecosystems, and food is considered an ecosystem good with labor and built capital inputs. In traditional economic analyses, agricultural value is measured by the total market value of crops produced. While this measure is useful, market value is only a small portion of the total value agricultural lands provide through pollination, carbon sequestration, aesthetic value and other services. Marine ecosystems are the largest sources of food from wild ecosystems. Globally, fish and seafood are the primary source of protein for one billion people, with fishing and fish industries providing direct employment to some 38 million people.[22]

Local Example:

- Charlotte's Blueberry Park has become a popular source of food for local community members and many visiting berry lovers. Provided to the public for free, about 15 acres of the park are dedicated to maintenance of blueberry bushes. Hundreds of people come each year to collect the berries from more than 3,000 bushes.[44]
- Chum salmon have been observed in strong numbers in Swan Creek Park along with substantial numbers of juvenile coho salmon.[45]
- Several creeks and lagoons within Tacoma once maintained habitat to support the spawning of coho and chum salmon[9] but no longer do so due to development of residential neighborhoods. Efforts to restore these areas are underway, and more are pending. The most promising potential is in the Puget Park gulch and in Titlow Park, where salmon feeder fish have been documented.

Aesthetic Information

Aesthetic value, as an ecosystem service, refers to the appreciation of and attraction to beautiful places. The existence of national seashores, state and national parks, scenic areas and officially designated scenic roads and pullouts attest to the social importance of this service. There is also substantial evidence demonstrating the economic value of environmental aesthetics in higher housing values, wages and locational decisions.[46] Degraded landscapes are frequently associated with economic decline and stagnation.[47]

Local Example:

- Many successful efforts have been made in MPT parks to increase aesthetic value by constructing botanical landscapes that complement natural areas. The well-loved rhododendron gardens of Point Defiance, for example, are in close proximity to native habitat.
- According to the Phase I Economic Impact study of MPT parks, there is substantial aesthetic value gained by homes located near Tacoma parks. Even Ferry Park, located on less than an acre of land, contributes $16 per square foot of area for homes located within two blocks of the park. With much larger parks like Lincoln Park, the increased value applies to homes as far as five blocks away. This also contributes to a higher tax base for the city.

Impact of Stewardship Activities on Ecosystem Services

In 2007, the City of Tacoma developed the "Open Space Habitat and Recreation Plan" in collaboration with the Green Tacoma Partnership and Metro Parks.[48] Adopted as part of Tacoma's Comprehensive Plan, this guides the future identification, acquisition, restoration and maintenance of public spaces in addition to establishing Habitat Corridors as the most valuable city open space. The Cascade Land Conservancy subsequently undertook an analysis of the ecosystem conditions within the Habitat Corridors. They then received a federal grant to work with the Green Tacoma Partnership on the development of the "Restoration Action Plan,"[49] which will guide the long-term restoration and management priorities for Tacoma's habitat lands. The goal of the plan was to answer two questions: 1) how many acres and which sites throughout the city need only maintenance and monitoring, and how many require more extensive restoration; and 2) how many years and how much money would be needed for these efforts.

The restoration plan also prioritized sections of parks by subdividing larger sites into smaller sections by vegetation type and condition. Park sections were rated according to the following characteristics: current vegetation, invasive species, target community, habitat connectivity, current site use, need for restoration and existence of sensitive species.[49] The plan considers work within sections that need only preventative maintenance in order to prevent further degradation to be the most efficient use of resources. The costs associated with restoration and maintenance were also included in the Restoration Action Plan.

This systems approach is essential in ensuring that the final choices of restoration projects will indeed maximize the benefits received. The methodology and prioritization list from the Restoration Action Plan will be used to analyze the future benefit of MPT restoration goals.

In order to show the true monetary impact of these restoration projects and to validate the priority list as it stands, an assessment of the added benefit of ecosystem services is necessary. Over time, people will receive value from ecosystem services that could potentially be increased under different restoration management plans. If the benefits received from restored ecosystem services are far greater than the costs of restoring those ecosystems, then restoration may be worth supporting. One study showed a rate of return of $6 for every dollar spent on restoration in the Puget Sound basin.[50]

Valuation of ecosystem quality must consider the cost of degradation due to lack of maintenance and restoration resources. The degradation includes the loss of ecosystem services caused by invasive species and improper use. The valuation analysis is presented in Part VI of this report. In the next section of this report, the connection between human well-being and natural systems is examined.

Part IV Impact of MPT Natural Capital on Human Well Being

***Section Summary:** Urban parks provide surrounding communities with opportunities to explore and enjoy natural settings. These assets have been shown to support an array of health benefits including stress relief, toxin reduction and access to space for exercise. Neighborhood residents often come together to appreciate and protect these areas. In addition to providing health benefits, the zoos and nature centers at some MPT parks provide the community with opportunities to learn about the natural environment.*

Health: Categories of Health Benefits from Parks

In recent decades, increased understanding of how trees and greenspace in urban surroundings benefit people has developed to include social, psychological, and physical domains. In the wake of global climate change and increased population pressure, there is an increased demand for relief from the negative health effects associated with living in densely populated areas. The health consequences that put people at the highest risk in the U.S. include mortality from excessive heat, extreme weather, vectorborne and waterborne infections, mental stress, respiratory disease and air pollution. Many of these risks are the results of human activity and the production of goods.

Several categories of the health benefits of greenspace can be estimated in dollars, others are nearly impossible to value. The value of stress relief from a walk in the park, for example, is more difficult to measure than the reduced number of doctor visits per year. Crime reduction, mental illness alleviation and increased community strength are also missing in the economic valuation literature, but they are recognized as highly valuable in health literature. Specific examples of each of these benefit categories in Tacoma are detailed below.

Exercise

Obesity and medical conditions that result from physical inactivity have increasingly been a major concern in the U.S. Rather large economic costs have been associated with these health risks in recent studies. In 2009, the U.S. Centers for Disease Control estimated that $147 billion in medical costs could be attributed to obesity in the previous year.[51] A 2007 study from the National Center for Health Statistics found that 67% of adults in the U.S. are either overweight or obese. In 2006, a study found that 16% of U.S. children were considered obese.[52] Obesity has recently been considered a life-threatening disease, which has led state officials and policy makers to consider the epidemic a national concern.[53]

Domains of research in the field of physiological and epidemiological health have produced studies documenting the health benefits of physical activity. Inactivity alone is a risk factor for several chronic diseases such as type 2 diabetes, cardiovascular disease, osteoporosis, and depression.[6] The U.S. Centers for Disease Control and Prevention recommends that adults engage in 30 minutes of moderate exercise five times a week, or 20 minutes of vigorous exercise at least three times a week.[54] But according to the Washington State Department of Health in 2005, only 64% of adults in the U.S. met the exercise recommendations.

Research in the last decade has linked the presence of parks to increased levels of physical activity in several major cities, resulting in the improved health of those who visit parks. For example, a 2011 report from Scotland found that visitors to nature sites in the country enjoyed between $4.32 to $28.77 in benefits from reduced health costs, skill development and reductions in antisocial behavior for every dollar they invested in outdoor activities.[55]

The occurrence of increased physical activity in parks depends largely on the accessibility and quality of walking, biking, and even swimming environments, and community involvement plays a big role in the promotion of these activities, especially if the park maintains sporting facilities. An understanding of the precise role that the existence of green space plays in the promotion of formal exercise programs is still emerging. Evidence suggests that urban parks increase the attractiveness and incentive for the continuation of exercise through structured programs.

Local Example:

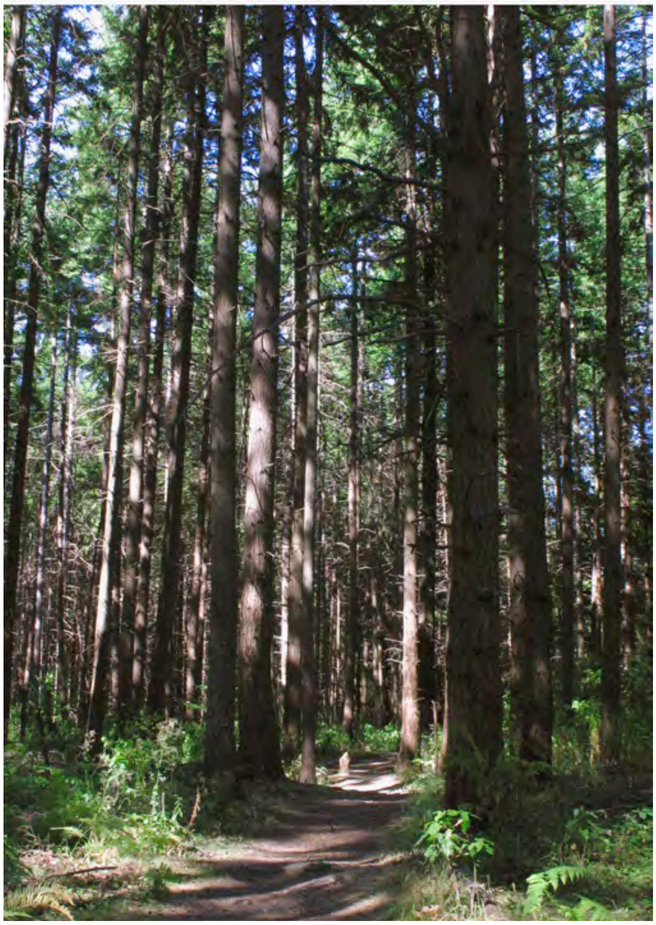
- The gravel path that stretches almost a mile around Wright Park serves hundreds of walkers and joggers in the summer. Similarly, the paths in Wapato Park, Lincoln Park and on Ruston Way are all well-utilized. In Point Defiance, Five Mile Drive, a winding stretch of road that tours through the park, provides a smooth pathway for thousands of cyclists and runners every year.
- K-12 schools and sporting organizations regularly make use of Vassault Park, Jane Clark Park, Northeast Tacoma Playfield and Stewart Heights. There, sports fields host competitive games for a wide range of ages and attract crowds of parents and supporters. Many schools use nearby parks as running courses for physical education classes and cross-country teams. Metro Parks also participates in the Northwest Youth Sports Alliance, offering many of its fields for youth soccer, lacrosse, tackle/flag football, baseball and fastpitch.[56]
- Metro Parks hosts many running, walking, biking and even swimming events, promoting physical activity by people of all ages.[57] Throughout the year various competitions take place combining foot races and family activities.

Mental Health

A vigorous domain of research on the subject of the natural environment and its effect on stress and physiological states has recently been produced. Early research in the field was conducted by Roger Ulrich under his "Stress Reduction Theory," which claims that natural environments promote recovery from any form of stress, whether short or long term.[58] Ulrich's research also demonstrates that post-surgical patients with hospital windows overlooking trees rather than brick walls recover more rapidly and require less pain relief.[59]

In 2003, work by Grahn and Stigsdotter, which was said to be "by far the most robust study" on the natural environment and stress,[60] showed the relationship between levels of stress and the availability of greenspace. The authors conducted a study in Sweden that randomly selected 1,000 individuals and questioned them about their health and their use of urban green spaces close to their homes. The study concluded that regardless of age, social class or gender, there were statistically significant relationships between the use of urban greenspaces and reports of sickness, stress and depression.[60] Several more recent studies argue that exposure to open space, forests, near shore environments and even wildlife contributes to the successful treatment of ADHD in youth, reduced levels of fear in high-density neighborhoods, the alleviation of aggressive behavior, better neighborhood relations, and a greater sense of personal happiness.[61]

Additional studies show that public greenspaces improve public attitudes toward the urban environment. A study conducted in Chicago showed that the development of urban parks boosted community pride, improved the local neighborhood and offered additional means of recreation and exercise that were previously unavailable.[62]



Local Example:

- While studies about mental health benefits have not been made at MPT parks specifically, it is safe to assume that the same benefits observed in studies done elsewhere would apply. Many MPT parks maintain extensive trail systems where visitors can escape the stressors of life in an urban environment. Point Defiance trails wind through old-growth forest, a rare and precious resource for city-dwellers. Several parks relatively unknown to the general Tacoma population also provide long trail systems. A large percentage of DeLong Park, Puget Creek, Snake Lake, Swan Creek Park, China Lake Park and Charlotte's Blueberry Park consist of peaceful wooded areas with trails.

Air Pollution Removal

In its 2011 annual report, the American Lung Association wrote that in the year prior, Los Angeles had 310,610 cases of underage asthma and 1,030,481 adult cases.[63] This proliferation in respiratory disease is a consequence of air pollution from industrial production and vehicular exhaust. Other cities like Pittsburgh or Cincinnati face the same issues. In order to comply with regulations under the Clean Air Act, billions of dollars have been spent in the U.S. to meet air quality requirements.

As air pollution has become a globally recognized hazard to human health, more studies have begun attempts to value air pollution reduction by measuring the rate of toxins absorbed by trees. In 2006, one report measured the amount of atmospheric gases removed by forests in the U.S. The study concluded that trees in U.S. cities removed approximately 711,000 metric tons of carbon monoxide, nitrogen dioxide, sulfur dioxide and other particulates that were less than 10 micrometers in diameter.[64] These particulates are the most damaging to human health. Tree cover in urban areas also provides shade to homes, lowering energy costs and in turn reducing carbon emissions from local power plants. The study concluded that for each acre of forested land, an average level of pollution removal was worth $300 per year.

Local Example:

- The MPT parks with the largest amounts of forest cover are Northwest Trek, Point Defiance, Swan Creek Park, Snake Lake, China Lake Park and Titlow Park, which combined consist of approximately 1,385 acres of varied forests, all providing cleaner air.
- Although they do not contain as large an amount of forest as the parks above, those parks located near the most highly developed regions in Tacoma provide the largest air purification benefit per tree. Wright Park and McKinley Park are closest to the heaviest commercialized and industrialized areas, downtown Tacoma and the Port of Tacoma. The communities near Interstate 5 and Highway 16 suffer from the largest amounts of car pollution in Tacoma. Here, residents benefit enormously from the chemical absorption of the park forests close by, which include Wapato Park, South Park, Wapato Hills, Lincoln Park, McKinley Park, Meadow Park Golf Course, Snake Lake Park and China Lake Park.
- Each winter, individuals burn wood products that sometimes contain hazardous chemicals. In 2006, the Puget Sound Clean Air Agency designated the southern region of Tacoma as a "nonattainment area," meaning that fine particle pollution exceeds the national limit, posing a health risk.

Community Benefits

People benefit from positive social interactions, and parks and open spaces encourage an even greater sense of community with more opportunities for social interactions to occur. Lower-income communities with a larger population of at-risk youth and families are even more likely to benefit from the social interactions made available by shared green space.[6] Also, Kweon et al. found a positive link between the social integration of the elderly in a neighborhood and their exposure to green common spaces.

Before scientific studies established the social, physical and mental benefits of interaction with natural environments, parks were recognized as places where people come together. Today, strong social institutions have formed around local parks, further enhancing their benefits. Community gardeners, educators and recreational sporting teams are all active users of parks and in many cases are also actively involved in park upkeep and enhancement.

During economic downturns it is even more essential that communities pitch in and help maintain their parks. In her recent paper, Dr. Kathy Wolf recognized that urbanization challenges ecosystem health, and in light of the threat of budget reductions, parks are at greater structural risk.[65] But when community groups assist with the upkeep of their parks, Wolf argues, those parks are more likely to sustain a healthy ecosystem.

Local Example:

- Many people come to Tacoma each summer to enjoy the botanical gardens at several MPT parks. Metro Parks dedicates much space to landscaped gardens and borders, partnering with the Tacoma Rose Society, the Tacoma Garden Club, the American Dahlia Society, the Tahoma Fuchsia Society, the Pierce County Iris Society and the Tacoma Chapter of the American Rhododendron Society.[12] Since 1938, Wapato Park has displayed plantings that include Japanese maples, perennials, sunflowers, begonias and more.[11] In Point Defiance, large sections of the park are dedicated to gardens featuring hundreds of plant species.

Education

Physical play positively influences the earliest stages of the development of human cognitive activities, social interaction, language development and general body strengthening. In a paper released in 2002, the Association for Childhood Education International illustrated how play acts as a vehicle for increasing neural structures when children practice skills they will use later in life.[66] Play and learning go hand in hand. Unfortunately, in a world where standards for learning have become tougher and more competitive, the opportunity for children to play has been greatly reduced compared to previous generations.

The good news is that experts still recognize the significance of play-based learning and emphasize the importance of parks in an urban environment. Creating spaces for play has become increasingly important to communities. But playing in parks is not limited to climbing on play structures or on ballfields. In fact, recent studies, including one from the National Academy Press, argue that parks have additional educational value. The National Academy Press study states that children and adolescents receive the greatest advantage from community-based activities that help them build essential skills and knowledge.[67] Examples include programs in which children and teens participate in replanting forests and clearing parks of garbage. Similarly, in a 2007 paper, Wolf argues that this learning process helps youth ease the process of transitioning into adulthood.[68] Wolf presents data showing how adults who engaged in these services in their school years were more likely than their peers to have social and political connections in their community and gain a higher level of education.

Local Example:

- Educational tour sessions are offered at Fort Nisqually in Point Defiance Park. The tours are purposed for youth but are available to all ages. Interpreters teach children about the daily lives of families during the fur trade era.

- MPT zoos offer many educational programs for families and schools. More than 20,000 students and parents attend field trips to Northwest Trek each year to learn about the native animals of the Northwest.[69] The Discovery Program at the Point Defiance Zoo and Aquarium provides school-age children field trip experiences with professional instruction and opportunities to handle artifacts.
- The "Nurture in Nature" preschool program at the Tacoma Nature Center offers a nine month educational program for preschoolers. The program combines hands-on outdoor experience with traditional education methods to help prepare preschoolers for kindergarten.[70]

Social Capital

Volunteers and donors come together to keep parks alive and thriving. Within a community, parks and community efforts to maintain them increase social capital, which was defined earlier as, “The inventory of organizations, institutions, laws, informal social networks, and relationships of trust that make up or provide for the productive organization of the economy.” This increase in social capital creates a stronger sense of community, making the neighborhood safer and stronger, even in communities that had previously suffered from fear or alienation due to lack of usable public spaces.

Local Example:

- In 2010, more than 52,000 hours were volunteered toward efforts to improve parks in Tacoma, 10,000 of which were contributed by youth organizations.[f] Social capital is strengthened by the existence of MPT parks.

f Information provided by MPT.

Part V

Economic Value of MPT Natural Capital

***Section Summary:** The economic value of ecosystem services generated in MPT Parks was estimated using benefit transfer methodology. The results show that ecosystem goods and services within MPT parks generate at least **$4 million to $16.4 million** in economic value annually, assuming the parks are in their pristine condition. In later sections of this report, the condition status of each park will be assessed and used to discount this amount above. Combining the ecosystem value with a partial valuation of the social capital, education and health benefits, MPT parks provide between **$34.9 million and $47.2 million** in value each year.*

Ecosystem Service Valuation

Overview

The valuation of ecosystem services within MPT parks can be divided into the following steps:

- **Quantification of Land Cover Classes:** First, Geographic Information Systems (GIS) data is used to assess the acreage of each land cover class within the parks. Examples of land cover classes include forest, forested wetland, urban greenspace and beach. Land cover classes were chosen based on the ability to derive ecosystem valuation data for that type of class.
- **Identification of Ecosystem Services and Valuation of Land Cover Classes:** Next, ecosystem services are identified within each land cover class, and each land cover class is assigned a total high and low annual per-acre value for its ecosystem services.
- **Valuation of Ecosystem Services in MPT Parks:** Finally, the total high and low annual values of ecosystem services for each land cover class is multiplied by the acreage of that land cover class within the parks to arrive at total high and low annual value estimates. Land cover class values are summed to arrive at a total annual value for MPT Parks. Net present values are calculated for the parks over 100 years at two discount rates: zero (no discount) and 4.125%. The use of the discount rate is explained in more detail in Part VI of this report.

Quantification of Land Cover Classes

Geographic Information Systems data is used to assess and categorize the land cover in MPT parks. The GIS data is gathered through aerial and/or satellite photography and can be classified according to several classification systems or "layers." Earth Economics maintains a database of peer-reviewed valuation studies organized by land cover class, which typically requires GIS data from several different sources. For this valuation, MPT parks were divided into 10 land cover classes.

The United States Geological Survey 2006 National Land Cover Database (NLCD) was used as the foundational GIS layer. NLCD land cover types found in MPT parks are listed in Table 2, and referenced by Table 3. Another layer, consisting of the Pierce and King County Urban Growth Area boundaries, was then combined with the NLCD layer using specific rules to yield 10 final land cover classes.[g] Table 3 presents the final land cover classes and acreages that comprise MPT parks as categorized for this report, a description of the layer(s), and the rationale employed to obtain the acreage values.

g Excluding "Developed Land," as it is not valued in this report.

Table 2 – NLCD Land Type Codes and Definitions

NLCD Code	NLCD Description
11	Open Water
21	Low Intensity Residential
22	High Intensity Residential
23	Commercial/Industrial/ Trans
24	Developed High Intensity
31	Barren Rock/Sand/Clay
41	Deciduous Forest
42	Evergreen Forest
43	Mixed Forest
52	Shrub/Scrub
71	Grassland/Herbaceous
90	Woody Wetlands
95	Emergent Herbaceous Wetlands

Identification of Ecosystem Services

The spatial distribution of goods and services produced in a region's economy can be mapped across the landscape. Mapping goods and services provided by factories, restaurants, schools and businesses provides a view of the economy of that region. For example, retail, residential and industrial areas occur in different parts of the landscape. The economic value of these goods, services, housing and industry can also be estimated from market or appraisal values.

The distribution of ecosystem services throughout MPT parks is similar. Each land cover class, from wetland to mature forest to agricultural field, provides economically valuable goods and services. For example, a forest provides ecosystem services such as flood risk reduction, biodiversity, climate regulation and soil formation. Shrubs provide shoreline stabilization and climate regulation, but little soil formation.

