Economic Arguments for Protecting the Natural Resources of the East Buttes Area in Southeast Portland

FINAL REPORT

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EXECUTIVE SUMMARY

The East Buttes study area is bounded by Powell Boulevard to the north, the southern extent of the Johnson Creek watershed to the south, I-205 to the west, and the portion of Pleasant Valley within the City boundary to the east. Some of the largest remaining tracts of riparian and upland habitat within Portland city limits are located within these boundaries. These resources provide ecological benefits, including habitat for native salmon and trout species. Uncontrolled stormwater running off expanded areas of impervious surfaces and development in the flood zone increases risks to these resources. This report documents the economic benefits to City of Portland (City) residents, businesses and municipal-service providers of protecting the area's natural resources and associated ecosystem services. Discussion of these benefits is organized into four arguments that support protection:

1. **Protection reduces flood and landslide risks to private property, public infrastructure, and commerce.** The East Buttes area includes topography and drainage patterns that pose risks to private property and economic commerce. Landslides threaten development on, above, and below steeply-sloped areas. Floods frequently occur within the Johnson Creek floodplain, damaging residences, businesses, and roads. Increasing development and impervious surfaces in risk-prone areas will exacerbate stormwater-related landslide and flood problems, putting more properties at risk and adversely impacting public infrastructure and services. The increased volume of stormwater generated by increasing expanses of impervious surfaces in the upland areas of the East Buttes will, in turn, increase landslide and flooding risks downstream from the study area. Protecting the forests, meadows, and riparian areas within the East Buttes area will help minimize the costs associated with flooding and landslides.
2. **Protection reduces public expenditures on stormwater planning, design, and maintenance; hazard mitigation and cleanup; and developing land-use guidelines that attempt to addresses the area's challenges associated with stormwater flows, flooding and landslides**. The East Buttes' steep topography poses challenges for stormwater management. Controlling stormwater from developed properties in these areas involves complex engineered solutions, and in some cases is not technically or economically feasible. Developing stormwater management controls in problem areas can take significant amounts of City staff time and budget. Mitigating current problems, cleaning-up stormwater-related erosion and flooding, and developing permitting guidelines to address these problems also take significant amounts of City resources. Protecting the area's capacity to manage stormwater naturally will help reduce the amount the City spends on stormwater planning, construction, maintenance, and post-disaster clean up.

3. **Protection preserves the value of prior public investments in the Johnson Creek watershed.** The City of Portland, Metro, the Johnson Creek Watershed Council, Reed College and the 40-Mile Land Trust, among other groups, invest in projects that protect and enhance recreational access and watershed health (i.e., reduce flooding, improve water quality, enhance habitat). Development in sensitive areas of the East Buttes that contributes to flooding, erosion, siltation and other stormwater-related problems, threatens these investments.

4. **Protection preserves and enhances the value of ecosystem goods and services provided by the East Buttes' natural resources.** The natural resources found within the East Buttes area include upland forests and meadows that cover the butte tops, and lowland wetlands, forested riparian areas, and floodplain that surrounds portions of Johnson Creek and associated wetlands. These resources provide an array of ecosystem goods and services. These ecosystem goods and services are important to people, and hence, have economic value. We describe values of eight ecosystem goods and services provided by the natural resources in the East Buttes area:

    - Water storage and release
    - Aquatic and terrestrial habitat
    - Nutrient and pollutant filtration
    - Soil retention and erosion control
    - Local climate regulation
    - Global climate regulation
    - Scenic and aesthetic amenities
    - Recreational opportunities

    Protecting the East Buttes, particularly forested areas, helps secure the availability of these eight ecosystem goods and services.

Table 1 summarizes the values associated with each of these economic arguments for protection. These quantified values underestimate the total value of protecting the East Buttes' natural resources for two reasons. First, in some cases data do not exist or are not available that describe the biophysical attributes that generate economic value (e.g., the number of salmon that benefit from a given protection effort). Second, in some cases, data on biophysical or other relevant attributes exist and are available, but data on economic values are not available or economists have not yet calculated values for these attributes (e.g., complete data on the economic importance of actions that mitigate global climate change).

Protecting the East Buttes' natural resources through acquisition, regulatory measures, conservation easements, restoration, and other programs can produce a variety of benefits. Because many of the benefits arise from preserving the area's natural ability to attenuate stormwater runoff, the City may be able to maximize its investments by targeting areas where there are few technically feasible options for meeting stormwater management and drainage requirements. While there are numerous tools available to protect these resources, land-acquisition programs, such as the Johnson Creek Willing Seller

Program, and land use regulations, such as environmental overlay zones, are among the most effective means of protecting the value of important natural resources and affected properties and minimizing stormwater-related risks.