Table 3 – MPT Land Type Cover Class and Acreage

Land Cover Class	Acreage	Data Source(s)/Layers Used and Rationale
Beach	19.48	NLCD 31
Developed	286.97	NLCD 22, 23, 24
Urban Green Space	630.70	NLCD 21 - By definition is mostly composed of lawn grass
Grasslands	49.78	NLCD 71
Shrub/Scrub	96.74	NLCD 52
Evergreen Forests	936.68	NLCD 42
Forest	654.00	NLCD 41, 43
Lakes/Rivers	25.14	NLCD 11 minus Marine
Wetlands	11.95	NLCD 95
Forest Wetlands	58.64	NLCD 90
Marine	30.86	NLCD 11 minus Lakes/Rivers
Total	**2800.94**	

Land Cover Class Value
Natural capital in MPT parks generates a flow of value analogous to an annual stream of income. As long as this natural infrastructure of the park system is not degraded or depleted, this flow of value will likely continue into the distant future. This flow of value is expressed in $/acre/year, which represents the dollar value generated by a single ecosystem service on a particular land cover class. For example, urban wetlands in Western Washington were shown to provide up to $51,000/acre/year in flood risk reduction benefits.[71]

The full suite of ecosystem services produced by a particular land cover class yield a total flow of value for that land cover class. In the case of wetlands, this means summing all of its known ecosystem service values (i.e. water regulation, habitat, recreation, etc.) for which valuation studies have been completed. This number can then be multiplied by the number of acres of wetlands in MPT parks for a value in $/year.

By "transferring" values from a database of peer-reviewed academic studies and journal articles, an appraisal of ecosystem service benefits can be accomplished. This approach is known as "benefit transfer." This is an appraisal approach, rather than a precise measure, because a full valuation of a specific location would require at least 140 separate studies. An appraisal approach is less expensive and yet provides valuable economic information. This is the same reason that businesses and houses are valued with an appraisal approach. This methodology is not perfect. Just as a house may be in better condition than a house from which a "comp" was drawn for valuation, natural systems also vary in the benefits they provide. For example, a wetland immediately upstream from a town likely provides greater flood risk reduction value than a more distant upstream wetland.

Understanding the spatial valuation of ecosystem services on the landscape is the object of a National Science Foundation grant to Earth Economics and academic partners. This work will greatly advance our ability to track value spatially. The valuation of MPT ecosystem services involved over 212 studies. See Appendix C for the list of primary studies applied to MPT park valuations. These primary studies each utilized at least one of the eight valuation methods shown in Table 4.

Table 4 - List of Ecosystem Service Valuation Methods

Avoided Cost (AC): 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.
Replacement Cost (RC): services can be replaced with man-made systems; for example waste treatment provided by wetlands can be replaced with costly built treatment systems.
Factor Income (FI): services provide for the enhancement of incomes; for example water quality improvements increase commercial fisheries catch and therefore fishing incomes.
Travel Cost (TC): service demand 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.
Hedonic Pricing (HP): 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.
Marginal Product Estimation (MP): service demand is generated in a dynamic modeling environment using a production function (Cobb-Douglas) to estimate the change in the value of outputs in response to a change in material inputs.
Contingent Valuation (CV): 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.
Group Valuation (GV): this approach is based on principles of deliberative democracy and the assumption that public decision making should result, not from the aggregation of separately measured individual preferences, but from open public debate.

Due to limitations in the range of primary valuation studies conducted on ecosystem services, not all ecosystem services identified as valuable for each land cover class could be assigned a dollar value. For example, the land cover class “Urban Greenspace” has been valued for only four ecosystem services – climate regulation, aesthetic value, water regulation, and science and education – despite the fact that urban greenspace clearly provides biological control, disturbance prevention, nutrient cycling and a number of other important benefits. A matrix that summarizes the suite of ecosystem services identified by each land cover type in MPT parks, compared with those that were actually valued in this study, is provided in Table 5.

Table 5 indicates that a large number of valuable ecosystem services (for each land cover class) could not be given a dollar value estimate as they have yet to be valued in a primary study. This suggests that the estimates provided here significantly undervalue of the true benefits. As further primary studies are added to the database, the combined known value of ecosystem services in MPT parks will rise.

Several primary studies, although applicable to this study, were left out of the report because the same methodologies were used in the Phase I analysis of MPT parks. For example, the hedonic pricing method often utilizes the changes in property values in order to value the inclusion or exclusion of a park or natural settings close to a home. Because the Phase I report estimated the benefits of increased property value from parks, this methodology was left out of the ecosystem service valuation. Below, Tables 6 – 10 summarize the final ecosystem service values for individual land cover classes in MPT parks.

Table 5 – Ecosystem Services Valued and/or Identified in MPT Parks

	Beach	Evergreen Forests	Forest Wetlands	Forests	Grasslands	Lakes/Rivers	Marine	Shrub/Scrub	Urban Greenspace	Wetland	Developed
Provisioning Services											
Food					x		x				
Raw Materials		x		x			x			x	
Genetic Resources											
Medicinal Resources											
Ornamental Resources											
Regulating Services											
Gas Regulation		x	x	x	x	x	x	x	x	x	
Climate Regulation		x	x	x	x	x			x	x	
Disturbance Prevention	x	x	x	x						x	
Soil Retention		x		x	x						
Water Regulation				x	x	x			x	x	
Water Supply		x	x	x			x			x	
Biological Control				x	x			x			
Water Qty./Waste Trtmt.				x	x					x	
Soil Formation					x						
Nutrient Regulation		x					x			x	
Pollination					x						
Habitat Services											
Habitat and Biodiversity		x		x			x	x		x	
Nursery		x	x	x			x	x			
Informational Services											
Aesthetic Information	x	x	x			x		x		x	
Recreation	x	x	x	x		x			x	x	
Cultural & Artistic Info.	x						x				
Science and Education								x			
Spiritual & Historic Info.											

Key:

	Ecosystem service produced by land cover class but not valued in this report
x	Ecosystem service produced by land cover class and valued in this report
	Ecosystem service not produced by land cover class

Table 6 - High and Low Dollar per Acre Estimates for Beach and Forest

	Beach (per acre)		Forest (per acre)	
	Low	High	Low	High
Aesthetic & Recreational	$2,572.18	$49,024.61	$0.24	$2,173.94
Biological Control			$9.26	$9.68
Disturbance Regulation	$23,922.63	$23,922.63	$1.40	$5.14
Food Production				
Gas & Climate Regulation			$14.11	$1,066.19
Habitat Refugium & Nursery			$1.08	$2,922.84
Nutrient Cycling			$74.25	$1,135.29
Pollination			$67.82	$400.06
Raw Materials			$0.53	$1.87
Science and Education			$39.71	$68.35
Soil Erosion Control			$112.55	$112.55
Soil Formation				
Storm Protection				
Waste Treatment			$168.95	$168.95
Water Regulation			$10.35	$542.86
Water Supply			$9.81	$1,770.38
Total	**$26,521.86**	**$72,974.29**	**$510.05**	**$10,378.09**

Table 7 - High and Low Dollar per Acre Estimates for Grasslands and Lakes/Rivers

	Grasslands (per acre)		Lake/River (per acre)	
	Low	High	Low	High
Aesthetic & Recreational			$2.05	$21,215.04
Biological Control	$13.09	$13.63		
Disturbance Regulation				
Food Production	$33.03	$33.03		
Gas & Climate Regulation	$0.08	$168.74		
Habitat Refugium & Nursery			$2.33	$18.74
Nutrient Cycling				
Pollination	$14.48	$427.18		
Raw Materials				
Science and Education				
Soil Erosion Control	$17.20	$17.20		
Soil Formation	$0.59	$0.67		
Storm Protection				
Waste Treatment	$51.60	$51.60	$148.12	$1,925.56
Water Regulation	$1.78	$4.11	$2,978.00	$5,207.61
Water Supply			$10.60	$1,012.99
Total	**$131.85**	**$716.15**	**$3,141.09**	**$29,379.94**

Table 8 - High and Low Dollar per Acre Estimates for Marine and Wetland Forests

	Marine (per acre)		Wetland Forests (per acre)	
	Low	High	Low	High
Aesthetic & Recreational	$189.87	$594.50		
Biological Control			$3.61	$3.61
Disturbance Regulation				
Food Production			$10.84	$10.84
Gas & Climate Regulation	$108.09	$784.47	$0.43	$54.99
Habitat Refugium & Nursery	$0.55	$2.95		
Nutrient Cycling			$44.93	$125.88
Pollination				
Raw Materials			$0.05	$0.05
Science and Education				
Soil Erosion Control				
Soil Formation				
Storm Protection	$1,412.71	$1,412.71		
Waste Treatment				
Water Regulation				
Water Supply	$43.07	$139.10		
Total	**$1,754.29**	**$2,933.73**	**$64.95**	**$300.28**

Table 9 - High and Low Dollar per Acre Estimates for Shrubs and Urban Greenspace

	Shrub/Scrub (per acre)		Urban Greenspace (per acre)	
	Low	High	Low	High
Aesthetic & Recreational	$0.19	$2,173.94	$1,358.38	$3,981.97
Biological Control				
Disturbance Regulation				
Food Production				
Gas & Climate Regulation	$6.68	$193.97	$28.87	$942.11
Habitat Refugium & Nursery	$1.32	$538.74		
Nutrient Cycling				
Pollination				
Raw Materials				
Science and Education	$39.71	$68.35		
Soil Erosion Control				
Soil Formation				
Storm Protection				
Waste Treatment				
Water Regulation			$6.16	$184.04
Water Supply				
Total	**$47.90**	**$2,974.99**	**$1,393.41**	**$5,108.13**

Table 10 - High and Low Dollar per Acre Estimates for Evergreen Forest and Wetland

	Evergreen Forest (per acre)		Wetland (per acre)	
	Low	High	Low	High
Aesthetic & Recreational	$875.17	$875.17	$1.67	$4,640.38
Biological Control				
Disturbance Regulation	$1.40	$1.40	$433.68	$51,095.00
Food Production				
Gas & Climate Regulation	$14.48	$14.48	$4.69	$516.65
Habitat Refugium & Nursery	$2.80	$2.80	$9.48	$13,557.50
Nutrient Cycling	$1,135.29	$1,135.29	$521.35	$7,465.11
Pollination				
Raw Materials	$1.87	$1.87	$2,815.59	$2,815.59
Science and Education				
Soil Erosion Control	$112.55	$112.55		
Soil Formation				
Storm Protection			$18.35	$8,576.86
Waste Treatment			$76.37	$1,810.17
Water Regulation			$148.45	$17,347.20
Water Supply	$21.48	$21.48	$0.77	$33,960.48
Total	**$2,165.05**	**$2,165.05**	**$4,030.40**	**$141,784.94**

Annual Flow of Ecosystem Service Value

Values for all land cover classes were combined. Table 11 summarizes the valuation of ecosystem services across all land cover types in MPT parks. The table includes each land cover class with its acreage and value, and the total annual value for all lands within MPT parks. The low and high values represent the range of the lowest and highest values in the peer-reviewed literature. Though a great deal of research has been completed on ecosystem services in the last 30 years, this is still a new field. Many ecosystem services identified as valuable have no valuation studies. For example, though snowpack is critically important for potable water and flood protection, there are virtually no valuations of snowpack. There are also geographical gaps, where studies may have been conducted in one state or region but not others. To conduct original studies would require more than 100 studies for an individual study area. Due to the extremely high costs associated with conducting original research for ecosystem services in MPT parks, we use the benefit transfer, or appraisal method, for providing a range of values for ecosystem service benefits.

Economic Contributions of Health and Education

Overview

The valuation methods for the economic contributions of health and education used in this study were adopted from those found in the 2011 report, "The Economic Benefit of Seattle's Park and Recreation System" by the Trust for Public Lands.[51] These valuation methods include avoided health costs, air purification benefits, educational value and social capital value. They by no means describe all of the health, education and social benefits provided by parks, but they do provide at least a baseline set of values. These methods are described below.

- **Avoided Health Costs:** People who do not follow the recommended levels of moderate and vigorous physical activity have higher rates of heart disease, obesity and other health problems. There are measureable health costs associated with the treatment of these ailments. Regular physical activity at parks improves health

Table 11 – Annual Value of MPT Ecosystem Services by Land Type

	Acreage	Low and High Values (per Acre)		Low and High Totals (Values x Acreage)	
Land Cover Types	**Acres**	**Low**	**High**	**Low**	**High**
Beach	19.48	$26,494.81	$72,947.24	$516,037.61	$1,420,788.50
Developed	286.97	$0	$0	$0	$0
Urban Greenspace	630.70	$1,393.41	$5,108.13	$878,832.92	$3,221,721.73
Grassland	49.78	$131.84	$716.15	$6,563.86	$35,651.61
Shrub/Scrub	96.74	$47.90	$2,974.99	$4,633.79	$287,791.19
Evergreen Forest	936.68	$2,165.05	$2,165.05	$2,027,962.09	$2,027,962.09
Forest	654.00	$510.05	$10,378.09	$333,573.05	$6,787,297.98
Lakes/Rivers	25.14	$3,141.09	$29,379.94	$78,981.51	$738,747.69
Wetlands	11.95	$4,030.40	$141,784.94	$48,170.72	$1,694,590.67
Woody Wetlands	58.64	$1,753.74	$2,906.54	$102,847.72	$170,453.84
Marine	30.86	$121.22	$337.43	$3,741.43	$10,414.72
Total	**2,800.94**	**$39,789.51**	**$268,689.50**	**$4,001,344.70**	**$16,395,420.02**

and reduces health costs. The value to improved quality of life far surpasses the measureable avoided health costs. With data from the parks on physical activity and participation and the known relationship to health improvements and avoided health costs, the dollar value of avoided health costs provided by parks can be estimated.

- **Air Purification Benefits:** Trees remove contaminants and particulates from the air. This natural pollution reduction is particularly valuable in cities, where high densities of people and high air pollution levels combine to cause higher rates of respiratory diseases. The tree cover in MPT parks improves air quality by absorbing potentially hazardous gases and reducing particulates created by heavy traffic and industrial activity. The physical reductions in pollution provided by park tree cover and the reduced health costs to citizens are both measurable and provide a dollar estimate for the air purification value of parks. Again, this is an avoided cost approach, so it does not capture the value of improved quality of life that people experience with fewer and less acute respiratory diseases.

- **Educational Value:** Many of the activities that take place in MPT parks teach attending youth about service, sportsmanship, cooperation, science, ecosystems, civics and history. The value of education is harvested across a lifetime. Again a minimal baseline estimate of the education value provided to kids by parks can be obtained by using the same dollar value per educational hour as is applied to the public schools in Washington.

- **Social Capital Value:** Much of what it takes to maintain MPT is provided by volunteers. Where practical and possible, volunteers implement restoration, maintenance and general upkeep with their time and work. Much of the donated time comes in the form of service programs, such as Boy and Girl Scout activities and other family activities that promote the health and education of youth. There is great social, community and cultural benefit provided for which valuation methods are insufficient for estimating a dollar value. However, the physical improvements to parks and the hours of volunteer time that replace what otherwise would be paid time can be valued. Providing a low per-hour estimate for these volunteer hours in parks provides, again, a minimal baseline estimate for social capital value provided by MPT.

Reduced Health Cost Value

In a 2008 report, the Round Rock City Parks and Recreation Department in Texas estimated the benefits to locals visiting parks for exercise, while excluding those who also use health clubs. For this value we have adopted a similar methodology using the data available on percentage of residents who use parks for exercise, based on a national sample.[72] Using a formula that estimates the reduced medical costs associated with being active in parks can provide a conservative estimate of the value of health care savings provided by parks.

Using health studies from seven states, the Trust for Public Land attributed an average value of $351 in medical savings for adults who regularly exercise in parks, and $702 for those over the age of 65 who regularly exercise in parks.[51] The standards for exercise were based on the U.S. Centers for Disease Control and Prevention recommendation of 30 minutes of moderate exercise five times a week or 20 minutes of vigorous exercise at least three times a week for adults. Medical costs can vary across the country, and Washington state yields average medical costs that are 9.9% lower than the average national costs.[73] Therefore, a multiplier (.901) was used to compensate for Washington's healthier population and lower-than-average medical costs.

Children are the primary users of many of MPT's smaller parks - playing, climbing and running. However, there is no data on the number of children who utilize either the smaller neighborhood parks or major Tacoma parks. Though many families utilize these parks often, this lack of data, along with the difficulty in estimating how much exercise children receive from school and youth programs, makes estimating their health benefits difficult. Because children set lifelong exercise habits, however, the value may be very large. This study excludes any estimate of the health benefits of parks to children from birth to age 17. It is important to eventually estimate this value, as children who play regularly in parks are far less likely to experience childhood obesity, a strong indicator of adult obesity. The lifelong benefits of avoiding childhood obesity are discussed in a 2007 study by the National Initiative for Children's Healthcare Quality Child and Policy Research Center.[74] According to this study, approximately 29.5% of children in Washington State ages 10 to 17 are either overweight or obese. Their health could be greatly improved by greater play in parks. There are many components of health benefits from public parks that have been omitted from this study due to the limited data and time available.

Below are the calculations of the annual health cost reductions from meeting physical activity levels recommended by the Centers for Disease Control and Prevention. Each age group is split in order to show the varied benefits across different users and the assumptions therein. These figures represent a highly conservative estimate of the health benefits provided by MPT parks.

Table 12 - Health Cost Reduction Table

Annual Health Cost Reduction	
Subject	**Calculation**
	*Children 0-17 health benefits not estimated
Health Cost Savings Per Individual (Tacoma Population)	Adults (18-64 years): $351 * (122,714) Seniors (65+ years): $702 * (22,683)
Percent of WA Residents who meet Physical Activity Recommendations	Adults (18-64 yrs): .664 (66.4%) Seniors (65+ yrs): .475 (47.5%)
Percentage of Residents who Exercise in Parks	.296 (29.6%)
WA State Health Cost Multiplier	.901 (90.1%)
Total	Adult: $7,627,563.125 Seniors: $2,017,194.227
	Grand Total: $9,644,757.35

Value of Air Purification

Scientific studies have shown the air purification value of trees in cities and city parks. Health studies provide a basis for estimating the dollar value of lower health care costs with improvements in air quality. A study of the "Green Belt" in Ontario estimated a value of pollution reduction by trees at about $150 per hectare per year.[75] There is a difference in value between coniferous forests and deciduous. Evergreen trees provide purification value during the winter months, when the Puget Sound basin often experiences degraded air quality, as well as during the summer when both deciduous and coniferous trees provide benefits. In this case, the Ontario estimates were applied to areas that share similar attributes. The estimate of air purification value is an underestimate for the MPT system because many of the trees within the park system were not captured in the GIS data. NLCD GIS data categorizes park space with limited tree cover simply as developed greenspace, which does not capture tree cover in many parks and therefore excludes the air purification service those trees provide.

In this study, the Forest Service's Urban Forest Effects (UFORE) model, developed by the Northeast Research Station of the U.S. Forest Service in Syracuse, New York, has been adopted to measure the specific toxins absorbed by the tree cover types in MPT's urban parks. This tool takes into consideration the ambient air quality and the pollutant flow through a specific area at some given time period.

In order to equate the monetary value of pollutant removal, we use the median U.S. externality value for each pollutant, which is also referred to as the cost of preventing one unit of that pollutant from entering the atmosphere. Table 13 shows values provided from the UFORE model integrated with the externality value of each pollutant to calculate the combined value of pollution removal from the tree cover in MPT's urban parks.

Given the acreage of tree coverage provided by 2006 NLCS GIS data, the amount of pollutants absorbed by the 1,649.47 acres of tree cover was estimated separately from the urban park trees. Several MPT parks, including parts of Point Defiance Park, Northwest Trek and Wapato Park, are undeveloped and preserve a much denser tree cover compared to more urban parks.

Table 13 - Air Purification Values

Air Purification			
Eco Model (UFORE)		Tons Removed	Savings Per Ton of Pollution Removed
Carbon Dioxide (CO_2)		1,828.6	$72.94
Nitrogen Dioxide (NO_2)		8,899.8	$2,499.30
Ozone (O_3)		20,531.3	$5,765.81
Particulate Matter (PM10)		16,063.0	$3,011.9
Sulfur Dioxide (SO_2)		4,175.3	$287.04
		Total Value	**$11,636.99**
Benefit Transfer Method	Tree Acres	Value of Pollutants Removed	Pollution Removal Value
Wilson, S.J. 2008	1649.47	$150.24 acres/year	$247,816.37 (low value)
TPL Seattle, 2011	1649.47	$200.29 acres/year	$330,372.35 (high value)
		Total Value	$247,816.37 to $330,372.35
		Grand Total	**$259,453.36 to $342,009.34**

Educational Value

Popular field trip programs are offered at the Point Defiance Zoo, Northwest Trek, Fort Nisqually, Tacoma Nature Center and the Seymour Botanical Conservatory at Wright Park. Some programs involve students spending an entire day. The dollar value of this education is often overlooked.

Estimates of the education value of student time at MPT parks are based on the hourly value of public education in Washington State. Census Bureau data for Washington shows that the state spends an average of $8,377 per year on each pupil in the public school system.[76] Census data also shows that of that figure, employee wages and benefits alone (in Pierce County) make up an average of $5,505 in costs for each pupil. When assessing the number of school days required in Washington along with the average number of hours spent by children in class each day, a per-hour value for public education was determined. This figure is used in Table 14 below to estimate the educational value (cost/hour basis) a student receives education received in MPT zoo and park programs. Using survey data provided by MPT, the number of K-12 students and the hours of education were estimated. The results are shown below.

Table 14 - Educational Values

Youth Educational Value			
Program/Activity	**Attendees**	**$ rate (length program hours)**	**Total Value**
Northwest Trek Field Trips	14,377	$4.56468 (6.7)	$439,696.58
Point Defiance Zoo & Aquarium Field Trips	27,344	$4.56468 (6.7)	$836,270.67
Seymour Botanical Conservatory Field Trips	300	$4.56468 (.5)	$684.70
Tacoma Nature Center Field Trips	750	$4.56468 (2)	$6,847.02
Fort Nisqually (Student Tour) (Day Camp)	66 3,933	$4.56468 (1.5) $4.56468 (5)	$451.90 $89,764.43
		Total Value	**$1,373,715.30**

Social Capital Value

The economic value of social capital is difficult to measure and often regarded as priceless.[51] Two areas are considered here - cash donations from the community and volunteer time donated to MPT parks. Volunteerism in Tacoma, whether in children's programs or in the form of a bystander assisting a neighbor, is part of our social capital and often goes unnoticed. According to the Independent Sector, a national leadership forum focused on charities, foundations and corporate giving programs, the average hourly rate estimated for volunteer time in the U.S. is $21.36.[77] This rate is based on the average hourly earnings of all production and nonsupervisory employees on private nonfarm payrolls. This figure varies across the nation based on average wages, and the Washington state volunteer rate is $21.62.

Over 52,000 volunteer hours were recorded in MPT parks in 2010. Much of this work is donated by local community organizations like the Puget Creek Restoration Society. Volunteerism covers a wide range of activities. Special volunteer events draw volunteers from community clubs and educational institutions. To estimate a value of this volunteer time, only a small part of the total social capital provided by MPT parks - the sum of documented volunteer hours and donations - is used. These figures are calculated in Table 15 below and show the total value of volunteer time (a portion of social capital) provided.

Table 15 - Social Capital Values

Social Capital Value			
Volunteer Hours in 2010	**Hours** 52,165	**Rate** 21.62	**Total** $1,127,807.30
Donations and Grants in 2010			$5,764,913.00
		Total Value	**$6,892,720.30**

Total Value

Table 16 shows the values provided by MPT parks in terms of ecosystem service benefits, improved health and education and social capital. From these values a total annual value of $34,869,004 to $47,254,582 is derived.

Table 16 - Total Annual Value

Annual Valuation Category	Total Low Value	Total High Value
All Ecosystem Service Values*	$4,001,344.70*	$16,395,420.02*
Health Cost Reduction Benefits	$9,644,757.35	$9,644,757.35
Air Purification Values	$259,453.36	$342,009.34
Youth Education Values	$1,373,715.30	$1,373,715.30
Social Capital Value	$6,892,720.30	$6,892,720.30
Grand Total	$22,171,991.01	$ 34,648,622.31

*Final value of all ecosystem services calculated in Part VI below.

The value of all ecosystem services above is realized when assuming that all ecosystems within each MPT park are in pristine condition. What will be revealed in Part VI below is that a majority of the parks have been degraded ecologically over time due to human development and primarily the introduction of invasive species. In some cases, the ecosystem services that exist may function at only 50% capacity. In this final section, an assessment of the Restoration Action Plan will demonstrate how park restoration activities can increase the quality of natural ecosystems and add to the current value of the park system.

Part VI

Value of MPT's Stewardship and Sustainability Practices

Section Summary: *Residential development around parks has introduced a wide variety of non-native species that have the potential to cause extensive damage to natural ecosystems in Tacoma. In order to control this invasive threat, restoration and long-term maintenance is necessary. Budget cuts have limited needed restoration, so projects have been prioritized. Projecting the benefits of restoration involves the discounting of ecosystem service benefits of degraded lands, which will aid in prioritization.*

The value of Metro Parks' stewardship practices provides increased environmental quality through restoration. This value can be measured by the increased ecosystem service benefits provided by restoration. Some of the ecosystem services that benefit from park restoration, also listed above in Part V, include increased nutrient regulation and soil retention, better disturbance prevention and water regulation, higher-quality habitat, and often increased aesthetic and recreational enjoyment. In a pristine state, the value of MPT parks ecosystem services would equate to $34.9 million to $47.3 million per year for 10 partially valued ecosystem services. But, according to the Restoration Action Plan of 2010, over 750 acres of land are in need of restoration. The removal of invasive species is a high priority in the MPT park land restoration plan with replanting of native species. This will result in vegetation cover changes over time (ivy replaced by native species for example). This shift increases the ecosystem functions and consequently the benefits.

Parks restoration recovers lost ecosystem service benefits. Restored park ecosystems will continue to increase in value in perpetuity. The short-term benefits of restoration are limited as the young trees and shrubs grow. When given enough time to flourish in its natural state, new vegetation strengthens its ability to support native habitat, contribute to the cycle of nutrients and defend against continuous invasive threat.

In the remainder of this section, the value of MPT's stewardship activities is assessed based on current ecosystem quality and the future post-restoration quality.

Current Status of MPT Park Lands

The introduction of invasive species can dramatically reduce the ecosystem goods and services natural systems provide. Reed canary grass expansion, for example, reduces biodiversity by choking off waterways and causing increased flooding, preventing salmon from spawning. The costs associated with invasive species are not trivial. In some cases, they reach billions of dollars.[78]

In the months since the release of the Restoration Action Plan (RAP), MPT has already restored 29.3 acres in 13 of its parks. According to the plan, approximately 727 acres of land are still in need of restoration.[49] Restoring these parks primarily consists of the removal of invasive species, a process that is labor and time intensive. Successfully restoring park lands usually requires several years of monitoring and maintenance to ensure that residual invasive species are removed. The labor required to fully restore the park lands, monitor and maintain them for the long term would cost approximately $23.5 million over the next 20 years.[49]

Restoration Prioritization

The RAP methodology categorized restoration priorities in MPT parks as short-term actions in high-priority parks and long-term plans for lower-priority parks. This list was prioritized according to "Habitat Triage Values" that used a matrix system to determine priority ratings for each habitat management unit based on the quality of the habitat composition and the threat of invasive species cover.[49] Using the two values, each park section was assigned to one of nine possible categories in the Habitat Triage matrix. The top row of the matrix in Figure 13 below – categories 1, 2, and 3 – comprise native areas dominated by mature conifers, madrones, oaks, riparian forests, wetlands or other native vegetation. The bottom row of the matrix – categories 7, 8, 9 – identifies forests with little or no target plant communities.

Figure 6 – Habitat Triage Value Matrix

Source: Green Tacoma Partnership

In Appendix E, an MPT Park Ecosystem Status Table shows each park along with the Habitat Triage Values and the distribution of acres for each park section.

Ecosystem Services and Ecosystem Health

Even where invasive species have a strong presence in a park's ecosystem, not all ecosystem services are lost. Although the system may be severely degraded, invasive species may still provide some ecosystem services. For example, reed canary grass has high primary productivity but greatly reduces biodiversity.

Understanding the relationship between ecosystem services and the level of ecosystem health helps with management and planning for invasive species removal and other restoration actions. Metro Parks set up an exemplary system for making the tough choices of restoration within a limited budget by using a habitat triage value matrix. Parks with the smallest threat from invasive species and containing a higher level of target plant composition receive a triage value of 1, considered "Good." The "Fair" status was associated with ecosystems that fell under the triage value of 2, 4 or 7, suggesting some invasive threat or weakened habitat composition but posing no immediate threat to the longevity of the park. In Table 17 below, the remaining values are given for poor and dysfunctional ratings requiring more urgent action.

Table 17 - Ecosystem Categorization Table

Habitat Triage Value	Ecosystem Status	Ecosystem Service Degradation Multiplier
1	Good	1 (100%)
2, 4, 7	Fair	0.8 (80%)
5, 8	Poor	0.5 (50%)
3, 6, 9	Dysfunctional	0.3 (30%)

Ecosystem service degradation values were assigned to each ecosystem status. This reduces ecosystem services based on grades associated with each park. The multipliers for this study were selected by a panel of experts that included economists and ecologists. Although the values do not reflect the reduced rate that invasive species and degraded habitat composition remove from ecosystems precisely, for the purpose of this report they sufficiently suggest the lost value. The ecosystem status of each park in need of restoration is also provided in the MPT Park Ecosystem Status Table in Appendix E.

These ecosystem service discount values from the table above were applied to each park examined in the restoration plan. From these values, the total ecosystem service calculations from Part V will be adjusted to show the reduced value of MPT parks affected by invasive species in their current state.

Value of Park Restoration

Table 18 includes the reduced ecosystem service values and shows ecosystem service values in the current state as determined by the invasive species analysis, and under a condition of full restoration with a park-by-park analysis.

Table 18 - Value of MPT Parks at a Non-Discounted vs Discounted Viewpoint

Park	Value of Land Without Multiplier		Value of Land With Multiplier (2011)	
	Low	High	Low	High
Alderwood Park	$7,493.95	$80,308.67	5,995.16	$64,246.94
Browns Point Playfield	$923.18	$7,510.82	$461.59	$3,755.41
Charlotte's Blueberry Park	$7,424.08	$52,393.34	3,821.36	$26,382.87
China Lake Park	$41,761.48	$204,022.20	$22,182.01	$108,368.42
Delong Park	$37,395.04	$780,455.96	16,314.57	$340,494.50
Franklin Park	$3,772.64	$35,691.67	$2,009.24	$19,008.90
Garfield Park	$7,832.75	$63,725.78	3,149.28	$25,621.95
Irving Park	$847.04	$6,891.37	$254.11	$2,067.41
Lincoln - Eldridge Park	$1,732.15	$14,092.46	1,385.72	$11,273.97
McKinley Park	$24,764.03	$201,475.70	13,376.57	$108,829.39
Meadow Park Golf Course	$4,826.37	$45,660.72	$3,861.09	$36,528.58
Metro Parks Headquarters	$7,897.02	$62,865.20	3,919.34	$31,200.37
Norpoint Park	$8,470.41	$68,913.67	$3,873.55	$31,514.45
Oak Tree Park	$14,294.70	$113,794.65	$11,025.29	$87,768.24
Oakland Madrona Park	$975.39	$3,575.69	$342.78	$1,256.60
Point Defiance Park	$893,200.04	$5,468,059.27	$816,417.63	$4,998,007.04
Puget Park	$29,420.69	$315,285.90	$20,793.59	$222,833.93
Ryan's Park	$3,469.60	$12,719.24	$2,641.92	$9,685.01
South End Recreation Area	$7,242.68	$58,925.05	$2,410.73	$19,613.29
Swan Creek Park	$266,948.79	$1,078,512.29	188,641.76	$762,140.33
Snake Lake Park	$93,037.20	$454,525.58	66,036.32	$322,614.93
Titlow Park	$95,979.28	$1,599,740.33	50,451.81	$840,908.63
Ursich Park	$5,659.68	$60,651.80	1,697.90	$18,195.54
Wapato Hills Park	$9,225.70	$53,205.69	7,380.56	$42,564.55
Wapato Park	$106,543.42	$1,641,573.23	47,637.32	$793,997.66
Totals	**$1,662,749.55**	**$12,342,224.11**	**$1,296,081.25**	**$8,928,878.92**

This analysis is important, because restoring park lands provides physical and functional improvements that provide economic benefits such as better flood protection, reduced erosion, greater aesthetic value (higher adjoining property values), biodiversity, recreation and other services. By understanding the economic benefits of restoration, decision-makers can better set investment and budget targets for park restoration. The public can also see park restoration as capital investments that produce solid economic benefits. Roughly, the difference between the damaged and undamaged park system, considering only the value of 10 of 23 ecosystem services, is between $366,668 and $3,413,345 *each year*. This demonstrates that the investment associated with restoration of even a single acre, which can reach into thousands of dollars over a multi-year process, is a good investment of public funds.

When the two-year analysis for the RAP started in 2005, MPT began restoration in many of the smaller parks. In the same year, voters passed an $84.3 million bond measure that allowed MPT to implement a program to fund many of the projects currently underway. In the MPT Park Ecosystem Status table in Appendix E, the status of each park is compared from the time of assessment to a review point at the beginning of 2011. During this period, 23 restoration projects were initiated in nearly 40 acres of parklands. Some restoration projects have been completed. Native vegetation has been restored, and the parks are well on their way to reaching their potential for ecosystem service benefits. This restoration work has already improved the ecosystem functions (natural functions of the park), ecosystem services (benefits people get from those improved functions) and produced increased economic value. In Table 19 below, the ecosystem service value for each park is shown in three different time periods to compare the increased benefits of restoration since the first analysis in 2005-07, and also to show the benefits of restoration project completion in a five-year projection.

Table 19 shows the ecosystem service value for each park during the 2005-07 planning period, at the early 2011 assessment and at a projected completion point in 2016. The estimated ecosystem service values for the 10 ecosystem services examined for each of the parks undergoing restoration is provided with low and high estimates for each of the three time periods. Because there is uncertainty in the amount of ecosystem service value provided, the low and high values likely bound the potential value gains for these 10 ecosystem services. Keep in mind, however, that there are 13 other categories of ecosystem services which may be improved with restoration that have not been valued. Because many of these parks are in highly urbanized areas with high population concentrations, the values may be far larger. Most of the appraisal or “comp” values utilized for this study are derived from areas with lower population densities. The economic value provided by parks is markedly increased as population density rises.

Park improvements made since the RAP analysis started in 2005 resulted in a range, per park, of an annual increase of $15,258 to $192,401 in ecosystem service benefits to the communities around MPT parks undergoing restoration by 2011. This added value is even more impressive considering the extensive use of volunteers to achieve it. Ecosystems once degraded by invasive species are now increasingly restored to natural vegetation and providing higher value. When considering the future projects to be completed by 2016, we can measure an even higher value recovered from the damaged parks. Approximately $23,128 to $264,000 per park, per year, in additional benefits to local communities will be achieved considering only 10 ecosystem services by 2016 due to restoration activities. Understanding the additional property value increase for adjacent properties, the resulting increased tax revenue and the increased employment from the projects would help fill out some of the additional gaps in assessing the full value of restoration.

Restoration also brings in businesses. After the City of Tacoma cleaned up Superfund sites on the Thea Foss Waterway, more than $350 million in new investments were made within five blocks of the waterway. One of the great attractions of Tacoma for businesses and residents is the quality and quantity of MPT park space.

Table 19 - Ecosystem Service Value at Different Points in Time

Park	Value in 2005-07		Value in 2011		Value in 2016	
	Low	High	Low	High	Low	High
Alderwood Park	$5,995.16	$64,246.94	5,995.16	$64,246.94	$5,995.16	$64,246.94
Browns Point Playfield	$461.59	$3,755.41	$461.59	$3,755.41	$461.59	$3,755.41
Charlotte's Blueberry Park	$3,250.45	$22,441.26	3,821.36	$26,382.87	$3,821.36	$26,382.87
China Lake Park	$22,182.01	$108,368.42	$22,182.01	$108,368.42	$22,182.01	$108,368.42
Delong Park	$13,256.93	$276,679.87	16,314.57	$340,494.50	$16,314.57	$340,494.50
Franklin Park	$1,814.11	$17,162.78	$2,009.24	$19,008.90	$2,139.33	$20,239.65
Garfield Park	$2,435.48	$19,814.62	3,149.28	$25,621.95	$3,434.80	$27,944.88
Irving Park	$254.11	$2,067.41	$254.11	$2,067.41	$254.11	$2,067.41
Lincoln - Eldridge Park	$1,385.72	$11,273.97	1,385.72	$11,273.97	$1,385.72	$11,273.97
McKinley Park	$11,092.43	$90,245.93	13,376.57	$108,829.39	$14,899.34	$121,218.38
Meadow Park Golf Course	$3,861.09	$36,528.58	$3,861.09	$36,528.58	$3,991.18	$37,759.33
Metro Parks Headquarters	$3,919.34	$31,200.37	3,919.34	$31,200.37	$3,919.34	$31,200.37
Norpoint Park	$3,873.55	$31,514.45	$3,873.55	$31,514.45	$3,873.55	$31,514.45
Oak Tree Park	$11,025.29	$87,768.24	$11,025.29	$87,768.24	$11,432.36	$91,008.72
Oakland Madrona Park	$342.78	$1,256.60	$342.78	$1,256.60	$342.78	$1,256.60
Point Defiance Park	$816,417.63	$4,998,007.04	$816,417.63	$4,998,007.04	$817,485.97	$5,004,547.23
Puget Park	$20,431.57	$218,954.29	$20,793.59	$222,833.93	$21,034.95	$225,420.36
Ryan's Park	$1,868.58	$6,850.00	$2,641.92	$9,685.01	$2,951.26	$10,819.01
South End Recreation Area	$2,172.80	$17,677.52	$2,410.73	$19,613.29	$2,505.91	$20,387.60
Swan Creek Park	$188,641.76	$762,140.33	188,641.76	$762,140.33	$188,841.82	$762,948.63
Snake Lake Park	$63,661.71	$311,013.97	66,036.32	$322,614.93	$67,619.40	$330,348.90
Titlow Park	$47,343.00	$789,092.38	50,451.81	$840,908.63	$51,695.34	$861,635.13
Ursich Park	$1,697.90	$18,195.54	1,697.90	$18,195.54	$1,697.90	$18,195.54
Wapato Hills Park	$7,380.56	$42,564.55	7,380.56	$42,564.55	$7,380.56	$42,564.55
Wapato Park	$46,057.00	$767,657.73	47,637.32	$793,997.66	$48,290.17	$804,879.07
Total	**$1,280,822.58**	**$8,736,478.20**	**$1,296,081.25**	**$8,928,878.92**	**$1,303,950.49**	**$9,000,477.90**

Total Ecosystem Service Value

Not every land type within each park was subject to invasive species. Within more heavily used MPT parks, maintenance to remove invasive species and prevent greater damage and costs was implemented. In parks such as Northwest Trek or Point Defiance Park, high visitation rates alone justify the costs of maintaining parklands without consideration of additional ecosystem service benefits. In Table 20 below, the annual values of all ecosystem services in degraded areas and in areas that need only preventative maintenance are combined to show that the ecosystem services provided by all MPT parks are worth between $3.6 million and $13.0 million each year.

Table 20 – Annual Ecosystem Service Valuation of All Parks

Ecosystem Service Quality Category	Total Low Value	Total High Value
Land With Needed Restoration	$1,296,081.25	$8,928,878.92
Land With No Needed Restoration	$2,338,595.14	$4,053,195.63
Grand Total	**$3,634,676.39**	**$12,982,074.54**

The values provided for ecosystem services have been expressed in annual benefits. Yet, unlike many consumable products that provide value over very short periods of time, parks provide value across generations. The recreational, aesthetic, ecological, social, health and other benefits provided by parks traverse decades. That is why MTP is a public tax jurisdiction, to ensure the stewardship and improvement of the multi-year, multi-generational benefits provided by parks. The annual benefits realized from parks undergoing additional future restoration will also provide increased ecosystem service benefits each year. Finally, the benefits that parks provide are becoming increasingly scarce and more valuable, unlike many built goods and services like cell phones or plastic toys, which are more abundantly available with falling costs. In the following sections, we will analyze how the annual flow of realized benefits from parks can be converted into an estimate of asset value. That enables restoration to be correctly seen as capital investment that provides an annual flow of benefits.

Present Value

A building or factory produces a flow of valuable goods and services over time. The sales value of the building or factory is the asset value. The annual flow of economic returns may be the income from rent or sales. Like other assets, ecosystems also provide a flow of benefits across time. It is then reasonable to think about their analogous asset values.

The asset value of many typical economic assets can be estimated by calculating the net present value, which is a discounted sum of annual future benefits.

Calculating the net present value of an asset in traditional economics requires the use of a discount rate in order to account for the loss of purchasing value of a dollar over time. The Army Corps of Engineers uses a 4.125% discount rate for large projects, which lowers the value of the benefits by 4.125% every year into the future. Seattle Public Utilities and some other institutions use a 5% discount rate for capital construction projects. Some economists have advocated that natural capital have a lower discount rate (some advocate zero) because the benefit stream is more certain over longer periods of time. Natural capital has greater capacity for self-maintenance and does not physically depreciate, while all built capital assets eventually fall apart or lose their usefulness. Thus the stream of benefits provided in the future declines or requires further investment to maintain. The forest that has filtered Seattle's drinking water for more than 100 years is not degraded. Within that time, the city would have had to build four filtration plants each having a lifespan of about 25 years. Thus discounting the future benefits of a filtration plant makes more sense than discounting the future benefits of a forest, if all generations are treated equally. There is a robust discussion about discount rates because "net present value" is not from the perspective of someone living in the future; it is calculated from the perspective of a person in the present.

A discount rate is designed to reflect the following for a person or investor today:

1. **Pure time preference of money.** This is the rate at which people value what they can have now, compared with putting off consumption or income until later.
2. **Opportunity cost of investment.** A dollar in one year's time has a present value of less than a dollar today, because a dollar today can be invested for a return in one year.

The methodology for calculating present values is the same as calculating compound interest, only in reverse. The farther out in time we go, the less value that dollar has today to a person living in the present. Therefore, when considering a stream of benefits over time, a benefit derived in 50 years is worth far less than the same benefit today. By applying this methodology to a continual stream of benefits, we can derive an approximate value of the asset in today's dollars.

The net present value of MPT parks, in this study was valued using two discount rates: zero and 4.125%.

Discounting has limitations. Using a discount rate assumes that the benefits humans reap in the present are more valuable than the benefits provided to future generations. Renewable resources should be treated with lower discount rates than built capital assets because they provide a rate of return over a far longer period of time. Most of the benefits that natural assets such as MPT parks provide reside in the distant future, whereas most of the benefits of built capital, such as roads, reside in the near-term (roads always need repair and maintenance), with few or no benefits provided into the distant future. Both types of assets are important to maintain a high quality of life, but each operates on a different time scale. It would be unwise to treat human time preference for a forest as if it were a building, or a building as if it were a disposable coffee cup.

Results

Overall, 17 categories of ecosystem services were valued across 10 land cover classes for 10 of 23 ecosystem services. These services were valued according to their ecosystem status; in some parks, degradation levels discounted ecosystem service values by 50 percent. In addition, the implicit value of MPT parks was measured using four other categories, including health cost reduction, air purification, educational and social capital benefits. Health values excluded children up to age 18. Educational value only included school children. When including the reduced ecosystem services from some degraded parks, **the results show that MPT parks generate at least $21.8 million to $31.2 million in goods and services every year.**

Table 21 - Total Annual Value (including ecosystem quality multiplier)

Annual Valuation Category	Total Low Value	Total High Value
All Ecosystem Service Values	$3,634,676.39	$12,982,074.54
Health Cost Reduction Benefits	$9,644,757.35	$9,644,757.35
Air Purification Values	$259,453.36	$342,009.34
Youth Education Values	$1,373,715.30	$1,373,715.30
Social Capital Value	$6,892,720.30	$6,892,720.30
Grand Total	**$21,805,322.7**	**$31,235,276.83**

From this annual flow of value, a present value analogous to an "asset value" for these specific services can be calculated. To determine the asset value of MPT parks ecosystems to society, we apply a discount rate of 4.125% over 100 years from the present day. This assumes that the benefit stream will continue at the same rate and value for 100 years. More likely, the value of the benefits will increase over time as park areas become scarcer relative to the total population.