Table 1. Summary of the Values Associated with the Economic Arguments for Protection

Economic Argument	Description of Value	Value[a]
Reducing flood and landslide risks to private property, public infrastructure, and commerce.	Costs incurred from damage in the study area from the 1996 flood.	$728,000
	Costs incurred from damage downstream of the study area from the 1996 flood.	$5.4 million
	Costs of damage in and downstream of the study area from the 1995 flood.	$318,000
	Costs of damage in and downstream of the study area from the 1994 flood.	$395,000
Reducing public expenditures on planning, construction, maintenance, and clean up.	Partial costs of soil disposal and city staff time spent cleaning up, repairing, and reconstructing stormwater controls, mid-1997 to 2008.	$364,968[b]
	Partial costs of city staff time spent on stormwater planning for one potential development in the East Buttes study area.	$42,000
Preserving the value of prior public investments in the Johnson Creek watershed.	Partial costs of restoration and recreation trail projects in the study area.	$27.8 million
Preserving and enhancing the value of ecosystem goods and services.	*Water storage and release:* avoided costs of reduced flooding. Value of increased stream flows to support salmonid habitat.	$6.1 million Unquantifiable at this time
	Habitat for aquatic and terrestrial species: protection of wetlands, value of habitat for bird watching, and value of protecting cutthroat trout.	$33,000 $3.3 million $1.7 million
	Nutrient and pollutant filtration: annual avoided healthcare costs associated with pollutants assimilated by trees.	$240,000
	Soil retention and erosion control: avoided costs associated with reduced sedimentation.	$37,600
	Local climate regulation: annual avoided costs associated with cooling.	$16,000
	Global climate regulation: annual value of sequestered carbon.	$91,896
	Scenic and aesthetic amenities: increased property values from parks and tree canopy.	$39.5 million
	Recreational opportunities: value of biking on the Springwater Corridor Trail in the study area.	$2 million

Source: ECONorthwest

[a] All values in 2008 dollars, except where otherwise noted.
[b] Value in unadjusted (nominal) dollars. The total value includes costs incurred between 1997 and 2008.

I. INTRODUCTION

A. Study Purpose

The East Buttes area of southeast Portland contains a mix of developed neighborhoods and commercial areas, interspersed with some of the largest parcels of undeveloped high-quality riparian and upland wildlife habitat inside Portland city limits (see Description of the Study Area on page 2, and the map in Figure 1 at the end of this section). The upland areas also provide important wildlife habitat for some of Portland's sensitive species and the riparian habitat along Johnson and Kelley Creeks supports native salmon and trout species. The landscape is dominated by steep slopes and bottomlands, which are prone to landslides and flooding. Development occurs primarily in the relatively flat lowlands and along some of the ridgelines of the East Buttes. Natural hazards may constrain existing and future development in the area.

The purpose of this report is to present the information that must be considered in planning future East Buttes area development. It describes four economic arguments that support protecting the unique and important remaining natural resources in the East Buttes area. City staff will consider this information as they develop and implement habitat-protection plans.

The analysis described in this report is not an economic assessment of the costs and benefits of protecting vs. not protecting habitat in East Buttes. Rather, the analysis assumes that the City and partner organizations, have already decided to protect habitat based on other studies, processes, or determinations. The information in this report describes the economic benefits that protecting upland and riparian natural resources in the East Buttes area would provide.

B. Study Methodology

To complete the economic analysis, ECONorthwest and EnviroIssues worked with City staff to identify the unique or important aspects of the natural resources in the East Buttes area. City staff produced a list of reports, data and other relevant background information that describes the natural resources in the area, and the area's zoning, land use, and development attributes. We developed the four economic arguments presented in this report using this information. The arguments are described in detail in Section II.

Where possible, we quantified economic benefits using local data. When local data were not available, data and budget constraints that prevented quantification were noted. In these instances, results were considered from studies conducted in Oregon, the Pacific Northwest, or in a few cases, other parts of the U.S. The resulting estimates of economic benefits provide *insights* into the economic significance or importance of a given benefit, e.g., reduced public expenditures on flood protection, rather than a precise measure of the benefit.

When the available data were insufficient to quantify an economic benefit, the economic significance of the benefit is noted qualitatively.

The following subsection describes the East Buttes' natural resources, landscape features, zoning, and current planning conditions. This information is background to the discussion of the four economic arguments, which are detailed in Section II.

C. Description of the Study Area

1. Boundaries

The study area is located in southeast Portland and is approximately 6,545 acres in size. Powell Boulevard forms the northern boundary, and the southern extent of the Johnson Creek watershed forms the southern boundary. From west to east, the study area begins at I-205 and extends to the portion of Pleasant Valley within the boundary of the City of Portland. Figures 1 and 2, at the end of this section, show these boundaries, and some of the major landscape features within the study area.

2. Landscape Features

The "East Buttes" area gets its name from the prominent hills that rise over 500 feet above the valley floor in this part of southeast Portland. The study area contains two major buttes: Powell Butte, north of Foster Road, and immediately to its south, Clatsop Butte. These Buttes are part of a larger complex of volcanic buttes that extend to the south and east, beyond the City of Portland limits, and outside of the study area. Residential development occurs on the north and west sides of the East Buttes and along the tops of some of the ridgelines; however, the Butte tops and eastern reaches of the study area remain relatively undeveloped, covered with forest vegetation, clearings, and meadows.

Major Landscape Features

Natural Features
Powell Butte
Clatsop Butte & Boring Hills
Johnson Creek
Kelley Creek

Open Spaces and Parks
Beggars tick Wildlife Refuge
Leach Botanical Garden
Gilbert Park
Bundy Park
Clatsop Butte Park
Powell Butte Park
Willamette National Cemetery

Transportation
I-205
Powell Boulevard
Foster Road
SE 122nd Avenue
Springwater Corridor Trail

Johnson Creek runs through the study area, cutting a path between Powell Butte and the Boring Hills. The steep sides of the East Buttes serve as natural conduits for rainwater to reach Johnson Creek. Small creeks and streams have cut steep ravines into the East Buttes over thousands of years. The ravines convey rainwater from the tops of the East Buttes to the valley floor. To the west of Powell Butte and the Boring Hills, the terrain flattens out, and Johnson Creek's floodplain opens up into more dense urban development. This part of the study area is less wooded and more densely developed with residential, commercial, and industrial uses.

Several major transportation corridors cross the study area. In addition to the study-area boundaries of Powell Boulevard on the north and I-205 on the west, Foster Road runs east-west and

SE 122nd Avenue runs north-south through the center of the study area. Foster Road is an important east-west thoroughfare, connecting cities to the east, such as Damascus and Pleasant Valley, to Portland's city center. Barbara Welch Road, a primary local thoroughfare linking SE Clatsop Street to Foster Road, lies between the Boring Hills in a steep canyon. Stormwater runoff frequently exceeds the drainage capacity along these streets, creating flooding and traffic hazards. Similar stormwater problems affect many smaller streets throughout the study area. The uncontrolled flows also erode soils and transport sediment into the area's streams.

Numerous parks and open spaces are scattered throughout the study area. Publicly owned parks and open spaces (managed by Portland Parks and Recreation [PPR], Bureau of Environmental Services [BES], the Water Bureau, Multnomah County, and Metro) amount to 1,579 acres, or approximately 24 percent of the East Buttes area. Beggars-tick Wildlife Refuge, Leach Botanical Garden, Gilbert Park, Bundy Park, Clatsop Butte Park, and Powell Butte Park serve a variety of purposes, providing natural wildlife habitat, trails, and opportunities for rest, relaxation, and play. The Willamette National Cemetery, on the west end of the study area, is also open to the public. The Springwater Corridor Trail runs the entire length of the study area from east to west, roughly following Johnson Creek and its associated wetlands. This trail provides access for pedestrians and bicyclists directly into downtown Portland, as well as to local recreational opportunities. It also complicates the area's natural drainage patterns, forming a barrier in many locations that keeps stormwater from directly flowing from wetlands and the floodplain into Johnson Creek.

Natural Resources and Ecosystem Services

Natural Resources
Upland forests
Riparian forests
Grassy meadows
Wetlands
Year-round streams
Intermittent streams

Ecosystem Services
Flood mitigation
Aquifer recharge
Fish and wildlife habitat
Scenic amenities
Temperature control
Carbon sequestration
Recreation and education
Air pollution mitigation

Consequences of Disturbance
Landslides and erosion
Increased flooding
Reduced water quality
Loss of habitat
Loss of migration corridors
Reduced species diversity
Loss of scenic amenities
Risk to homes
Disinvestment in property
Damage to public infrastructure

3. Natural Resources and Ecosystem Services

The natural resources found across the East Buttes area include upland and riparian forest ecosystems, wetlands, meadows, and year-round and intermittent streams. Figures 3 and 4, at the end of this section, provide City of Portland Natural Resource Inventory (NRI) data for streams, floodplains and wetlands, as well as vegetation communities in the study area. These natural resources provide ecosystem services to humans and fish and wildlife species including moderating temperature, mitigating air pollution, sequestering carbon, providing habitat, and serving as a scenic and recreational amenity and as educational resources for local residents and others throughout the region.