In the table below, each benefit category within MPT parks is valued over 100 years. In consideration of the parklands that have yet to be restored, it was assumed that all restoration will take place within the 100-year period, revealing the full ecosystem service value potential by the hundredth year.

Table 22 - Park Benefits Projected Over 100 Years

Park Benefits Projected Over 100 Years			
	Discount Rate	**Low Estimate**	**High Estimate**
Unmanaged Habitat for Park Ecosystem Service Valuation	0% (100 years)	$233,859,514	$405,319,563
	4.125% (100 years)	$55,697,742	$96,533,958
Managed habitat for Park Ecosystem Service Valuation	0% (100 years)	$148,124,874	$1,065,261,824
	4.125% (100 years)	$32,916,749	$231,724,715
Health Reduction, Air Purification, Educational and Social Capital Calculations	0% (100 years)	$1,817,064,631	$1,825,320,229
	4.125% (100 years)	$432,765,790	$434,732,005
Grand Total	0% (100 years)	$2,199,049,020	$3,295,901,616
	4.125% (100 years)	$521,380,281	$762,990,678

The asset value of MPT parks is between $521.4 million and $763.0 million, calculated at a 4.125% discount rate over the next 100 years. The MPT park asset values were also calculated at a zero discount rate, treating the value these ecosystems will provide to future generations as equal to that of present generations. **At a zero discount rate, the parks' asset value is estimated at between $2.2 billion and $3.3 billion.** Every dollar value used to derive these figures is provided in the detailed primary study information used in this benefit transfer and listed in Appendix C. Study limitations are discussed in Appendix F.

Part VII Applications of Study Findings

__Section Summary:__ Economies depend upon ecosystem goods and services and become weakened when regional ecosystems are degraded. The long-term health of MPT parks depends upon our ability to make wise choices and investments of sufficient size to increase the productive capacity of the parks' natural capital. This contributes to the total benefits provided within parks, and to the economic benefits parks provide to the community. Recommendations on how to understand and positively apply the results of this study are designated in bold text below.

Investing in the Future

The term "investment" describes the choices people make today to allocate resources for the best possible returns in the future. An economy is the product of previous decades of investment. Future generations will benefit or suffer from the choices made today. When Tacoma Public Utilities invested in a 43-mile pipeline from the Green River Watershed and in a subsequent watershed protection program, its leaders were considering not only the short-term costs and benefits of natural water filtration but also the long-term investment and benefits to future generations. In hindsight, this investment has vastly increased in both production and monetary value over time. Every gallon of water provided today is worth more, and the watershed provides a far larger quantity of water than it did 80 years ago.

The substantial economic value currently being generated in MPT parks demonstrates that nature provides a good investment opportunity. Restoration investments in parks pay off; they are investments worth making. While the Tacoma economy is already intertwined with its natural foundations, much can be done to further account for the natural goods and services that are produced for greater overall well-being in this Whole Economy.

As ecosystems in Tacoma become fragmented and scarce, it is imperative to consider both the retention (conservation) and the restoration of these systems as a key investment in the economy as supported by green infrastructure.

Decision Support

The large dollar values of ecosystem goods and services in MPT parks demonstrate the importance of ecosystems to the local economy. The appraisal values identified in this study are defensible and applicable to decision-making at every jurisdictional level.

This study provides decision-makers an opportunity to shift from addressing issues and challenges at single-issue scale to taking an integrated approach of developing a sustainable urban economy in which natural capital is an integral part of safe investments that maintain or rise in value over time.

Urban Park Characterization

Park characterizations and other urban land-based analysis should be informed by ecosystem service analysis. These characterizations have been advancing dramatically in recent years. Including the human economy and ecosystem services is crucial in advancing the understanding, value and depth of park characterization. Natural systems protect built structures directly, with flood and storm protection, erosion control and other regulating services, and provision the economy with water, food and other goods. It is important that state and federal agencies, particularly the Washington State Department of Natural Resources, the Washington State Department of Ecology, and the Army Corps of Engineers (all of which have supported ecosystem service analysis and valuations in the past for certain projects) adopt this analysis as a normal part of operations. Training for private firms – including consulting companies, government agencies and non-profits – in ecosystem service analysis should proceed at a rapid pace.

Economic benefits provided by ecosystems are important and need to be valued to properly inform public and private investment. These are improvements in economic analysis which promote better investment and are informed by ecosystem services. The mapping of ecosystem services on the landscape, their provisioning, beneficiaries and impediments all inform how institutions should be set up and how incentives and funding mechanisms should be created. By mapping the services parks provide, beneficiary areas can better be understood. For example, communities receive flood protection from park lands.

Urban Park characterization should include ecosystem services, which are crucial to solving many biological and economic sustainability issues in Tacoma.

Cost-Benefit Analysis

All federal and state agencies, cities, counties and many private firms utilize cost/benefit analyses to make investment decisions in areas such as health care, levee construction, education, road building, economic development, tax breaks and others. If a cost/benefit analysis is flawed, investments will be flawed. For example, currently a fish-processing plant counts as an asset in cost/benefit analysis, yet federal rules dictate that the system that actually produces the fish does not count as an asset and cannot be valued in the analysis.

In the U.S., significant changes in the federal cost/benefit analysis rules for water and land resources (“Principles and Guidelines”) are currently under consideration. Proposed changes include the valuation of ecosystem services. It is uncertain how long this consideration will take, but it is Earth Economics’ experience that when local and regional jurisdictions factor natural capital into cost/benefit analysis, better-informed decisions result.

When working with federal agencies on shared projects, jurisdictions have an opportunity to take a leadership role. The Army Corps of Engineers, for example, will grant exemptions to include the values of ecosystems in a cost/benefit analysis to ensure that they are considered along with built infrastructure for a more complete and accurate flood risk management plan and strategy. Local jurisdictions should encourage this during project planning.

Project Prioritization

Criteria for selection and prioritization of capital infrastructure projects need to reflect the goals of the communities and the policies of local jurisdictions. Though not a comprehensive list of criteria, some questions driven by ecosystem services-related policies include:

1. **Does the project enhance natural processes?**
2. **Do the project impacts enhance or degrade associated ecosystem services (such as habitat or water quality) at the site-specific or regional scales?**
3. **Are the costs and benefits (safety, health, economic and ecological) of this project distributed equitably over time and space?**

Environmental Impact Statements

In Washington, environmental impact statements often have an effect on project design, and thus investment, by identifying actions that reduce the negative environmental impacts or enhance restoration. One of the fundamental challenges of environmental impact statements is the lack of an economic interface. In other words, environmental damages can be quantified in scientific terms, but this has no common language with project financing, denominated in dollars. Ecosystem service identification and valuation often strengthen what is the weakest area of environmental planning and analysis - the economic implications and value provided by restoration projects.

In 2010, Earth Economics provided the first economic section in an environmental impact analysis for Snohomish County’s Smith Island restoration project.

Three scenarios were examined for ecosystem service enhancement and valuation. Providing this information allows for a stronger understanding of the economic benefits the project provides. Identifying the dollar value of ecosystem services enhanced by the project and provided to the public also strengthens the capacity for funding proposals.

Parks should include an ecosystem service analysis to strengthen environmental impact assessments. Policy makers in Washington should lead the nation in requiring ecosystem service analysis in all applicable environmental impact statements.

Internal Policy and Procedure Revamp

Shifting private and public investment toward green infrastructure, buildings and investment requires that natural capital be recognized as a capital asset that is measurable within standard accounting systems. The creation of Tacoma Public Utilities (TPU) in 1893 was a visionary and successful institutional development. Although considered a radical and expensive idea at the time, the construction of the 43-mile Green River pipeline to supply water to the city was approved by Tacoma's citizens in 1909. Had the utility required a threshold rate of return on investment, it would likely never have justified this daring project. The goal of the investment was not to maximize "net present value" but to provide safe and reliable drinking water for the people of Tacoma and Pierce County into the distant future. By 1968, Tacoma had acquired 10,000 acres of land surrounding the Green River Watershed and declared its source water protection program a success.[79] Although the project was controversial at the time and presented a number of legal, physical and political challenges, it is now recognized as a magnificent investment. Tacoma has since acquired an additional 5,000 acres in critical areas of the Green River Watershed.[80]

Decision-makers for local jurisdictions and tribes should consider an "Accounting Review" of existing capabilities to implement natural capital accounting within some of MPT parks. The review can be used to make recommendations for incorporating ecological economics and ecological accounting methods, procedures and auditing.

Green Jobs Analysis

Ecosystem services and jobs are closely connected. An examination of jobs created by capital and restoration projects that improve ecosystems generally looks at how many construction jobs are created by moving earth or planting native vegetation. Yet most restoration projects also provide quantifiable ecosystem goods and services that have economic importance and provide an increase in sustainable, well-paid jobs. Establishing an increase in permanent employment is far more important than providing temporary jobs, and federal agencies recognize and measure this accordingly.

In 2011, Washington state parks were facing budget cuts and the forced closure of most state Parks. Earth Economics had a study of the jobs provided by state parks to rural communities underway. After providing data to state legislators on the jobs supported by state parks, legislators agreed that funding was important (Earth Economics does not lobby or promote legislation). Both Democrats and Republicans joined in passing a $70 million funding mechanism called the Discover Pass.[1] The bill was called "absolutely critical" because 90 percent of the state parks budget was subject to being cut in the governor's original proposal.[81]

Jobs analysis (i.e., the number of jobs created) is increasingly important for securing funding and is a part of many federal applications. Restoration projects can and should be effectively linked to economic advancement and sustainability.

Conclusion

Summary of findings

There are many ways in which the economy of Tacoma – and the quality of life for its citizens – depend upon functioning ecosystems within its parks. When ecosystems are healthy, they provide vast amounts of economic value at a relatively low cost; once degraded, ecosystems require investments such as the installation of built infrastructure that depreciates over time. When sufficient parks are available and citizens enjoy them, there are gains to health, air quality and social cohesion.

This report provides an appraisal valuation of ecosystem services in MPT parks, quantifying the economic value supplied by nature in the parks every year. The results are compelling: By protecting against flooding and land degradation, by buffering climate instability, by maintaining critical habitat and providing recreation, raw materials, waste treatment, pollination and other benefits, **MPT park ecosystems provide between $3.6 million and $13.0 million in economic value every year.** A partial valuation of the social capital, education and health benefits shows between **$34.9 million and $47.2 million** in value provided by MPT parks each year.

Ecosystem services may also be treated like an economic asset, providing a stream of benefits over time the way a bridge or other capital infrastructure does. Valued as such, a discount rate may be applied to these services, allowing for calculation of the present value of these systems. **If treated as an asset with a lifespan of 100 years, the present value of MPT parks is between $521.4 million and $763.0 million, using a 4.125% discount rate.**

Though a snapshot in time, these appraisal values are defensible and applicable to decision-making at every jurisdictional level. Ecosystem service valuations can aid effective and efficient natural resource management. This study also introduces a Whole Economy model to explicitly link the regional economy to the park system. It can also be used to help guide advancements towards a sustainable green economy by shifting investments toward the enhancement and ideal balance of five capitals: natural, built, human, social and financial.

Quantification of tradeoffs among ecosystem services and their interactions with human well-being are now among the most pressing areas in urban contexts. Decision-makers– government, organizational, business and others – can use the concepts and values presented in this study to begin incorporating ecosystem services into agency goals, metrics, indicators, assessments and general operations. For example, ecosystem service values should be considered when developing budgets and program planning; in preparing grant applications to secure federal and outside funding; in examining policies and accounting practices; in reporting and aligning to Puget Sound health indicators, and in development review and permitting processes in urban areas.

Next Steps

While this report provides a valuation of ecosystem services in MPT parks and a whole view of the economy, it is only a first step in the process of developing better policies, measures, indicators and funding mechanisms. In turn, these will support discussions about the tradeoffs and the needed investments of public and private money at the right scale to improve the regional economy for the generations to come.

Next steps recommended in this study include:

1. Jobs-creation analysis of the results from restoration activities and expenditures in parks. The Phase I report for MPT parks showed that more than $22 million was spent annually by visitors to 18 of MPT's parks. This spending supports local store owners, vendors and other businesses that rely on these park visitors for sales of their goods and services. Using expenditure models, this economic activity can be shown to support thousands of jobs in Tacoma's economy.
2. Ecosystem service mapping of service beneficiaries and provisioners. Using hydrological models and GIS data, sophisticated maps can

show geospatially where specific ecosystem services, such as flood risk reduction or salmon habitat, are provisioned on the landscape and who is benefiting from those services. Mapping can also show impairments to ecosystem services, such as features on the landscape that impact salmon habitat. This mapping analysis could show spatially the communities that benefit from higher land values, flood protection, salmon productivity, recreational opportunity, better air quality and other benefits provided by the MTP system.

3. Funding mechanism review. After modeling the flow of ecosystem service benefits and impairments across the landscape, funding mechanisms can be designed for green infrastructure investments including parks. These investments typically reduce tax spending on solutions designed to address a single problem, such as flood risk reduction, and instead invest in a suite of ecosystem services for maximum economic returns. By understanding the value that parks provide in addition to recreation, new funding mechanisms for parks can be developed.

Residents and decision-makers in the Park District have an excellent opportunity to begin developing policies, measures and indicators that can provide the data and information needed to support discussions about the potential investments of public and private money – investments that ultimately effect economic and human well-being. Seizing the opportunity and rising to the challenge will ensure a sustainable and desirable future for all Tacoma park users.

Photo Credits

COVER
© Maya Kocian

PAGE 8
© Metro Parks Tacoma

PAGE 13
© Metro Parks Tacoma

PAGE 15
© Derek R. Audette

PAGE 19
© Lars Johansson

PAGE 22
© Maya Kocian

PAGE 23
© Metro Parks Tacoma

PAGE 24
© Phase4Photography

PAGE 25
© Roman Krochuk

PAGE 28
© PhotoXpress

PAGE 29
© J. Helgason

PAGE 30
© Metro Parks Tacoma

PAGE 31
© Maya Kocian

PAGE 32
© Kallerna - Wikicommons

PAGE 33
© Eugene Zelenko - Wikicommons

PAGE 34
© abet

PAGE 35
unknown

PAGE 36
© Vladimir Melnik

PAGE 37
© Lydur Skulason - Wikicommons

PAGE 38
© Emiliano Hernandez

PAGE 40
© Metro Parks Tacoma

PAGE 42
© Metro Parks Tacoma

PAGE 43
© Metro Parks Tacoma

PAGE 44
© Taavi Toomasson

PAGE 45
© Metro Parks Tacoma

PAGE 46
© Metro Parks Tacoma

PAGE 47
© Metro Parks Tacoma

PAGE 48
© iStockphoto

PAGE 48
© Eugene Zelenko - Wikicommons

PAGE 62
© Emiliano Hernandez

PAGE 75
© siarmstrong

Appendix A: Report References

1 Relyea, K., 2011. New Discover Pass needed to get to state parks, DNR lands starting July 1, The Bellingham Herald, Washington.

2 United Nations Population Fund, 2007. State of World Population 2007: Unleashing the Potential of Urban Growth, in: New York, N. (Ed.).

3 Matsuyama, K., Shigeru, S., 2011. Heatstroke Deaths Quadruple as Japan Shuns Air Conditioners to Save Power, in: Wei, T. (Ed.). Bloomber.

4 Stedinger, J., Griffis, V. , 2008. Floof Frequency Analysis in the United States: Time to Update. Journal of Hydrologic Engineering, 199-203.

5 Stearns, R., 2011. State Parks Announces Closures: Closure Plan Preserves Majority of System's Attendance and Revenue, in: Stearns, R. (Ed.), News Release. California Department of Parks and Recreation.

6 Gies, E., 2006. The Health Benefits of Parks.

7 Hebert, J., Turner, R., Hakam, H., 2010. Executive Summary Economic Impact Analysis Herbert Research Inc.

8 Port of Tacoma, 2011. Trade Highlights.

9 Metro Parks Tacoma, Tacoma Nature Center. Available at: http://www.metroparkstacoma.org/page.php?id=20

10 City of Tacoma, 2010. 2000 Census Data,. Available at: http://www.cityoftacoma.org/Page.aspx?nid=541

11 Metro Parks Tacoma, Wapato Annual Garden. Available at: http://www.metroparkstacoma.org/page.php?id=40

12 Metro Parks Tacoma, Gardens. Available at: http://www.metroparkstacoma.org/page.php?id=27

13 Metro Parks Tacoma, W.W. Seymour Botanical Conservator. Available at: http://www.metroparkstacoma.org/page.php?id=21

14 Metro Parks Tacoma, Bond Projects. Available at: http://www.metroparkstacoma.org/page.php?id=599#A-Z

15 Environmental Protection Agency, 2010. U.S. Environmental Protection Agency. Commencement Bay-Nearshore Tideflats.

16 Metro Parks Tacoma, Bond Proejct at a Glance. Available at: http://www.metroparkstacoma.org/page.php?id=895

17 Daily, G.C., 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, D.C.

18 Costanza, R., dArge, deGroot, Farber, Grasso, Hanon, Limburg, Naeem, Oneill, Paruelo, Raskin, Sutton, vandenBelt, 1997. The Value of the World's Ecosystem Services and Natural Capital. Nature 387, 253-260.

19 Batker, D.K., de la Torre, I., Costanza, R., Swedeen, P., Day, J., Boumans, R., Bagstad, K., 2010. Gaining Ground. Wetlands, Hurricanes and the Economy: The Value of Restoring the Mississippi River Delta., in: Economics, E. (Ed.), Tacoma, WA.

20 CH2MHILL, 2002. Draft Cedar Treatment Facilities: Cost Estimate for Filtration Addition, Prepared for Seattle Public Utiities.

21 De Groot, R., Wilson, M.A., Boumans, R.M.J., 2002. Ecosystem functions, goods and services: Classification, description and valuation guidelines. Ecological Economics 41, 393-408.

22 United Nations Environmnetal Program, 2005. The Millennium Ecosystem Assessment, in: Hassan, R., Scholes, R., and Ash, N. (Ed.), Ecosystem and Human Well-being: Current Status and Trends. Island Press, Washington D.C., Covelo, CA, and London.

23 Konrad, C.P., 2003. Effects of urban development on floods. U.S. Geological Survey Fact Sheet FS-076-03.

24J ensen, C., 2008. Schools Partner in Natural Habitat Expansion, Tacoma Weekly, Tacoma.

25 Syvitski, J.P.M.e.a., 2005. Impact of Humans on the Flux of Terrestrial Sediment to the Global Coastal Ocean. Science 308, 376-380.

26 Stamets, P., 2005. Mycelium Running: How Mushrooms Can Help Save the World. Ten Speed Press.

27 Polis, G.A., Anderson, W.B., Holt, R.D., 1997. Toward an integration of landscape and food web ecology: the dynamics of spatially subsidized food webs. Annual Review of Ecology and Systematics 28, 289-316.

28 Casola, J., Kay, J., Snover, A.K., Norheim, R.A., Whitely Binder, L.C., Climate Impacts Group, 2005. Climate Impacts on Washington's Hydropower, Water Supply, Forests, Fish, and Agriculture, in: Washington, U.o. (Ed.), Center for Science in the Earth System Joint Institute for the Study of the Atmosphere and Ocean, Seattle, WA.

29 Moore, R.D., Wondzell, S.M., 2005. Physical hydrology and the effects of forest harvesting in the Pacific Northwest: A review. Journal of the American Water Resources Association 41, 763-784.

30 Marx, J., Bary, A., Jackson, S., McDonald, D., Wescott, H., 1999. The Relationship Between Soil and Water How Soil Amendments and Compost Can Aid in Salmon Recovery, Washington Organic Recycling Council, Washington.

31 United States Department of Agriculture, 1983. Soil Survey of Snohomish County Area, Soil Conservation Service (now the Natural Resources Conservation Service).

32 Weslawski, J.M., P.V.R. Snelgrove, L.A. Levin, M.C. Austen, R.T. Kneib, T.M. Iliffe, J.R. Garey, S.J. Hawkins, Whitlatch, R.B., 2004. Marine sedimentary biota as providers of ecosystem goods and services, in: Hall, D.H. (Ed.), Sustaining Biodiversity and Ecosystem Services in Soils and Sediments. Island Press, Washington D.C., Covelo, CA, London.

33 Embrey, S., Inkpen., 1998. Nutrient Transport in Rivers in Puget Sound Basin, Washington 1980-1993, U.S. Geological Survey Water Resources Investigation Report.

34 Garber, J., Collins, Davis, 1992. Impacts of Estuarine Benthic Algal Production on Dissolved Nutrients and Water Quality in Yaquina River Estuary, Oregon. Water Resources Research Institute- Oregon State University, Corvalis, OR.

35 Kurz, W.A., Dymond, C.C., Stinson, G., Rampley, G. J., Neilson, E.T., Carroll, A.L., Ebata, T., and Safranyik, L., 2008. Mountain Pine Beetle and Forest Carbon Feedback to Climate Change. Nature 452, 987-990.

36 Risch, S.J., Andow, D., Altieri, M.A., 1983. Agroecosystem Diversity and Pest Control: Data, Tentative Conclusions, and New Research Directions Environmental Entomology 12, 625-629.

37 Lichtfouse E., M., N., Debaeke, P., 2009. Sustainable Agriculture. Springer, EDP Sciences.

38 Lichtfouse, E., Navarrete, M., Debaeke, P., 2009. Sustainable Agriculture. Springer, EDP Sciences.

39 Worm, B., E.B. Barbier, et al, 2006. Impacts of biodiversity loss on ocean ecosystem services. Science 314, 787-779.

40 Vitousek, P.M., Ehrlich, P.R., Ehrlich, A.H., Matson, P.A., 1986. Human Appropriation of the Products of Photosynthesis. BioScience 34, 368-373.