The upland portions of the study area include the forested sides of the East Buttes and the open meadows on the Butte tops. Under natural conditions, the upland forested landscapes help mitigate flooding and erosion. The upper mulch layer of the forest floor, along with the trees, shrubs, and groundcovers, holds stormwater and releases it slowly over time.

Removing this layer and associated vegetative cover changes the stormwater hydrology so that stormwater runs across the soil surface rather than percolating into the ground. This runoff contributes to more frequent and rapid flooding in the surrounding streams. The upland forests and meadows of the East Buttes also support species diversity. They offer important stopover habitat for neo-tropical migratory birds and habitat for sensitive species, such as great horned owls, hawks, and coyotes.[1] These natural resources also provide habitat corridors connecting the riparian habitat of Johnson Creek with other habitat refuges to the south and east.

The lowland portions of the study area include wetlands and riparian forests surrounding Johnson Creek and its tributaries, including Kelley Creek. These natural resources provide important habitat for native and threatened or endangered fish species, such as coho salmon, cutthroat, steelhead, and rainbow trout, and lamprey.[2] Other sensitive species, including several salamander, toad, and frog species, also live in the lowland parts of the East Buttes area. Natural wetlands and floodplains along the streams help mitigate flooding and improve water quality by filtering pollutants and sediments. The streams and riparian vegetation also enhance the recreational experience for users of the Springwater Corridor Trail, which follows Johnson Creek.

4. Current Conditions in the Study Area

The following paragraphs describe current conditions of some of the natural resources in the East Buttes area.

Flooding

Parts of the study area are highly susceptible to flooding. Figure 3, referenced on the previous page, shows the 100-year floodplain of Johnson Creek. Properties within the floodplain flood frequently and risk future inundation and damage. Development upstream of the floodplain, including on the sides and tops of the East Buttes, can increase flooding risks downstream by expanding areas of impervious surface, which increases stormwater runoff into Johnson Creek. Due, at least in part, to an increase in impervious surfaces in the Johnson Creek watershed, less precipitation is needed to create a peak flood event and the basin is responding with higher peaks for a given amount of precipitation. That is, the creek is becoming "flashier."[3]

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[1] Johnson Creek Watershed Council. 2003. *Johnson Creek Watershed Action Plan: An Adaptive Approach.* Retrieved February 10, 2009, from http://www.jcwc.org/actionPlan/WAP10.30.03.pdf

[2] Tinus, E.S., J.A. Koloszar, and D.L. Ward. 2003. *Abundance and Distribution of Fish in City of Portland Streams.* City of Portland, Bureau of Environmental Services, Endangered Species Act Program and Oregon Department of Fish and Wildlife. December.

[3] City of Portland. 2005. *Johnson Creek Watershed Characterization* [Draft]. March. Retrieved June 24, 2008, from http://www.portlandonline.com/shared/cfm/image.cfm?id=75912; City of Portland, Bureau of Planning. 1991. *Johnson Creek Basin Protection Plan.*

Landslides

The City classifies portions of the East Buttes as slope and landslide hazard areas, shown in Figure 5, at the end of this section. Landslides can occur on steep slopes during storm events.[4] Land uses on or above steep slopes that remove natural vegetation and increase the saturation of soils also increase the risks of landslides and associated economic costs. Adding to this risk is the fact that the more commonly used stormwater best management practices (BMPs) that function properly on level sites may not function properly on steep slopes. Uncontrolled stormwater saturates soils and inundates local drainages, both of which can increase landslide risks.[5] Cuts into steep slopes for roads and driveways also increase slope instability and landslide risks.

Portions of Johnson Creek and its tributaries that have undercut stream banks and steeply-sloped banks may promote slumping and landslides. Land uses that change vegetation patterns and expand areas of impervious surfaces generate stormwater flows that increase the velocity and volume of peak flows in the area's streams. The resulting bank erosion can increase slumping and landslides into the stream.[6]

Climate change may alter patterns of precipitation in ways that increase the risk of both flooding and landslide hazards. The most recent predictions of the effects of climate change in the Pacific Northwest suggest that overall winter precipitation will increase and more precipitation will fall as rain during the winter months, increasing winter streamflows. Precipitation events are also expected to increase in intensity, with more rain falling over shorter periods of time. While the effects of these trends likely will be more pronounced in basins that receive both snow and rain during the winter, it is possible that predicted increases in precipitation during the winter months would negatively impact the frequency and intensity of flooding in the East Buttes area, and increase landslide hazards associated with saturated soils.[7]

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[4] Burns, S., W. Burns, D. James, and J. Hinkle. 1998. *Landslides in the Portland, Oregon Metropolitan Area Resulting from the Storm of February 1996: Inventory Map, Database and Evaluation*. Metro. August 27.