41 Pauly, D., Christensen, V., 1995. Primary production required to sustain global fisheries. Nature 374, 1245-1271.

42 Pimm, S.L., 2001. A Scientist Audits the Earth, Rutgers University Press, New Brunswick, New Jersey.

43 Orr, J.C., V. Fabry, O. Aumont, et al, 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437, 681-686.

44 Metro Parks Tacoma, Charlotte's Blueberry Park. Available at: http://www.metroparkstacoma.org/page.php?id=649

45 Pierce County Public Works and Utilities Water Programs Division, 2008. Swan Creek Pedestrian Bridge Replacement, Fish and Wildlife Habitat Assessment Report, Washington.

46 Palmquist, R.B., 2002. Hedonic models, in: Bergh, J.C.J.M.v.d. (Ed.), Handbook of Environmental and Resource Economics. Edward Elgar Publishing, Cheltenham, UK.

47 Power, T.M., 1996. Lost Landscapes and Failed Economies. Island Press, Washington, D.C., Covelo, CA, and London.

48 City of Tacoma, 2007. Open Space Habitat and Recreation Plan. Available at: http://cms.cityoftacoma.org/planning/OSHP/OpenSpace_FactSht.pdf

49 Green Tacoma Partnership, 2010. Restoration Action Plan.

50 Earth Economics, 2010. Flood Control District Levy Increase, in: Batker, D. (Ed.), WRIA 9 Policy Briefs: Funding Mechanisms for Salmon Habitat and Watershed Health.

51 The Trust for Public Land, 2011. The Economic Benefit of Seattle's Park and Recreation System.

52 Wilkins, D., 2006. Childhood Obesity: Costs, Treatment Patterns, Disparities in Care, and Prevalent Medical Conditions. Available at: http://www.medstat.com/pdfs/childhood_obesity.pdf

53 U.S. Deptartment of Health and Human Services, 2008. Health, United States , 2008, Centers for Disease Control and Prevention and National Center for Health Statistics.

54 Washington State Health Department, 2007. Physical Activity.

55 Jordan, H., 2011. Scottish Urban Nature Sites' Value Calculated.

56 Metro Parks Tacoma, Youth Baseball/Fastpitch. Available at: http://www.metroparkstacoma.org/page.php?id=295

57 Metro Parks Tacoma, Runs/Walks. Available at: http://www.metroparkstacoma.org/page.php?id=1199

58 Ulrich, R.S., 1983. Aesthetic and Affective Responses to Natural Environment, in: Altman, I., Wohlwill, J (Ed.), Behaviour and the Natural Environment. Plenum Press, New York, NY.

59 Ulrich, R.S., 1983. View through a window may influence recovery from surgery. Science 224, 420-421.

60 Grahn, P., Stigsdotter, U.A. , 2003. . Landscape planning and stress. Urban Forestry and Urban Greening 2, 1-18.

61 Wolf, K.L., 2004. Public Value of Nature: Economics of Urban Tree, Parks and Open Space, in: Miller, D.a.W.J.A. (Ed.), Design with Spirit: Proceedings of the 35th Annual Conference of the Environmental Design Research Association. Environmental Design Research Association, Edmond, OK.

62 De Sousa, C.A., 2006. Unearthing the benefits of brownfield to greenspace projects: an examination of project use and quality of life impacts. Local Environment 11.

63 Davis, A., 2011. Deadlist Air Pollution in U.S. 10 Worst Cities, Huffington Post.

64 Nowak D., C., D., Stevens, J. , 2006. Air Pollution Removal By Urban Trees and Shrubs in the United States. Urban Forestry and Urban Greening 4, 115–123.

65 Wolf, K.L., Blahn, D., Brinkley, M. R., 2011. Environmental Stewardship Footprint Research: Linking Human Agency and Ecosystem Health in the Puget Sound Region, Urban Ecosystem.

66 Isenberg, J.P., Quisenberry, N., 2002. Play: Essential for All Children, Association for Childhood Eduation Internationally.

67 Turner, M., 2004. Urban Oarjs as Parnters in Youth Development, Beyond Recreation. The Urban Institute, Washington, D.C.

68 Wolf, K.L., 2007. Tree and Youth in the City: Research on Urban Forest Stewardship & Positive Youth Development, Sustaining America's Forests: Proceedings of the Society of Amercan Foresters National Conventionl. Society of American Foresters, Bethesda MD.

69 Northwest Trek Wildlife Park, 2011. For Teacher and Schools.

70 Metro Parks Tacoma, Nature Preschool Available at: http://www.metroparkstacoma.org/page.php?id=1041

71 Leschine, T.M., Wellman, K.F., Green, T.H., 1997. The economic value of wetlands: Wetlands' role in flood protection in Western Washington, Prepared for the Washington State Department of Ecology, Olympia, Washington.

72 Brownson, R.C., Baker, E. A., Housemann, R.A., Brennan, L.K., Bacak, S.J., 2001. Environmental and Policy Determinants of Physical Activity in the United States. American Journal of Public Health 91.

73 Kaiser Family Foundation, State Health Facts. Available at: http://www.statehealthfacts.org/index.jsp

74 Marder, W., Chang, S., 2006. Childhood Obesity: Costs, Treatment Patterns, Disparities in Care, and Prevalent Medical Conditions. Available at: http://www.medstat.com/pdfs/childhood_obesity.pdf

75 Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's ecoservices, David Suzuki Foundation, Vancouver B.C.

76 U.S. Census Bureau, 2007. Public Education Finances, in: Bureau, U.S.C. (Ed.).

77 Independent Sector, Value of Volunteer Time. Available at: http://independentsector.org/volunteer_time

78 Washington State Department of Ecology, Non-native Invasive Freshwater Plants: Reed Canarygrass. Available at: http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua011.html

79 Historylink, 2010. Tacoma Public Utilities.

80 Tacoma Water, 2008. Protect/Serve Your Water 2008.

81 Armstrong, C., 2011. $30 Annual Fee to Bring Cars into State Parks is Likely to be a Reality., Islands Sounder, Washington.

82 Norgaard, R., Costanza, R., Cumberland, J., Daly, H., Goodland, R., 2007. An Introduction to Ecological Economics, in: Cleveland, C.J. (Ed.), Encyclopedia of Earth, Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment.

83 Daly, H.E., Farley, J., 2004. Ecological Economics: Principles and Applications. Island Press, Washington D.C.

84 Ficken, R.E., LeWarne, C.P., 1988. Washington: A Centennial History, Washington Centennial Commission

85 Alig, R., Plantiga, A., 2004. Future forestland area: impacts from population growth and other factors that affect land values. Journal of Forestry.

86 Haberl, H., Erb, K.H., Krausmann, F., Gaube, V., Bondeau, A., Plutzar, C., Gingrich, S., Lucht, W., Fischer-Kowalski, M., 2007. Quantifying and mapping the human appropriation of net primary production in earth's terrestrial ecosystems. Proceedings of the National Academy of Sciences of the United States of America 104, 12942-12947.

87 World Wildlife Fund, 2008. Living Planet Report 2008. World Wildlife Fund, Zoological Society of London, and Global Footprint Network.

88 Farley, J., 2009. Conservation Through the Economics Lens. Environmental Management 22, 1399-1408.

89 United Nations, 2000. The Millennium Ecosystem Assessment, in: Hassan, R., Scholes, R., and Ash, N. (Ed.), Ecosystems and Human Well-being: Current Status and Trends, Island Press. Washington D.C., Covelo, CA, and London.

90 Costanza, R., Waigner, L., Folke, C., Maler, K., 1993. Modeling Complex Systems. BioScience 43, 545-555.

91 Gunderson, L.H., Holling, C.S., 2002. Resilience and Adaptive Cycles, Gunderson, L.H., Holling, C.S. (Eds.), 2002. Panarchy: understanding transformations in human and natural systems.

Appendix B: Additional Ecological and Economic Concepts

What's an Economy for, Anyway?

In the late 18th century, Adam Smith, David Ricardo and others articulated many of the basic market concepts that guide economic policy today. When Smith and Ricardo lived, world population was less than one billion, the Industrial Revolution was just beginning, the science of ecology did not exist, and natural goods and services were plentiful relative to manufactured and built capital[82]. Thus, the economy focused on improving quality of life through built capital, allocating plentiful natural resources to build and distribute these man-made goods.

The Three Economic Questions

Economics is the study of the allocation of limited, or scarce, resources, among alternative, competing ends. This definition can be stated as three questions,[83] in a prioritized order:

1. What ends do we desire?
2. What scarce resources do we need to attain these ends?
3. What ends receive priority, and to what extent do we allocate resources to them?

Traditionally, economists have answered "utility" or "human welfare" to the first question. Human welfare was thought to depend on what people wanted, revealed through market transactions, i.e. goods and services they bought and sold. Early economics assumed that markets revealed what people most desired, and that the scarcest resources were those that were built. So early economics paid the most attention to just one mechanism for allocating alternative resources to alternative ends: the market. Early economics focused secondarily on how the final goods and services were divided up (i.e., distribution), and not at all on the problem of an economy's size relative to the ecosystems in which it existed (i.e., scale).

Economic activity is tracked using measures such as the Gross Domestic Product (GDP). GDP adds together both final goods and services (salmon, theater visits, etc.) and "bads" (oil spill cleanup costs, policing costs, etc.) to arrive at an indication of the economy's total throughput.[h] Today, GDP is used to measure total output, assuming that the market supplies most of our desired ends (or more specifically, preferences that people reveal for market goods and services). GDP is often inappropriately used as a human welfare measure, a purpose for which it was never intended.[i]

Because built capital was the primary goal of economic production, measures like the GDP focus on goods and services sold in markets. Natural, social (such as culture), and human capital (such as education), on the other hand, have infrequently been included in economic analysis.[j] The figure below provides a sketch of the "Partial Economy" model, which includes the traditional "factors of production" and the GDP measure.

---

[h] Throughput is rate at which material and energy resources are used by an economy.

[i] The architects of the GDP, John Maynard Keynes and Simon Kuznets, cautioned against using the GDP as a measure of the welfare of a nation. In 1962, Kuznets lamented that, "…the welfare of a nation can scarcely be inferred from a measurement of national income as defined by the GDP… goals for 'more' growth should specify of what and for what." (Anielski, 1999)

[j] An important caveat is that many of the environmental and social issues humans face today are due to insufficient attention to standard economics in everyday decision-making. Subsidized prices for natural resources, neglect of external costs and benefits, and political unwillingness to respect the basic notions of scarcity and opportunity cost are among the uneconomic policies that are often promoted in today's economy (Daly and Farley, 2004).

Figure 7 – The Parial Economy Model

A Shift in Scarcity

Over the past 50 years, humans have altered ecosystems more rapidly and extensively than in any comparable period in human history.[22] There is ample evidence that scarcity has shifted from built capital to natural capital. This is true for many resources within the Puget Sound. Our ability to lay asphalt outweighs our ability to provide flood risk reduction.

Similarly, once-extravagant timber harvests are now limited by land availability and tree growth, rather than available logging equipment. Consider that in 1900, the well-known timber magnate Frederick Weyerhaeuser purchased 900,000 acres of prime Washington forestland for just $137 million (in 2009 dollars), or approximately $150 per acre.[84; k] Compare this value with a more recent assessment of forestland among 38 counties in western Washington and Oregon, which found average values of $1,483 per acre.[85; l]

On a global scale, many expert studies now show that humans are depleting Earth's flow of natural goods and services faster than the flow can be regenerated, and in many areas humans are depleting the natural capital that produces this flow. For example, it has been estimated that humans now directly or indirectly appropriate up to 40% of the Earth's Annual Net Primary Productivity,[40; 86] dramatically reducing the amount available for other species, including those that support humans (such as fisheries). Net Primary Productivity is the total biomass that is produced by ecosystems through photosynthesis; it is the foundation for life on Earth.

Other measures present a similar picture. The World Wildlife Fund recently calculated the "Ecological Footprint" of humanity, or the land and sea area that would be needed to sustainably regenerate the resources that humans consume and the waste they produce annually. It was found that the current rate of human resource consumption and waste disposal requires 1.3 planet Earths – and this "footprint" is growing.[87]

An important reason for this shift in scarcity is that in the past century alone, the per-capita economic production of market goods and services, has increased nine-fold.[88] The next two figures illustrate the human economy's move from the "Empty World" situation of the past to the "Full World" situation that humans live in today.

[k] Weyerhaeuser's purchase cost him $5.4 million in 1900; this value was converted to 2009 dollars using http://www.westegg.com/inflation/ (retrieved November 2010).

[l] Original value in this 2004 study was $1,483. This value has also been converted to 2009 dollars using http://www.westegg.com/inflation/ (retrieved November 2010).

Figure 8 – Previous Empty World Situation

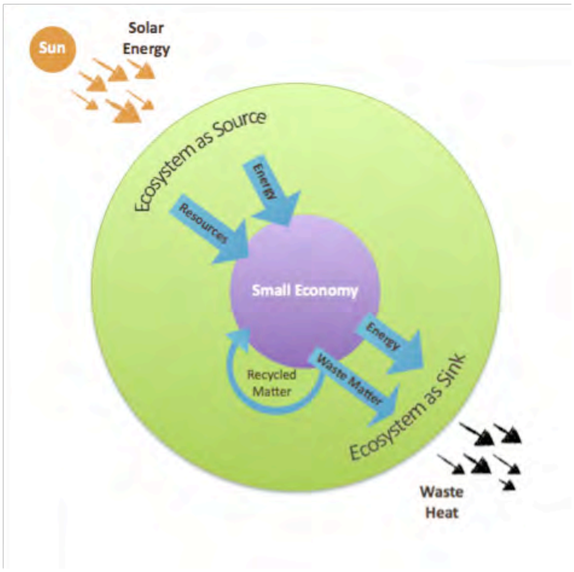
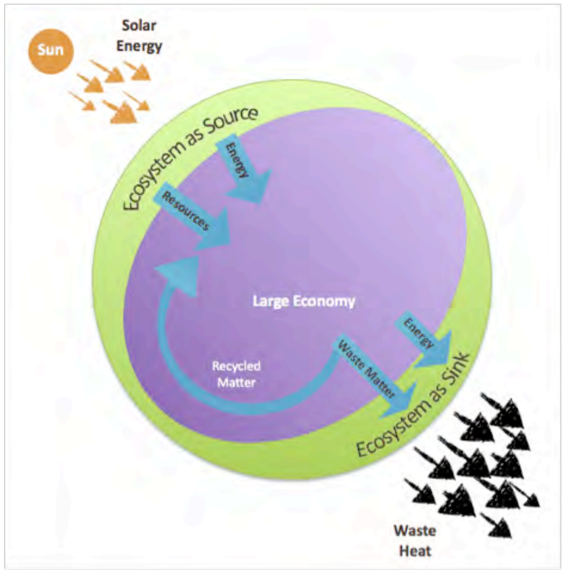


Figure 9 – Today's Full World Situation



Why has the "Shift in Scarcity" been Overlooked?

The success of the industrial revolution has greatly reduced the scarcity of market goods for much of the world's population. The shift in scarcity, from built capital to natural capital, holds major implications for the way the economy is structured and understood. Yet it implies rebalancing natural and built capital. Why has this change been overlooked? Here are two reasons.

- **Exponential Growth of Human Population.** With a constant rate of population growth, the Earth would be expected to grow from 50% full to 100% full in one doubling period – the same period it required to grow from 1% full to 2% full. With improvements in technology and general living standards, the human population has, in reality, grown exponentially and doubling periods have shortened. For example, it took about 123 years (1804 – 1927) for the Earth's population to grow from one billion to two billion, and just 47 years (1927 – 1975) to grow from two billion to four billion.[89] Not only have human populations grown exponentially, but so has each individual's absolute use of resources. The shift from an "empty world" to a "full world" has occurred more quickly than economic models have been able to acknowledge.
- **Complementary versus Substitutability.** If two goods or services are thought of as substitutes in an economic model, then a shortage of one does not limit the productivity of another. Rather than substitutes, water and pipes are complements for delivering water to the tap. By default, the Partial Economy model has tended to view natural capital as expendable, with the assumption that built capital can be a perfect substitute. This would also avoid the problem of scarcity. The false assumption that built capital and natural capital are perfect substitutes can be largely attributed to the failure of the Partial Economy model to include natural capital explicitly as an essential factor of production (likely because the model was devised while the Earth was still "empty").

If natural capital is thought of as a complement to built capital (and human, social and financial capital) in the creation of goods and services, as it always must be to varying degrees, then its scarcity constrains the other capitals by definition. Some natural goods and services, such as oxygen production and carbon sequestration, can be thought of as complements to all types of built capital, because there is no practical built substitute (i.e. all built capital production would cease in the absence of oxygen). Natural capital is essential to built capital; indeed, all built capital is derived from natural capital.

The Whole Economy Model

Ecological economics grounds economic thinking in the physical reality of today's "full world," a necessary advancement of economic thought. Ecological economics is built upon supply and demand, and on the market economics of efficient allocation. It adds the constraints of shrinking oil supplies and other physical constraints, and the problem of scale (i.e. sustainability). Understanding the relationship between ecosystems, the economy, and human well-being is critical to economic progress in the 21st century.[83]

The "Whole Economy" model, illustrated in Figure 5, demonstrates that production of goods and services is tied to five forms of capital (natural, built, human, social, and financial) and that ecosystem goods and services contribute to human well-being, both directly and by providing natural capital for the production process. The negative feedback loops from pollution and degradation are also included. In addition, there are four guiding principles for a healthy economy: good governance, sustainability, efficiency, and justice, which are displayed in blue.

Figure 10 – The Whole Economy Model

Desired Ends, Scarce Resources and Guiding Principles

Earlier in this section, three core questions of economics were posed. Answering the first guides the rest. What ends do we desire?

Desired Ends: Human Well-Being

Human well-being is not a rigidly defined state but a combination of physical and abstract human ends and needs that differ among individuals and places. Many of these ends can be met on the market, but many cannot. For example, some basic shared needs may include a dependable supply of food and clean drinking water, and physical and financial security, family, health and social bonds such as friendship. Meeting the suite of human needs, now and into the future, largely depends on understanding the extent of society's scarce resources and how they are allocated to different ends.

Scarce Resources: The Five Capitals
Five Capitals represent the scarce resources that ultimately go towards human needs and human well-being, essential to economic progress. They are: natural, built, human, social and financial capital. Natural capital underlies all others, which in turn create the conditions for a healthy and sustainable economy:

- **Natural Capital.** The stock of minerals, energy, plants, animals and ecosystems found on earth that yields a flow of natural goods and services. When taken as one whole system, natural capital provides the total biophysical context for the human economy.
- **Human Capital.** The self-esteem and knowledge acquired through education, technical and interpersonal skills, such as communication, listening, cooperation, and individual motivation to be productive and socially responsible.
- Social Capital. The inventory of organizations, institutions, laws, informal social networks, and relationships of trust that make up or provide for the productive organization of the economy.
- **Built Capital.** The infrastructure of technologies, machines, tools and transport that humans design, build and use for productive purposes. Coupled with learned skills and capabilities, the economy's built techno-infrastructure is what directly allows raw materials (i.e. natural capital) to be converted into a flow of economic goods and services, the products that are typically found in markets.
- **Financial Capital.** The shares, bonds, banknotes, and other paper and electronic financial assets that play an important role in the economy, enabling the other combinations of capital (e.g. healthcare, education) to be owned, traded and allocated. Financial capital is based on trust and represents a promise that it will eventually be honored with one of the other types of "real" capital.

Attaining Desired Ends: The Four Guiding Principles
The third question of economics is the least straightforward, namely: What ends get priority, and to what extent do we allocate resources to them? While the question cannot be answered directly, Four Guiding Principles help to address the long-term attainment of human well-being.

- **Sustainability**. Living within a physical scale that does not destroy the basic ecosystems that maintain the economy. Ecosystems are part of the economy's "commonwealth," which can be managed sustainably to produce economic benefit to current and future generations, or mismanaged at great cost.
- **Justice**. Fair distribution of public and private gains from natural, built, human, social, and financial goods and services to ensure maximum benefit for the lowest public investment. Intergenerational distribution is equally important; our children, grandchildren and future generations should be given fair access to the Earth's stock of mineral and ecological resources.
- **Efficiency**. Careful decision-making regarding how and where resources are moved or invested to produce different suites of goods and services. People must consider the most efficient balance of built, natural, human, social and financial capital for the types of goods and services they wish to enjoy, and whether or not a particular balance is detrimental to the goal of long-term sustainability.
- **Good Governance.** This principle consists of two elements:
  a. Creation and maintenance of both private and public institutions and groups, policy instruments, systems, and markets that ensure sustainability, justice and efficiency are achieved.
  b. Employing measurements that give an accurate indication of the Whole Economy's health, measuring what our scarce resources are and whether desired ends are being met.

Addressing Inherent Complexity

The economy is a complex system. Complex systems are characterized by strong (usually non-linear) interactions between the parts, and complicated feedback loops that make it difficult to distinguish cause from effect, with significant time and space lags, discontinuities, thresholds, and limits.[90; 91]
"Resilience" implies the potential of a system to continue functioning effectively after a disturbance. A system is assumed to be fragile when resilience is low. Fragile systems tend to be replaced when disturbed; for example, wetlands that are converted to open water produce reduced amounts of ecosystem services and provide less economic value. Without resilience, an entire economic system can also collapse and revert to a less productive one. Economic goals are more surely reached when building in resilience, rather than building a more brittle system, as the recent financial crisis demonstrated.

Appendix C: Value Transfer Studies Used – Full References

Adger, W.N, K. Brown, R. Cervigni, and D. Moran. 1995. Towards Estimating Total economics value of forests in Mexico. Ambio 24(5): 286-296.

Allen, J., M. Cunningham, A. Greenwood, and L. Rosenthal. 1992. The value of California wetlands: an analysis of their economic benefits. Campaign to Save California Wetlands, Oakland, California.

Amigues, J. P., C. Boulatoff, B. Desaigues, C. Gauthier, and J. E. Keith. 2002. The benefits and costs of riparian analysis habitat preservation: a willingness to accept/willingness to pay contingent valuation approach. Ecological Economics 43: 17-31.

Barrow, C.J. 1991. Land degradation. Cambridge University Press, Cambridge.

Bennett, R., R. Tranter, N. Beard, and P. Jones. 1995. The value of footpath provision in the countryside: a case-study of public access to urbanfringe woodland." Journal of Environmental Planning and Management 38: 409-417.

Bergstrom, J., B.L. Dillman, and J. R. Stoll. 1985. Public environmental amenity benefits of private land: the case of prime agricultural land. South Journal of Agricultural Economics 7: 139-149.

Berrens, R. P., P. Ganderton, and C. L. Silva. 1996. Valuing the protection of minimum instream flows in New Mexico. Journal of Agricultural and Resource Economics 21: 294-308.

Birdsey, R.A. 1996. Regional Estimates of Timber Volume and Forest Carbon for Fully Stocked

Timberland, Average Management After Final Clearcut Harvest. In Forests and Global Change: Volume 2, Forest Management Opportunities for Mitigating Carbon Emissions, eds. R.N. Sampson and D. Hair, American Forests, Washington, DC.

Bishop, Kevin. 1992. Assessing the benefits of community forests: An evaluation of the recreational use benefits of two urban fringe woodlands. Journal of Environmental Planning and Management 35: 63-76.

Bocksteal, N.E., K.E. McConnell, and I.E. Strand. 1989. Measuring the benefits of improvements in water quality: the Chesapeake Bay. Marine Resource Economics 6: 1-18.

Bouwes, N. W. and R. Scheider. 1979. Procedures in estimating benefits of water quality change. American Journal of Agricultural Economics 61(3): 635-639.

Bowker, J.M., D.B. English, and J.A. Donovan. 1996. Toward a value for guided rafting on southern rivers. Journal of Agricultural and Resource Economics 28: 423-432.

Boxall, P. C., B. L. McFarlane, and M. Gartrell. 1996. An aggregate travel cost approach to valuing forest recreation at managed sites. Forestry Chronicle 72: 615-621.

Burt, O.R. and D. Brewer. 1971. Estimation of net social benefits from outdoor recreation. Econometrica 39: 813-827.

Canadian Urban Institute. 2006. Nature Counts: Valuing Southern Ontario's Natural Heritage. Toronto, Canada http://www.canurb.com/media/pdf/Nature_Counts_rschpaper_FINAL.

Copeland, J.H., R.A. Pielke, and T.G.F. Kittel. 1996. Potential climatic impacts of vegetation change: a regional modeling study. Journal of Geophysical Research (submitted).

Cordell, H. K. and J. C. Bergstrom. 1993. Comparison of recreation use values among alternative reservoir water level management scenarios. Water Resources Research 29: 247-258.

Costanza, R., R. dArge, R. deGroot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. Oneill, J. Paruelo, R. G. Raskin, P. Sutton, and M. vandenBelt. 1997. The value of the world's ecosystem services and natural capital. Nature 387: 253-260.

Costanza, R., Wilson M, Troy A, Voinov A, Liu S, J. D'Agostino. 2006.The Value of New Jersey's Ecosystem Services and Natural Capital.

Creel, M. and J. Loomis. 1992. Recreation value of water to wetlands in the San-Joaquin Valley – linked multinomial logit and count data trip frequency models. Water Resources Research 28: 2597-2606.

Croke, K., R. Fabian, and G. Brenniman. 1986. Estimating the value of improved water-quality in an urban river system. Journal of Environmental Systems 16: 13-24.

Danielson, L., T. J. Hoban, G. Vanhoutven, and J. C. Whitehead. 1995. Measuring the benefits of local public-goods - environmental-quality in Gaston County, North-Carolina. Applied Economics 27: 1253-1260.

De Groot, R.S. 1992. Functions of nature: evaluation of nature in environmental planning, management, and decision making. Amsterdam: Wolters-Noordhoff.

Dodds, W.K., K.C. Wilson, R.L. Rehmeier, G.L. Knight, S. Wiggam, J.A. Falke, H.J. Dalgleish, and K.N.

Bertrand. 2008. Comparing ecosystem goods and services provided by restored and native lands. BioScience 58 (9): 837-845.

Dodds, W.K., K.C. Wilson, R.L. Rehmeier, G.L. Knight, S. Wiggam, J.A. Falke, H.J. Dalgleish, and K.N.

Bertrand. 2008. Comparing ecosystem goods and services provided by restored and native lands. BioScience 58 (9): 837-845.

Doss, C. R. and S. J. Taff. 1996. The influence of wetland type and wetland proximity on residential property values. Journal of Agricultural and Resource Economics 21: 120-129.

Duffield, J. W., C. J. Neher, and T. C. Brown. 1992. Recreation benefits of instream flow - application to Montana Big Hole and Bitterroot Rivers. Water Resources Research 28: 2169-2181.

Fankhauser, S., and D.W. Pearce. 1994. The social costs of greenhouse-gas emissions - an expected value approach. Energy Journal 15:157-184.

Farber, S. and R. Costanza. 1987. The economic value of wetlands systems. Journal of Environmental

Management 24: 41-51. Garber, J.H., J.L. Collins, and M.W. Davis. 1992. Impacts of estuarine benthic algal production on dissolved nutrients and water quality in Yaquina River Estuary, Oregon. Water Resources Research Institute, Report WRRI-112, Oregon State University, Corvallis.

Gibbons, D.C. 1986. The economic value of water. Resources for the Future, Washington D.C.

Gramlich, F.W. 1977. The demand for clean water: the case of the Charles River. National Tax Journal 77(30): 183-194.

Greenley, D., R. G. Walsh, and R.A. Young. 1981. Option value: empirical evidence from a case study of recreation and water quality. The Quarterly Journal of Economics 96(4): 657-673.

Haener, M.K., and Adamowicz, W.L. 2000. Regional forest resource accounting: A northern Alberta case study. Canadian Journal of Forest Research 30(2): 264-273.

Hayes, K.M., T.J. Tyrrell, and G. Anderson. 1992. Estimating the benefits of water quality improvements in the Upper Narragansett Bay. Marine Resource Economics 7: 75-85.

Henry, R., R. Ley, and P. Welle. 1988. The economic value of water resources: the Lake Bemidji survey. Journal of the Minnesota Academy of Science 53: 37-44.

Hougner, C. 2006. Economic valuation of a seed dispersal service in the Stockholm National Urban Park, Sweden. Ecological Economics 59(3): 364-374.

Howe, C.W., and K.W. Easter. 1971. Interbasin transfer of water: Economic issues and impacts. Baltimore: The Johns Hopkins Press.

Johnston, R. J., T. A. Grigalunas, J. J. Opaluch, M. Mazzotta, and J. Diamantedes. 2002. Valuing estuarine resource services using economic and ecological models: the Peconic Estuary System study. Coastal Management 30: 47-65.

Jones, O.R., H.V. Eck, S.J. Smith, G.A. Coleman, and V.L. Hauser. 1985. Runoff, soil, and nutrient losses from rangeland and dry-farmed cropland in the southern high plains. Journal of Soil and Water Conservation 1: 161-164.

Kahn, J. R. and R. B. Buerger. 1994. Valuation and the consequences of multiple sources of environmental deterioration - the case of the New-York Striped Bass fishery. Journal of Environmental Management 40: 257-273.

Kazmierczak, R.F. 2001. Economic linkages between coastal wetlands and habitat/species protection: a review of value estimates reported in the published literature. LSU Agricultural Economics and Agribusiness Staff Paper. http://www.agecon.lsu.edu/faculty

Kealy, M. J. and R. C. Bishop. 1986. Theoretical and empirical specifications issues in travel cost demand studies. American Journal of Agricultural Economics 68: 660-667.

Kenyon, W. and C. Nevin. 2001. The use of economic and participatory approaches to assess forest development: a case study in the Ettrick Valley. Forest Policy and Economics 3: 69-80.

Kreutzwiser, R. 1981. The economic significance of the long point marsh, Lake Erie, as a recreational resource. Journal of Great Lakes Resources 7:105-110.

Krieger, D.J. 2001. Economic value of forest ecosystem services: A review. The Wilderness Society. Washington, D.C. http://www.wilderness.org/Library/Documents/upload/Economic-Value-of-Forest-Ecosystem-Services-A-Review.pdf

Kulshreshtha, S. N. and J. A. Gillies. 1993. Economic-evaluation of aesthetic amenities - a case-study of river view. Water Resources Bulletin 29: 257-266.

Lampietti, J.A., and J.A. Dixon. 1995. To see the forest for the trees: a guide to non-timber forest benefits. The World Bank, Environmental Economics Series 013, Washington, D.C.

Lant, C. L. and G. Tobin. 1989. The economic value of riparian corridors in cornbelt floodplains: a research framework. Professional Geographer 41 (3): 337-349.

Lant, C. L. and R. S. Roberts. 1990. Greenbelts in the corn-belt - riparian wetlands, intrinsic values, and market failure. Environment and Planning 22: 1375-1388.

Leggett, C. G. and N. E. Bockstael. 2000. Evidence of the effects of water quality on residential land prices. Journal of Environmental Economics and Management 39: 121-144.

Loomis, J. B. (1996), Measuring the Economic Benefits of Removing Dams and Restoring the Elwha River: Results of a Contingent Valuation Survey, Water Resour. Res., 32(2), 441–447

Loomis, J. B. 1988. The bioeconomic effects of timber harvesting on recreational and commercial salmon and steelhead fishing: A case study of the Siuslaw National Forest. Marine Pollution Bulletin 5:43-60.

Loomis, J.B. 2002. Quantifying Recreation Use Values from Removing Dams and Restoring Free-Flowing Rivers: A Contingent Behavior Travel Cost Demand Model for the Lower Snake River. Water Resources Research 38 (6)

Mahan, B. L., S. Polasky, and R. M. Adams. 2000. Valuing urban wetlands: A property price approach. Land Economics 76: 100-113. Mates. W., Reyes, J. 2004. The economic value of New Jersey state parks and forests. New Jersey Department of Environmental Protection.

Mathews, L. G., F. R. Homans, and K. W. Easter. 2002. Estimating the benefits of phosphorus pollution reductions: an application in the Minnesota River. Journal of the American Water Resources Association 38: 1217-1223.

Maxwell, Simon. 1994. Valuation of rural environmental improvements using contingent valuation methodology: a case study of the Martson Vale Community Forest Project. Journal of Environmental Management 41: 385-399.

McPherson, E. G. 1992. Accounting for benefits and costs of urban greenspace. Landscape and Urban Planning 22: 41-51.

McPherson, E. G., K. I. Scott, and J. R. Simpson. 1998. Estimating cost effectiveness of residential yard trees for improving air quality in Sacramento, California, using existing models. Atmospheric Environment 32: 75-84.

Mullen, J. K. and F. C. Menz. 1985. The effect of acidification damages on the economic value of the Adirondack Fishery to New-York anglers. American Journal of Agricultural Economics 67: 112-119.

Olewiler, N. 2004. The value of natural capital in settled areas of Canada. Ducks Unlimited Canada and the Nature Conservancy of Canada. http://www.ducks.ca/aboutduc/news/archives/pdf/ncapital.pdf

Oster, S. 1977. Survey results on the benefits of water pollution abatement in the Merrimace River Basin. Water Resources Research 13: 882-884.

Pate, J., and J. Loomis. 1997. The effect of distance on willingness to pay values: a case study of wetlands and salmon in California. Ecological Economics 20(3): 199-207.

Patrick, R., J. Fletcher, S. Lovejoy, W. Vanbeek, G. Holloway, and J. Binkley. 1991. Estimating regional benefits of reducing targeted pollutants - an application to agricultural effects on water-quality and the value of recreational fishing.

Perrings, C. 1995. Economic values of biodiversity. In Global Biodiversity Assessment, edited by R.T. Watson, V.H. Heywood, I. Baste, B. Dias, R. Gamez, T. Janetos, W. Reid and R. Ruark. United Nations Environmental Programme (UNEP)

Pimentel, D. 1998. Benefits of biological diversity in the state of Maryland. Ithica, NY: Cornell University, College of Agricultural and Life Sciences.

Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, S. Crist, P. Sphpritz, L. Fitton, R. Saffouri, R. Blair. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science 267: 1117-1123.

Pimentel, D., C. Wilson, C. McCullum, R. Huang, P. Owen, J. Flack, Q. Trand, T. Saltman, and B. Cliff. 1997. Environmental and Economic Benefits of Biodiversity.

Piper, S. 1997. Rigonal impacts and benefits of water-based activities: an application in the Black Hills region of South Dakota and Wyoming. Impact Assessment 15: 335-359.

Postel, S., and S. Carpenter. 1997. Freshwater ecosystem services. In Ecosystem services: their nature and value, edited by G. Daily. Washington, D.C.: Island Press.

Prince, R. and E. Ahmed. 1989. Estimating individual recreation benefits under congestion and uncertainty." Journal of Leisure Research 21: 61-76.

Rein, F. A. 1999. An economic analysis of vegetative buffer strip implementation - Case study: Elkhorn

Slough, Monterey Bay, California. Coastal Management 27: 377-390.

Ribaudo, M. and D.J. Epp. 1984. The importance of sample descrimination in using the travel cost method to estimate the benefits of improved water quality. Land Economics 60: 397-403.

Rich, P. R. and L. J. Moffitt. 1982. Benefits of pollution-control on Massachusetts Housatonic River – a hedonic pricing approach. Water Resources Bulletin 18: 1033-1037.

Robinson, W.S, R. Nowogrodzki, and R.A. Morse. 1989. The value of honey bees as pollinators of US crops. American Bee Journal 129(7): 477-487.

Sala, O.E. and f. M. Paruelo. 1997. Ecosystem services in grasslands. In Nature's services: Societal dependence on natural ecosystems, edited by G. C. Daily, 237-252. Washington, D.C.: Island Press.

Sanders, L. D., R. G. Walsh, and J. B. Loomis. 1990. Toward empirical estimation of the total value of protecting rivers. Water Resources Research 26: 1345-1357.

Sandhu, H.S., Wratten, S.D., Cullen, R., and Case, B. 2008. The future of farming: The value of ecosystem services in conventional and organic arable land. An experimental approach. Ecological Economics 64: 835-848.

Shafer, E. L., R. Carline, R. W. Guldin, and H. K. Cordell. 1993. Economic amenity values of wildlife – 6 case-studies in Pennsylvania. Environmental Management 17: 669-682.

Sharma, N.P. 1992. Managing the world's forests: looking for balance between conservation and development. Dubuque, Iowa: Kendall/Hunt Publishing Company.

Smith W.N. et al. 2001. Estimated changes in soil carbon associated with agricultural practices in Canada. Canadian Journal of Soil Science 81: 221-227.

Southwick, E. E. and L. Southwick. 1992. Estimating the economic value of honey-bees (hymenoptera, Apidae) as agricultural pollinators in the United States. Journal of Economic Entomology 85: 621-633.

Thibodeau, F. R., and Ostro, B.D. 1981. An economic analysis of wetland protection. Journal of Environmental Management 12: 19-30.

Tyrvainen, L. 2001. Economic valuation of urban forest benefits in Finland. Journal of Environmental Management 62: 75-92.

van Kooten, G. C. and A. Schmitz. 1992. Preserving Waterfowl Habitat on the Canadian Prairies: Economic Incentives Versus Moral Suasion. American Journal of Agricultural Economics 74: No 1 (Feb., 1992), pp. 79-89.

Walsh, R.G., D.A. Greenley, and R.A. Young. 1978. Option values, preservation values, and recreational benefits of improved water quality: a case study of the South Platte River Basin, Colorado. EPA, report no. 600/5-78-001.

USA.

Ward, F. A., B. A. Roach, and J. E. Henderson. 1996. The economic value of water in recreation: Evidence from the California drought. Water Resources Research 32: 1075-1081.

Whitehead, J. C. 1990. “Measuring Willingness-to-Pay for Wetlands Preservation with the Contingent Valuation Method.” Wetlands 10:187-201.

Whitehead, J. C., T. L. Hoban, and W. B. Clifford. 1997. Economic analysis of an estuarine quality improvement program: The Albemarle-Pamlico system. Coastal Management 25: 43-57.

Willis, K. G. 1991. The recreational value of the forestry commission estate in Great Britain - a Clawson-Knetsch travel cost analysis. Scottish Journal of Political Economy 38: 58-75.

Willis, K.G. and G.D. Garrod. 1991. An individual travel-cost method of evaluating forest recreation. Journal of Agricultural Economics 42: 33-42.

Wilson, S.J. 2008. Ontario’s wealth, Canada’s future: Appreciating the value of the Greenbelt’s ecoservices. Vancouver, BC: David Suzuki Foundation, www.davidsuzuki.org/Publications/Ontarios_Wealth_Canadas_Future.asp.

Woodward, R., and Wui, Y. 2001. The economic value of wetland services: a meta-analysis. Ecological Economics 37(2): 257-270.

Young, C.E. and J.S. Shortle. 1989. Benefits and costs of agricultural nonpoint-source pollution controls: the case of St. Albans Bay. Journal of Soil and Water Conservation 44(1): 64-67.

Appendix D: Value Transfer Studies Used by Land Cover Class

Land Class Cover	Ecosystem Service	Study Author(s)	Minimum Value ($)	Maximum Value ($)
Beach	Aesthetic & Recreational	Kline, J. D. and Swallow, S. K.	$37,988.14	$49,024.61
		Bell, F.W. and Leeworthy, V.R.	$2,572.18	$2,847.08
		Silberman, J., et al.	$23,768.98	$23,768.98
	Cultural & Spiritual	Taylor, L. O. and Smith, V. K.	$27.05	$27.05
	Disturbance Regulation	Parsons, G. R. and Powell, M.	$23,922.63	$23,922.63
Forest	Aesthetic & Recreational	Bennett, R., et. al.	$182.15	$182.15
		Bishop, K.	$1,939.63	$2,173.94
		Boxall, P. C., McFarlane, B. L. and Gartrell, M.	$.26	$.26
		Haener, M. K. and Adamowicz, W. L.	$.24	$.24
		Maxwell, S.	$12.69	$12.69
		Prince, R. and Ahmed, E.	$2.19	$2.79
		Willis, K. G. and Garrod, G. D.	$4.04	$4.04
		Willis, K.G.	$.70	$205.33
		Dodds, W.K., et al.	$875.17	$875.17
		Shafer, E. L., et al.	$112.21	$580.47
		Wilson, S. J.	$120.77	$120.77
	Biological Control	Wilson, Sara J.	$9.26	$9.26
		Krieger, D.J.	$9.68	$9.68
	Disturbance Regulation	Dodds, W.K., et al.	$1.40	$5.14
	Gas & Climate Regulation	local estimate	$58.73	$1,066.19
		Pimentel et al.	$15.38	$15.38
		Mates. W., Reyes, J.	$57.50	$253.87
		Wilson, S. J.	$14.11	$331.57
	Habitat Refugium & Nursery	Amigues, J. P., et. al.	$73.90	$2,922.84
		Haener, M. K. and Adamowicz, W. L.	$1.99	$13.64
		Kenyon, W. and Nevin, C.	$538.74	$538.74
		Shafer, E. L. et. al.	$4.63	$4.63
		Dodds, W.K., et al.	$2.80	$2.80
		Garber et al.	$290.62	$487.40
		Wilson, S. J.	$1.08	$1.08
	Nutrient Cycling	Dodds, W.K., et al.	$74.25	$1,135.29
	Pollination	Hougner, C.	$67.82	$304.59
		Wilson, S. J.	$213.92	$400.06
	Raw Materials	Dodds, W.K., et al.	$.53	$1.87
	Soil Erosion Control	Dodds, W.K., et al.	$112.55	$112.55

	Waste Treatment	Wilson, Sara J.	$168.95	$168.95
	Water Regulation	Wilson, Sara J.	$542.86	$542.86
		Olewiler, N.	$31.52	$31.52
		Loomis J.B.	$10.35	$10.35
	Water Supply	Ribaudo, M. and Epp, D. J.	$1,396.17	$1,770.38
		Dodds, W.K., et al.	$9.81	$9.81
	Science and Education	Bishop, K.	$39.71	$68.35
Grasslands	Biological Control	Pimentel et al.	$13.09	$13.63
	Gas & Climate Regulation	Wilson, Sara J.	$10.96	$168.74
		Costanza et al.	$5.23	$5.23
		Copeland et al.	$.08	$.08
	Pollination	Wilson, Sara J.	$427.18	$427.18
		Pimentel et al.	$14.48	$14.83
	Soil Erosion Control	Costanza et al.	$17.20	$17.20
	Soil Formation	Costanza et al.	$.59	$.59
		Sala and Paruelo	$.67	$.67
	Waste Treatment	Pimentel et al.	$51.60	$51.60
	Water Regulation	Costanza et al.	$1.78	$1.78
		Jones et al.	$4.11	$4.11
	Food Production	US Dept of Comm	$33.03	$33.03
Lakes/ Rivers	Aesthetic & Recreational	Bell, F. W.	$2,059.12	$2,059.12
		Burt, O. R. and Brewer, D.	$497.36	$497.36
		Cordell, H. K. and Bergstrom, J. C.	$145.79	$1,528.91
		Kahn, J. R. and Buerger, R. B.	$4.09	$4.09
		Kealy, M. J. and Bishop, R. C.	$13.93	$13.93
		Piper, S.	$258.69	$258.69
		Shafer, E. L. et. al.	$594.20	$1,186.17
		Loomis J.B.	$11,987.64	$21,215.04
		Postel & Carpenter	$126.50	$126.50
		Patrick, R.,et al.	$2.05	$31.01
		Ward, F. A., et al.	$22.06	$2,066.27
	Habitat Refugium & Nursery	Kahn, J. R. and Buerger, R. B.	$2.33	$18.74
		Loomis J.B.	$17.40	$17.40
	Waste Treatment	Gibbons	$148.12	$1,925.56
	Water Regulation	Gibbons	$2,978.00	$5,207.61
	Water Supply	Bouwes, N. W. and Scheider, R.	$664.98	$664.98
		Piper, S.	$47.57	$47.57
		Ribaudo, M. and Epp, D. J.	$908.35	$908.35
		Gibbons	$131.82	$1,012.99

Marine		Knowler, D.J., MacGregor, B.W., Bradford, M.J., Peterman, R.M.,	$10.60	$48.59
		Croke, K., et al.	$609.46	$609.46
		Henry, R., et al.	$462.34	$462.34
	Habitat Refugium & Nursery	Knowler, D.J., MacGregor, B.W., Bradford, M.J., Peterman, R.M.	$.55	$2.95
	Water Supply	Soderqvist, T. and Scharin, H.	$60.79	$101.06
		Hanley, N., Bell, D. and Alvarez-Farizo, B.	$139.10	$139.10
		Nunes, P and Van den Bergh, J.	$99.33	$99.33
Open Ocean	Biological Control	Costanza et al.	$3.61	$3.61
	Cultural & Spiritual	Costanza et al.	$5.07	$104.90
	Gas & Climate Regulation	Costanza et al.	$.43	$54.99
	Nutrient Cycling	Costanza et al.	$44.93	$125.88
	Raw Materials	Costanza et al.	$.05	$.05
	Food Production	Costanza et al.	$10.84	$10.84
Shrub	Aesthetic & Recreational	Bennett, R., et. al.	$182.15	$182.15
		Bishop, K.	$1,939.63	$2,173.94
		Boxall, P. C., McFarlane, B. L. and Gartrell, M.	$.19	$.19
		Haener, M. K. and Adamowicz, W. L.	$.22	$.22
		Maxwell, S.	$12.69	$12.69
		Prince, R. and Ahmed, E.	$1.60	$2.05
		Willis, K.G.	$.45	$205.33
		Shafer, E. L., et al.	$580.47	$580.47
	Gas & Climate Regulation	local estimate	$6.68	$193.97
	Habitat Refugium & Nursery	Haener, M. K. and Adamowicz, W. L.	$1.32	$9.11
		Kenyon, W. and Nevin, C.	$538.74	$538.74
		Shafer, E. L. et. al.	$3.21	$3.21
	Science and Education	Bishop, K.	$39.71	$68.35
Urban green space	Aesthetic & Recreational	Tyrvainen, L.	$1,358.38	$3,981.97
	Gas & Climate Regulation	Birdsey, R.A.	$219.10	$219.10
		McPherson, E. G.	$188.87	$942.11
		McPherson, E. G., Scott, K. I. and Simpson, J. R.	$28.87	$28.87
	Water Regulation	Birdsey, R.A.	$184.04	$184.04
		McPherson, E. G.	$6.16	$6.16
Wetland	Aesthetic & Recreational	Doss, C. R. and Taff, S. J.	$4,117.60	$4,549.07
		Kreutzwiser, R.	$195.20	$195.20
		Thibodeau, F. R. and Ostro, B. D.	$7.38	$23.60

	Whitehead, J. C.	$1,125.06	$2,262.04
	Dodds, W.K., et al.	$1,689.17	$1,689.17
	Woodward and Wui, (low value); New Jersey from A-C studies (for high value)	$1.67	$4,640.38
	Hicks et al.	$138.94	$138.94
	Jenkins et al.	$6.58	$6.58
	Whitehead et al.	$237.76	$237.76
	Allen, J. et al.	$111.76	$578.80
	Hayes, K. M., et al.	$1,306.18	$2,496.49
	van Vuuren, W. and Roy, P.	$868.94	$868.94
	Wilson, S. J.	$45.82	$133.45
	Cooper J. and Loomis, J.	$327.09	$1,284.51
	Mahan, B. L., et al.	$37.42	$37.42
Disturbance Regulation	Dodds, W.K., et al.	$14,820.94	$14,820.94
	Leshcine et al.	$7,830.00	$51,095.00
	Allen, J. et al.	$433.68	$7,756.20
Gas & Climate Regulation	Roel calculation for LA	$29.90	$271.71
	Dodds, W.K., et al.	$123.76	$123.76
	Jenkins et al.	$81.00	$81.00
	Wilson, S. J.	$4.69	$516.65
Habitat Refugium & Nursery	Pate, J. and Loomis, J.	$99.73	$317.07
	Vankooten, G. C. and Schmitz, A.	$9.48	$9.48
	Dodds, W.K., et al.	$179.33	$179.33
	Woodward and Wui, (low value); New Jersey from A-C studies (for high value)	$158.46	$510.41
	Allen, J. et al.	$5,566.12	$13,557.50
	Knowler, D. J. et al.	$10.60	$48.59
	Mazzotta, M.	$8,680.45	$8,680.45
Nutrient Cycling	Dodds, W.K., et al.	$7,465.11	$7,465.11
	Jenkins et al.	$521.35	$521.35
Raw Materials	Dodds, W.K., et al.	$2,815.59	$2,815.59
Storm Protection	Woodward and Wui, (low value); New Jersey from A-C studies (for high value)	$18.35	$8,576.86
Waste Treatment	Pate, J. and Loomis, J.	$76.37	$344.05
	(blank)	$162.58	$456.82
	Wilson, S. J.	$462.89	$1,810.17
Water Regulation	Thibodeau, F. R. and Ostro, B. D.	$1,490.24	$1,490.24
	Woodward and Wui, (low value); New Jersey from A-C studies (for high value)	$148.45	$2,914.00
	Allen, J. et al.	$5,604.48	$17,347.20
	Wilson, S. J.	$1,608.72	$1,608.72
Water Supply	Creel, M. and Loomis, J.	$584.41	$584.41
	Lant, C. L. and Roberts, R. S.	$.77	$.97

		Lant, C. L. and Roberts, R. S.	$.77	$.97
		Lant, C. L. and Tobin, G.	$189.11	$2,082.09
		Pate, J. and Loomis, J.	$3,537.89	$3,537.89
		Dodds, W.K., et al.	$1,379.54	$1,379.54
		Lant? - IL water qual study	$335.85	$335.85
		Woodward and Wui, (low value); New Jersey from A-C studies (for high value)	$10.01	$4,288.43
		Allen, J. et al.	$11,342.40	$33,960.48
		Hayes, K. M., et al.	$1,386.94	$2,155.91
		Wilson, S. J.	$681.89	$681.89
		Brouwer, R., et al.	$21.77	$53.16
Wetland Forest	Aesthetic & Recreational	Roel/Ken	$189.87	$594.50
	Gas & Climate Regulation	Roel/Ken	$108.09	$784.47
		Costanza et al.	$176.25	$176.25
	Storm Protection	Roel/Ken	$1,412.71	$1,412.71
	Water Supply	Roel/Ken	$43.07	$114.86
Evergreen Forest	Aesthetic & Recreational	Dodds, W.K., et al.	$875.17	$875.17
	Disturbance Regulation	Dodds, W.K., et al.	$1.40	$1.40
	Gas & Climate Regulation	Dodds, W.K., et al.	$14.48	$14.48
	Habitat Refugium & Nursery	Dodds, W.K., et al.	$2.80	$2.80
	Nutrient Cycling	Dodds, W.K., et al.	$1,135.29	$1,135.29
	Raw Materials	Dodds, W.K., et al.	$1.87	$1.87
	Soil Erosion Control	Dodds, W.K., et al.	$112.55	$112.55
	Water Supply	Dodds, W.K., et al.	$21.48	$21.48

Appendix E: Additional Tables and Charts

Site	2005-2007 Triage Category	Acres	2005-2007 Ecosystem Status	2011 Ecosystem Status	Years till Good
Alderwood Park*	4	3.21	Fair	Fair	
	7	3.00	Fair	Fair	
Browns Point Lighthouse	0**	2.13	NA	NA	
Browns Point Playfield	9	0.97	Dysfunctional	Dysfunctional	
Charlotte's Blueberry Park	5	1.37	Poor	Fair	
	8	3.31	Poor	Poor	
China Lake Park	0**	0.14	NA	NA	
	1	8.66	Good	Good	
	2	4.47	Fair	Fair	
	3	5.99	Dysfunctional	Fair	
	4	3.49	Fair	Fair	
	5	1.29	Poor	Poor	
	6	1.48	Poor	Poor	
	8	0.64	Poor	Poor	
	9	0.36	Dysfunctional	Dysfunctional	
DeLong Park	5	4.26	Poor	Poor	
	6	8.81	Poor	Poor	
	9	2.56	Dysfunctional	Fair	
Eldridge (Lincoln Park)	7	1.82	Fair	Fair	
Franklin Park	0**	0.28	NA	NA	
	4	1.27	Fair	Fair	
	5	1.07	Poor	Poor	
	5	1	Poor	Fair	5
	6	2	Dysfunctional	Dysfunctional	
	9	0.46	Dysfunctional	Dysfunctional	
Garfield Gulch	8	0.45	Poor	Poor	
	9	6.28	Dysfunctional	Dysfunctional	
	9	1.5	Dysfunctional	Fair	3
Heidelberg MPT HQ*	2	0.99	Fair	Fair	
	4	3.58	Fair	Fair	
	6	7.07	Dysfunctional	Dysfunctional	
Irving	9	0.89	Dysfunctional	Dysfunctional	
McKinley Park*	5	15.31	Poor	Poor	
	5	2	Poor	Fair	5
	5	3	Poor	Fair	4
	5	3	Poor	Fair	3
Meadow Park Golf Course	4	6.42	Fair	Fair	
	4	1	Fair	Fair	3
Norpoint Park	6	1.64	Dysfunctional	Dysfunctional	

	8	7	Poor	Poor	
	9	0.26	Dysfunctional	Dysfunctional	
Oak Tree Park	2	16.86	Fair	Fair	
	2	2	Fair	Fair	3
	2	1	Fair	Fair	4
	3	1.21	Dysfunctional	Fair	
	5	0.18	Poor	Poor	
	6	0.52	Dysfunctional	Dysfunctional	
Point Defiance Park	1	362.38	Good	Good	
	2	139.92	Fair	Fair	
	2	1	Fair	Fair	2
	4	62.83	Fair	Fair	
	5	18.12	Poor	Poor	
	5	1	Poor	Fair	3
Puget Creek Gulch*	2	10.92	Fair	Fair	
	3	0.56	Dysfunctional	Dysfunctional	
	5	4.81	Poor	Poor	
	6	1.1	Dysfunctional	Dysfunctional	
	7	5.99	Fair	Fair	
	8	1	Poor	Fair	3
Ryan's Park	4	1.06	Fair	Fair	
	6	1.11	Dysfunctional	Fair	4
	8	0.32	Poor	Poor	
South End Recreation Area	9	7.11	Dysfunctional	Dysfunctional	
	9	0.5	Dysfunctional	Fair	3
Swan Creek Park	1	88.3	Good	Good	
	2	52.47	Fair	Fair	
	2	1	Fair	Fair	2
	4	31.02	Fair	Fair	
	6	69.39	Dysfunctional	Dysfunctional	
	7	3.43	Fair	Fair	
	8	13.08	Poor	Poor	
	9	7.9	Dysfunctional	Dysfunctional	
Snake Lake Park*	1	23.16	Good	Good	
	2	2.09	Fair	Fair	
	3	2.22	Dysfunctional	Dysfunctional	
	4	0.8	Fair	Fair	
	5	17.01	Poor	Poor	
	5	5	Poor	Fair	4
	6	2.78	Poor	Poor	
	8	2.62	Poor	Poor	
	9	3.09	Poor	Poor	

Titlow Park	0**	0.36	NA	NA	
	2	4.36	Fair	Fair	
	3	4.22	Poor	Fair	
	3	2	Poor	Fair	5
	5	33.85	Poor	Poor	
	9	0.88	Poor	Poor	
	9	1	Poor	Fair	5
Ursich Gulch	9	4.69	Poor	Poor	
Wapato Hills Park	2	9.96	Fair	Fair	
Wapato Park	4	1.48	Fair	Fair	
	5	25.56	Poor	Poor	
	5	0.1	Poor	Fair	3
	6	0.62	Poor	Poor	
	8	6.46	Poor	Poor	
	9	1.16	Poor	Fair	3

*The measure of acreage used in the Restoration Action Plan differs slightly from those measured for this project.

**If a park section had an unknown habitat composition and invasive threat value, it was assigned a Habitat Triage Value of 0.

Appendix F: Study Limitations

The results of this first attempt to assign monetary value to the ecosystem services rendered by the Puyallup Watershed have important and significant implications on the restoration and management of natural capital. Valuation exercises have limitations that must be noted, although these limitations should not detract from the core finding that ecosystems produce a significant economic value to society. Benefit transfer analysis estimates the economic value of a given ecosystem (e.g., wetlands) from prior studies of that ecosystem type. Like any economic analysis, this methodology has strengths and weaknesses. Some arguments against benefit transfer include:

1. Every ecosystem is unique; per-acre values derived from another location may be irrelevant to the ecosystems being studied.
2. Even within a single ecosystem, the value per acre depends on the size of the ecosystem; in most cases, as the size decreases, the per-acre value is expected to increase and vice versa. (In technical terms, the marginal cost per acre is generally expected to increase as the quantity supplied decreases; a single average value is not the same as a range of marginal values).
3. Gathering all the information needed to estimate the specific value for every ecosystem within the study area is not feasible. Therefore, the "true" value of all of the wetlands, forests, pastureland, etc. in a large geographic area cannot be ascertained. In technical terms, we have far too few data points to construct a realistic demand curve or estimate a demand function.
4. To value all, or a large proportion, of the ecosystems in a large geographic area is questionable in terms of the standard definition of exchange value; we cannot conceive of a transaction in which all or most of a large area's ecosystems would be bought and sold. This emphasizes the point that the value estimates for large areas (as opposed to the unit values per acre) are more comparable to national income accounts aggregates and not exchange values (Howarth & Farber, 2002). These aggregates (i.e. GDP) routinely impute values to public goods for which no conceivable market transaction is possible. The value of ecosystem services of large geographic areas is comparable to these kinds of aggregates (see below).

Proponents of the above arguments recommend an alternative valuation methodology that amounts to limiting valuation to a single ecosystem in a single location and only using data developed expressly for the unique ecosystem being studied, with no attempt to extrapolate from other ecosystems in other locations. An area with the size and landscape complexity of the Puyallup Watershed will make this approach to valuation extremely difficult and costly. Responses to the above critiques can be summarized as follows (See Costanza et al., 1998; and Howarth and Farber, 2002 for more detailed discussion):

1. While every wetland, forest or other ecosystem is unique in some way, ecosystems of a given type, by their definition, have many things in common. The use of average values in ecosystem valuation is no more and no less justified than their use in other macroeconomic contexts; for instance, the development of economic statistics such as Gross Domestic or Gross State Product. This study's estimate of the aggregate value of the Puyallup Watershed's ecosystem services is a valid and useful (albeit imperfect, as are all aggregated economic measures) basis for assessing and comparing these services with conventional economic goods and services.
2. The results of the spatial modeling analysis that were described in other studies do not support an across-the-board claim that the per-acre value of forest or agricultural land depends on the size of the parcel. While the claim does appear to hold for nutrient cycling and other services, the opposite position holds up fairly well for what ecologists call "net primary productivity" or NPP, which is a major indicator of ecosystem health. It has the same position, by implication, of services tied to NPP – where each acre makes about the same contribution to the whole regardless of whether it is part of a large plot of land or a small one. This area of inquiry needs further research, but for the most part the assumption (that average value is a reasonable proxy for marginal value) is appropriate for a first approximation. Also, a range of different parcel

sizes exist within the study site, and marginal value will average out.

3. As employed here, the prior studies we analyzed encompass a wide variety of time periods, geographic areas, investigators and analytic methods. Many of them provide a range of estimated values rather than single-point estimates. The present study preserves this variance; no studies were removed from the database because their estimated values were deemed to be "too high" or "too low." Limited sensitivity analyses were also performed. The approach is similar to determining an asking price for a piece of land based on the prices for comparable parcels; even though the property being sold is unique, realtors and lenders feel justified in following this procedure to the extent of publicizing a single asking price rather than a price range.
4. The objection to the absence of even an imaginary exchange transaction was made in response to the study by Costanza et al. (1997) of the value of all of the world's ecosystems. Leaving that debate aside, one can conceive of an exchange transaction in which, for example, all or a large portion of a watershed was sold for development so that the basic technical requirement of an economic value reflecting the exchange value, could be satisfied. Even this is not necessary if one recognizes the different purpose of valuation at this scale – a purpose that is more analogous to national income accounting than to estimating exchange values (Howarth and Farber 2002).

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

The estimated value of the world's ecosystems presented in Costanza et al. (1997), for example, has been criticized as both (1) a serious underestimate of infinity and (2) impossibly exceeding the entire Gross World Product. These objections seem to be difficult to reconcile, but that may not be so. Just as a human life is "priceless," so are ecosystems, yet people are paid for the work they do.

That the value ecosystems provide to people exceeds the gross world product should, with some reflection, not be so surprising. Costanza's estimate of the work that ecosystems do is an underestimate of the "infinity" value of priceless systems, but that is not what he sought to estimate. Consider the value of one ecosystem service, such as photosynthesis, and the ecosystem good it produces: atmospheric oxygen. Neither is valued in Costanza's study. Given the choice between breathable air and possessions, informal surveys have shown the choice of oxygen over material goods is unanimous. This indicates that the value of photosynthesis and atmospheric oxygen to people exceeds the value of the gross world product – and oxygen production is only a single ecosystem service and good.

General Limitations

- **Static Analysis.** This analysis is a static, partial equilibrium framework that ignores interdependencies and dynamics, though new dynamic models are being developed. The effect of this omission on valuations is difficult to assess.
- **Increases in Scarcity.** The valuations probably underestimate shifts in the relevant demand curves as the sources of ecosystem services become more limited. The values of many ecological services rapidly increase as they become increasingly scarce (Boumans et al. 2002). If the Puyallup Watershed's ecosystem services are scarcer than assumed here, their value has been underestimated in this study. Such reductions in "supply" appear likely as land conversion and development proceed; climate change may also adversely affect the ecosystems, although the precise impacts are more difficult to predict.
- **Existence Value.** The approach does not fully include the infrastructure or existence value of ecosystems. It is well known that people value the existence of certain ecosystems, even if they never plan to use or benefit from them in any direct way. Estimates of existence value are rare; including this service will obviously increase the total values.
- **Other Non-Economic Values.** Economic and existence values are not the sole decision-making criteria.

Techniques called multi-criteria decision analysis are available to formally incorporate economic values with other social and policy concerns (see Janssen and Munda, 2002 and de Montis et al., 2005 for reviews). Having economic information on ecosystem services usually helps this process because traditionally, only opportunity costs of forgoing development or exploitation are counted against non-quantified environmental concerns.

GIS Limitations

- **GIS Data.** Since this valuation approach involves using benefits transfer methods to assign values to land cover types based, in some cases, on their contextual surroundings, one of the most important issues with GIS quality assurance is reliability of the land cover maps used in the benefits transfer, both in terms of categorical precision and accuracy.
    - Accuracy: The source GIS layers are assumed to be accurate but may contain some minor inaccuracies due to land use change since the data was sourced, inaccurate satellite readings and other factors.
    - Categorical Precision: The absence of certain GIS layers that matched the land cover classes used in the Earth Economics database created the need for multiple datasets to be combined. For example, a "riparian buffer" layer was not obtainable for the Puyallup Watershed, so the "riparian buffer" cover class was applied to all forest and layers (i.e. forest cover) within 50 feet of the Rivers and Lakes layer (NLCD Code 11 minus Estuary). This process is likely to produce some inaccuracies in final acreage values for each land cover class and thus affect the final dollar valuation of the Puyallup Watershed.

- **Spatial Effects.** This ecosystem service valuation assumes spatial homogeneity of services within ecosystems, i.e. that every acre of forest produces the same ecosystem services. This is clearly not the case. Whether this would increase or decrease valuations depends on the spatial patterns and services involved. Solving this difficulty requires spatial dynamic analysis. More elaborate systems dynamics studies of ecosystem services have shown that including interdependencies and dynamics leads to significantly higher values (Boumans et al., 2002), as changes in ecosystem service levels ripple throughout the economy.

Benefit Transfer/Database Limitations

- **Incomplete coverage.** That not all ecosystems have been valued or studied well is perhaps the most serious issue, because it results in a significant underestimate of the value of ecosystem services. More complete coverage would almost certainly increase the values shown in this report, since no known valuation studies have reported estimated values of zero or less. Table 5 illustrates which ecosystem services were identified in the Puyallup Watershed for each land cover type, and which of those were valued.
- **Selection Bias.** Bias can be introduced in choosing the valuation studies, as in any appraisal methodology. The use of a range partially mitigates this problem.
- **Consumer Surplus.** Because the benefit transfer method is based on average rather than marginal cost, it cannot provide estimates of consumer surplus. However, this means that valuations based on averages are more likely to underestimate total value.

Primary Study Limitations

- **Willingness-to-pay Limitations**. Most estimates are based on current willingness-to-pay or proxies, which are limited by people's perceptions and knowledge base. Improving people's knowledge base about the contributions of ecosystem services to their welfare would almost certainly increase the values based on willingness-to-pay, as people would realize that ecosystems provided more services than they had previously known.
- **Price Distortions**. Distortions in the current prices used to estimate ecosystem service values are carried through the analysis. These prices do not reflect environmental externalities and are therefore again likely to be underestimates of true values.
- **Non-linear/Threshold Effects.** The valuations assume smooth responses to changes in ecosystem

quantity with no thresholds or discontinuities. Assuming (as seems likely) that such gaps or jumps in the demand curve would move demand to higher levels than a smooth curve, the presence of thresholds or discontinuities would likely produce higher values for affected services (Limburg et al., 2002). Further, if a critical threshold is passed, valuation may leave the normal sphere of marginal change and larger-scale social and ethical considerations dominate, such as an endangered species listing.

- **Sustainable Use Levels.** The value estimates are not necessarily based on sustainable use levels. Limiting use to sustainable levels would imply higher values for ecosystem services as the effective supply of such services is reduced.

If the above problems and limitations were addressed, the result would most likely be a narrower range of values and significantly higher values overall. At this point, however, it is impossible to determine more precisely how much the low and high values would change.

Non Measurable Value in Stewardship Activities

The method used in this report is subject to limitations due to lack of data on the restoration of specific lands types. Given that the subject of invasive species is a generally broad category in which plants and animals can take many forms, detriment caused by nonnative species affects specific land types differently. On the contrary, the effect that invasive species have on the services general ecosystems provide is broadly similar. Between wetlands, forests and grasslands, if all land types are dominated by invasive species, the ability to sustain habitats, exchange nutrients and gain access to sources of water are all degraded.

Several of MPT parks are in the midst of restoration, a process that requires many months, even years, before the work can officially become finished. This analysis was not able to provide a habitat quality index, which would have enabled another variable in which to value a partially restored area on a sliding scale. Therefore, these lands were considered “unrestored” and the costs that have been realized from the unfinished restoration were not considered.

Appendix G: The Economic Value of Metro Parks Tacoma's Natural Capital

Summary of January 11, 2012 Workshop
On January 11, 2012, as this report was being circulated in draft, Metro Parks Tacoma hosted staff, partners and community members for a one day workshop. The workshop was held at Point Defiance Zoo and facilitated by Earth Economics. This document summarizes key outputs from the workshop.

Workshop objective:
To find a common value for the parks and find a way to collectively improve the community benefits that MPT provides:

- Provide a forum for MPT to listen and learn;
- Identify shared opportunities around investment and funding of ecosystem services, health and education benefits;
- Explore next steps for furthering our collective ideas.

The community has been very clear about sustaining what we have. This workshop is looking at defining the assets that should be sustained, including economic benefits that have been undervalued significantly. What specific steps do we invest in? Would this be a redefinition of the value statement?

Organizations and staff represented:
Metro Parks Tacoma: Jack Wilson (Executive Director), Andrea Smith (Board of Park Commissioners), Wayne Williams (Operations Manager), Brett Freshwaters (CFO), Kathy Sutalo, Nancy Davis, John Garner, Diane Tilstra, Jennifer Wolbrecht, Joe Brady, John Houck, Julie Parascondola, Kristi Evans, Marina Becker, Nancy Davis, Roxanne Miles, Shon Sylvia, Steve Knauer, Vito Lacobazzi, and Alyce McNeil
Greater Metro Parks Foundation: Drew Ebersole, Richard Brady, Sara Clair, Jennifer Chang, and Kory Kramer
City of Tacoma & Pierce County: Marianne Etienne, Naomi Etienne, Dr. Anthony Chen (Health Department), Ryan Dicks (Office of Sustainability), Victoria Woordards (City Council), and Karla Kluge
Earth Economics: Zac Christin (MPT Project Lead), David Batker (Executive Director), Jen Harrison-Cox (Managing Director), Noelani Kirschner (Intern/Note taker) and Julia Rodriquez (Intern/Note taker)
Other Organizations: Theresa Dusek (AHBL), Dalton Gittens (Community Council), Layne Alfonso (Geo Engineers), Kathleen Wolf (University of Washington), and Bill Brookreson (WA Native Plant Society)

Some highlights (by Brett Freshwaters):

- In 2010, more than 50,000 hours were volunteered to help the park system - the value of these volunteer hours was around $1.2 million.
- In the past year, $5.6 million donated by various organizations, granting agencies and individuals.
- 20 acres of parkland has been restored since 2008.
- There are over 5,000 trees in the parks, helps Tacoma's goal of having 30% canopy cover throughout the city.

What is MPT's Natural Capital?

In breakouts of 4-6 people, the group worked through the list of ecosystem services, identified and discussed examples of each in the Metro Parks system. They then categorized answers by Place, Program or Project. Table 1 summarizes results:

Ecosystem Services	*Places*	*Programs*	*Projects*
Gas regulation	• Open Space • Point Defiance Zoo • Ruston Way • Shoreline • NW Trek	• Chip-In • Open Space Program • Carbon sequestration through forest health	• Carbon sequestration through forest health • Turf conversion • Goldfish Hill • Environmental education • Forest restoration projects
Climate Regulation	• Urban Forests • Swan Creek	• Mulch not Burn • Community Gardens • Urban forestation development	• Environmental education • Forest restoration • Planting trees • Tree canopies • Non-motorized transportation
Disturbance Prevention	• Wapato Park • Wetlands • China Lake Park • Tacoma Nature Center • Delong Park • Titlow	• Invasive removal programs	• Rain gardens • Stormwater management • Garfield Gulch • Shoreline restoration • Wetland/ Stream regulation
Water Regulation	• Wapato Park • Swan Creek • Meadow Park	• None	• Bio-swales • Green space • Rain gardens •
Water Supply	• Wapato Park • NW Trek • China Lake • Aquifer Recharge Area	• None	• Rain barrels • Turf conversion • Demonstration xeriscape at MPT HQ
Soil Retention	• Puget Creek • McKinley Park • Pt. Defiance Zoo • Turf Conversion • Peninsula Park	• Native pPlant salvage • Shoreline enhancement • Wapato restoration • Steep slope restoration • Point Defiance	• Mulching • Titlow restoration
Soil formation	• Feeder bluffs at Pt. Defiance • Pt. Defiance Zoo	• Composting	• Mulching
Nutrient Cycling	• Snake Lake • Wapato • Titlow • Swan Creek • Tacoma Nature Center • China Lake • NW Trek • Pt. Defiance • Greenscapes • Wetlands • Forests	• Landscape Management Programs (e.g. leaving grass clippings on lawns, leaving woody debris in natural areas)	• Rain gardens • Mulching
Waste Treatment	• Wetlands • Snake Lake • Wapato • China Lake • Delong • Rain gardens	• National Pollutant Discharge Elimination System • Pet Scoop Program	• Rain gardens • Shoreline • Removal of pavement
Pollination	• Community Gardens • Charlotte's Blueberry Park • Swan Creek • Pt. Defiance • Flowering plants • Conservatory	• Native species • Community gardens • Green roofs • Horticulture programs • Integrated Pest Management (IPM)	•

Biological Control	• All natural areas	• Integrated Pest Management (IPM)	• Natural Habitat • Goats • Biological control of invasives
Habitat and Biodiversity	• Wapato • Pt. Defiance • Tacoma Nature Center • NW Trek • Oak Tree Park • Titlow Park • Swan Creek • Puget Creek Watershed	• Natural Areas Program • Pt. Defiance Zoo • Bioblitz • Native Plant Society • Chip-In	• Titlow Estuary • Tacoma Habitat Corridors • Turf conversions to mixed woody habitat • Replacement of lawn with meadow plants
Nursery	• Swan Creek • Puget Sound • Titlow • Marina and Shoreline Areas	• Native Plant Greenhouse • Natural Areas Program	• Shoreline cleanups • Natural area restoration projects
Food	• Swan Creek • Titlow • Puget Creek • Pt. Defiance • Ruston Way • Charlotte's Blueberry Park • Community Gardens •	• Community Gardens • Charlotte's Blueberry Park • Food banks	• Adding new community gardens
Raw materials	• STAR Center (LEED) • Oak Tree Park	• Browse Program (at the Pt. Defiance Zoo)	• None
Genetic Resources	• Old growth forests	• Natural Areas Program (conservation of natural diversity) • Pt. Defiance zoo endangered species breeding programs • Conservation of natural areas	•
Medicinal Resources	• None	• Natural Areas Program (conservation of natural diversity) •	• Yew conservation
Ornamental Resources	• Conservatory • Rhododendron Garden	• Ft. Nisqually classes • Display gardens, hanging baskets, Conservatory, tree collection, Zoo plantings.	• Specialty Gardens
Aesthetic	• Pt. Defiance • Tacoma Nature Center • Gardens • Beach/ Shoreline	• PTSD recovery programs • Trails • Increased worker productivity • Higher commercial rents • Cultural experience	• None
Recreation	• All MPT Parks	• Youth at Risk Nature Program • Child ADHD treatment • Community to Regional Program • Adult sports games • Outdoor recreation • Trails • Playgrounds and spraygrounds	• Shoreline activities • Trail improvements • Playground and sprayground additions and upgrades

Cultural and Artistic	• Discovery Pond	• Community Care Program Resilience • Ecotourism • Neighborhood crime reduction • Arts programs in the MPT Recreation Department	• First Night
Spiritual and Historical	• Ft. Nisqually • Pt. Defiance • Old Town Park • Conservatory	• Fort Nisqually programs • Job Carr Cabin • Conservatory music and meditation programs	• Acquiring, cataloging and conserving historic artifacts. • Preserving and restoring historic buildings (Ft Nisqually, Titlow Lodge, Pagoda, Conservatory)
Science and Education	• Pt. Defiance Zoo & Aquarium • Tacoma Nature Center • NW Trek • Conservatory • SAMI (Science and Math Institute) • Ruston Way • Zoo Education program	• Outdoor classrooms • Green campuses • Snake Lake and Tacoma Nature Center • SAMI • SOTA (School of the Arts) • Tiptoe through Tidepools • Nature walks	• New Zoo and Trek exhibits • Bioblitz • Citizen participation in natural area restoration and maintenance • Green Tacoma Partnership training programs for volunteers

The next step identified is to look at those services which have a market value, a regulatory driver or clear beneficiaries in order to frame economic value, relate to investment need and develop funding mechanisms.

Discussion

The following section is a compilation of verbatim notes taken throughout the day. They have been minimally edited for fluidity and context clarity. Each section has suggested next steps, actions or opportunities.

What do we want to achieve with the current resources we have?

We need to better mobilize people within the community to help them better understand the value of the ecosystem services. Participating in hikes, restoration, community gardens, bird lists, etc., help the community become involved. Facing tight budgets, we need to mobilize more people than we have in the past, simplify engagement processes and have elders act as mentors to help others maintain, sustain, and improve. We've got to get people involved and looking long term at these things. What are we doing for the next generation? How can we make their lives better than they are right now? We need to maintain and improve these services for the communities, so we can achieve more with fewer resources.

Who is the best group/org/agency to identify these ecosystem services?

Work with the established organization and groups within the parks. For example, Puget Gulch, McKinley Park, Charlotte Blueberry Park, etc. **The staff knows the programs, day in and day out, they know the areas and the community. These people should focus on the individual aspects of their park, create a clear and focused identity for the public to be drawn into.** Make it an individual destination; this way people would know the specific features of each park and are drawn to each park because of their specific identity.

How does this relate to our discussion on social and health benefits?

This is potentially paradigm shifting. Even in the Health Department we hear a lot about the environment vs. economy debate. **As I see it, government, business, and elected officials need to get on the same page in terms of vision for the community.** In the Health Department we've been trying to increase the breadth of knowledge in our Trends Report to include environmental impact, etc. We're also interested in the planning aspect of our communities, such as the sub-area plan for the MLK district. Maybe there could be something at the Health Department that gives information about the parks and vice versa; at the parks there could be information about the Health Department for people who might not necessarily see that information. We could utilize cross-

communication and cross-advertising.
An outside the box funding mechanism idea: We talk about the health benefits of the Park District, what about the idea of a Healthy Population District? This concept could pull together a consortium of groups or beneficiaries that provide programs and services for a healthy population. Maybe a voter approved tax? Or a shared funding mechanism that groups can do together?

How do identify health benefits when that information (risk mitigation) is so incomplete?

In terms of bringing what now could be considered "theoretical", something that we've been toying with, we've talked with the Tacoma City Chamber and they have a Work Well program that connects healthier lifestyles to the workplace. I know some of this might be done through volunteering, but we want to integrate more within Multicare. We want to make connections with physical activity through the workplaces; we could give credit to certain workplaces. **Recognition doesn't actually work unless people get involved.** For example Aveda Corporation encourages employees to get involved within communities, pays their employees to do this. They're part of a local community and this shows through their work. Forterra is working on a collaboration with the UW environmental department on public health. Sends folks out into the community and the results are fantastic.

How does community fit into landscape?

When we talk about the community fitting into ecosystem, I think about Tacoma's habitat corridors plan. The future links between the corridors are not written into the plan, but the way to move it forward is to think about the community's goals for the future. How do we make this allowed and incorporate it? Programs to help people plant native species within their property, possibly. **You can't just have one vehicle; you need a community effort to get the job done.** Talk to different groups, there needs to be systemized coordination between groups and organizations. Right now we're too nuclear, we need to be more strategic.

How do we build on the economic cycle?

Now is the time to be rethinking. We're ready as a culture and a global community to make a change. The Occupy Movement is an example. The economy grew to global level, and we are struggling with insufficient outdated macroeconomic measures. We reevaluate and create new economics (eartheconomics) that accounts for global health, happiness and equality.
We are being told 'you need to get ready to earn less for more work and forget retirement'. A new vision is emerging that says 'let's have a healthier life, more time with our friends and family'. This was exactly the debate that was taking place back in 1905. We need to have seller be honest instead of buyer beware.

What's the best way to connect to the public?

Reach out to the collective audiences of all the organizations present today. We need unified messaging across all partners about ecosystem services. But collectively, we need a mechanism to reach consensus on what that messaging is. The Conservation District sees a huge benefit in getting volunteers involved within the communities, and should look at developing an urban conservation program. How do we get the word out in real English? How do we not use too much lingo? Sans academic jargon. Communication can't be underemphasized.
Volunteers also want to see the intrinsic things that are there, when restoring. Instead of only pulling plants, they should see the frogs in the pond, the interactive things that come back and benefit from the restoration. Environmental education piece, restoration piece- we need to figure out a way to bring all of these pieces together. Bring the folks together, so there's a sense of community for those restoring so they'll come back. We have a brand new program partially managed by the City of Tacoma and by MPT and we're getting ready to do a site walk with a new group of stewards where we were able to save a piece of land. We're combining their volunteer activities with a walk to talk about the ecosystem & amphibian life and build an emotional bond between people by encouraging families to come back and teach one another – this will help build that community and we think that it could be really popular. It almost needs a business plan set out for how do we combine these types of things, we want to bring the stewards together, so it's more like an invitation to come to

our place and making it more personable. It's almost like putting together a business plan to coordinate these different efforts that are happening.

Who else from the community should have been at this discussion/ workshop?

There is an opportunity to reach the science community as well; most scientists are thinking about large tract forest systems. To get these connections between the community and my colleagues [research universities] would be great as well. There are a lot of community groups that do restoration; these types of groups need to be at this discussion, businesses that have interest in improving community needs, schools, Puget Sound Partnership, Community Gateway members. Anyone trying to figure out the cost-benefit ratio, more City of Tacoma and Pierce County staff, press, Forever Green, elected officials, Pierce County Parks. We need to engage regulators here to help simplify the regulatory process - when you create a process it doesn't necessarily mean that things will get done. We need to engage with the people because then it will get done. We are focusing on human needs/interests. The needs of salmon and other species need to be represented as well.
What are the barriers to advancing ecosystem service concepts in planning, assessment and accounting?
Money to learn and implement new programs is the main inhibiting factor. We don't have the dollars to apply to park projects or research or process changes. When they start to budget things, environment projects fall down on the list of importance because decision makers do not understand their economic value. The City cares about these issues, however when you have to balance things but you can't back it up with the dollars, the projects move down the priority list. We need funding mechanisms to tax the people harming ecosystems so we do not have to spend so much on restoration. That's why we have to have a clearly defined destination, a clear goal as to what we have to do to get us there. When public service does projects, they should look to do their projects using ecosystem service values then the most cost efficient manner will also be the most environmentally beneficial manner.
We're talking about green infrastructure. We've done a little research on transportation, conducting and sharing info. How do we do that for green and environmental, to share information? We don't have a portal for green infrastructure. We need to reinvent the wheel and get the word out to the public about the research for green planning.

How could MPT better support the community?

Explore this idea of parks as being the primary mission but that MPT also provides a plethora of other benefits (like health, community cohesion, etc)? We need to better develop and communicate the idea of provisioning these multiple benefits help mutually reaching all of our goals. A natural capital institution. **Our economy in the NW wasn't affected as much by the economic downturn because of our economic diversity. If we allow ourselves to change in little ways constantly, we avoid collapse caused by large changes.** We should look at the economy as requiring diversity like we look at ecosystems requiring biodiversity. All the little diversity add up to this messy soup that is Tacoma and yet Tacoma is very stable. MPT is an integral component to that soup.
Build partnerships using documentation that shows the value to public health provided by these ecosystems, and then develop a willing and mutual beneficial partnership where partner organizations provide a degree of financial support to help maintain the value given by these ecosystem services. It's also a great message to say that your $1 is going to buy you this. The per-person amount of money that you collect will result in something that has a greater reward. We need to show that the benefit outweighs the cost.

What specific messaging do we need to develop?

We need to send the messaging out to lots of different companies. How well we get the message out through public outreach helps raise the dollars needed to invest in green infrastructure. When we spread the word that parks and the environment are valuable then we are more likely to get support. We should say 'your dollar will give this specific outcome,' then the public will help. In terms of messages, this has been an economic study, but I think the messages need to be combined with the emotional arguments as well. What kind of city do you want for your grandchildren? The economics backs the dollar argument but people need to feel the emotional involvement as well.

How can MPT better benefit the business community?

Preliminary economic research looked at park attendance rates and impact on business. The number of businesses within a quarter square mile had a positive correlation with the annual number of attendees. If these business districts come to realize the benefit of family programs within local parks, then the transition to collaborative investment will make better sense. Again, this is preliminary research, to understand more directly MPT impact on business, more analysis is needed.

One program example comes from Boeing's health care. Their medical insurance is free for employees, but unless they fill out a form, employees are charged $40 a month. By integrating programs that have nature association within them, it will have many more health benefits for the people, and they will thus have less medical problems. Some companies charge employees more for smoking. With MPT, we have different kinds of incentives that employees do to reduce their insurance bill, like "we've gotten health exams, we've done this many walks, we've done xyz". There could be arranged activities to get people involved, like facilitating group walks. It gets people involved and has more value. There's a coordination of the groups that makes it much more worthwhile. MPT has many activities that people can do but they need to get it out to companies and have them promote it within their employees, then it would really help the parks and the health benefits.

We need to build a program that is a package deal, where its set up so that people can go through and check a list, to bolster an already existing program in one of our organizations. Suggest we start with what's there [for parks' activities], build on that, and spread the word to businesses.

Are we missing anything in today's discussion?

We need to determine if we are underinvested in some of our shared areas? Are there places that we need to further investment because they're lacking? We need to do this when looking ahead to 2013/2014 budget. Look for potential grant funding to jumpstart some of these ideas. For example, the big piece that's missing from the Restoration Action Plan is where's the funding coming from? We need help identifying sources and how to rally for support.

Organizationally we want to think about how to get the educational pieces and environmental pieces to come together. There are a lot of monitoring things as well, water quality, animal surveys, etc. Anything you can think of, we want to know how the system is functioning. You have to look at all the features. That's why Puget Creek gets so many volunteers because there is so much interactions like this. Keep the people involved, so it isn't just a one and done deal. We want them to keep coming back. To show you how hungry people are for these things, my office used to receive phone calls all the time about people interested in these types of services. We have an average of 500 individuals coming to participate to every low-tide nature walk we had at the beach, and now we could focus on getting more educational partners involved.

We might be thinking about outreach opportunities. With MPT there are so many things, we don't need to invent new things, we can just connect better.

Recap of Key Questions for Future Focus

1. How do we better collaborate/coordinate on outreach?
2. How can this work inform state/local legislation?
3. How do we develop economic (and emotional) messages in cohesive fashion?
4. How do we simplify messaging?
5. How can we collaborate for funding initiatives?
6. What are new shared goals/vision?
7. How do we measure success?
8. How do you capture employee productivity?
9. How does the community fit into the landscape?
10. Can good health in parks be reflected in insurance rates?
11. Are we underinvested in certain areas?

About Earth Economics

Since 1998, Earth Economics has been providing science-based economic analysis for sound action in project and planning efforts. We apply ecosystem service and whole systems analysis to complex, multi-jurisdictional problems and use our findings to create accounting and funding mechanisms for shifting investments towards building sustainable economies. By using systems modeling, GIS mapping and new science-based economic tools, combined with financial and accounting analysis, we are able to help decision makers, business leaders and the public recognize that intact ecosystems provide immense value to regional and local economies. We have a track record of developing case studies, piloting tools and delivering solutions that can be adapted and applied nationally and internationally. We are a 501c3 non-profit proudly based in Tacoma, Washington.

Mission Statement:
Earth Economics applies new economic tools and principles to meet challenges of the 21st century: achieving the need for just and equitable communities, healthy ecosystems, and sustainable economies.

Program Work:

- Ecosystem Service Valuations: Working with public, private and NGO agencies, Earth Economics' Ecosystem Service Valuation (ESV) studies quantify the value of the goods and services provided by regional ecosystems. This valuation justifies the shift of investment toward environmental preservation and/or restoration.
- Economic Environmental Impact Statements: Working with planners, policy makers and private consulting firms, Earth Economics provides justification for specific projects and scenarios based on environmental economic analysis.
- Jobs Analysis: Working with local and regional economists, agencies, businesses and jurisdictions, Earth Economics analyzes the jobs that will be created, maintained, or lost by doing or not doing a project.
- Accounting and Management Strategies: Working with public utilities, businesses, large land owners and managers, Earth Economics identifies, and helps clients adopt, new management approaches that value ecosystem services in addition to built infrastructure and raw materials.
- Scenario Mapping and Modeling: Working with leading systems modelers, ecologists and hydrologists,
- Earth Economics analyzes ecosystem services such as freshwater provisioning, carbon sequestration, flood protection, biodiversity and hurricane protection. This information is used to provide current and future maps showing ecosystem services provisioning, beneficiaries and damage under different planning scenarios.
- Funding Mechanisms for Conservation and Restoration: Working with local and state jurisdictions, Earth Economics applies innovative approaches to fund critical natural infrastructure and conservation work.
- Educational Outreach: Working with philanthropic organizations, environmental and policy NGOs, schools and public agencies, Earth Economics conducts workshops, lectures and media events to increase awareness about ecological economics.
- Conversion to Sustainability: Working with the electronic recycling industry, paper mills and other industries, Earth Economics helps catalyze the shift from unsustainable to sustainable technology and industrial processes.
- Further Valuation Studies: Working with academics from around the world, Earth Economics is continually upgrading and refining our Benefit Value Transfer tool and ESV Study Database to ensure the most up-to-date appraisals possible.

EARTH ECONOMICS

What is your planet worth?

Earth Economics
1121 Tacoma Avenue South
Tacoma, WA 98402

www.eartheconomics.org
253.539.4801