[5] Metro Regional Government (Metro). 1999. *Regional Hazard Mitigation Policy and Planning Guide*. June.

[6] Flood and Landslide Mitigation Work Group (FLMWG). 1996. *City of Portland Flood and Landslide Hazard Mitigation Plan*. October.

[7] Climate Impacts Group. 2008. *Climate Change Scenarios.* August 1. Retrieved October 7, 2008, from http://www.cses.washington.edu/cig/fpt/ccscenarios.shtml

Water Quality

Johnson Creek regularly receives a "very poor" rating on Oregon Department of Environmental Quality's (Oregon DEQ) Water Quality Index (OWQI), and is listed as water-quality-limited for temperature, fecal coliform, and toxics. The OWQI provides a general indication of water quality based on several parameters including temperature, dissolved oxygen, biochemical oxygen demand, pH, total solids, ammonia and nitrate nitrogen, total phosphorus and fecal coliform.[8] To improve water quality in Johnson Creek, the Oregon DEQ has established total maximum daily loads (TMDLs)[9] for three specific pollutants: pesticides (including dieldrin and dichloro-diphenyl-trichloroethane [DDT]), bacteria, and temperature. It is currently developing TMDLs for polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs).[10] Other water quality problems include high sediment load, low summer flows, and concentrations of pollutants such as heavy metals.

Tree Canopy

There are currently 2,013 acres of tree canopy in the study area. This represents approximately 30 percent of the 6,545-acre study area, and is higher than the city-wide tree canopy coverage of approximately 24 percent (not including Forest Park). Between 1972 and 2002, the overall tree canopy coverage has increased slightly in the East Buttes area, with a greater increase (5 to 10 percent) in the western and northern part of the study area, and a smaller increase (1 to 5 percent) in the eastern and southern part of the study area. Between 1991 and 2002, however, the southeastern portion of the study area experienced a small decline (1 to 5 percent) in canopy cover. This decline is consistent with trends occurring in other outlying areas of Portland during this time period.[11] Figure 6, at the end of this section, shows the changes in tree canopy coverage in the East Buttes area for 1972 to 1991 and 1991 to 2002.

Hazard Areas

Potential landslide hazard
These areas fall within zones of high landslide potential, including slopes of 15 percent or greater. Seven percent of the study area falls within this designation.

Potential flood hazard
These areas fall within the 100-year flood plain and have repeatedly flooded. Approximately eight percent of the study area falls within this designation.

Potential wildfire hazard
Areas surrounded by natural vegetation subject to wildfire risk. Forty-two percent of the study area falls within this designation.

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[8] Oregon Department of Environmental Quality. No Date. *Oregon Water Quality Index Report For Lower Willamette, Sandy, and Lower Columbia Basins, Water Years 1986-1995.* Retrieved October 6, 2008, from http://www.deq.state.or.us/lab/wqm/wqindex/lowillsandy.htm

[9] A TMDL is the calculated pollutant amount that a waterbody can receive and still meet Oregon water quality standards. *See* Oregon Department of Environmental Quality. No Date. http://www.deq.state.or.us/WQ/TMDLs/TMDLs.htm.

[10] Johnson Creek Watershed Council. 2008. *Johnson Creek: The State of the Watershed.* Spring. Retrieved October 6, 2008, from http://www.jcwc.org/pdf/JCWC_SoW2008Spring.pdf

[11] Poracsky, J. and M. Lackner. 2004. *Urban Forest Canopy Cover in Portland, Oregon, 1972-2002: Final Report.* Portland State University, Geography Department, Cartographic Center. April.

Zoning Code Descriptions

R10
Residential development with one unit every 10,000 square feet. Includes 22 percent of the study area.

OS
Open space land, intended to protect public and private areas of open, natural, and improved park lands. Includes 14 percent of the study area.

EP, p
Protection overlay zone, applied to areas that contain significant resources where development is rarely allowed. Includes 16 percent of the study area.

EC, c
Conservation overlay zone, applied to areas with important natural resources where "environmentally sensitive" development practices are allowed. Includes 19 percent of the study area.

5. Land Use Planning

The following paragraphs describe the regulatory measures taken by the City of Portland to protect property owners and natural resources in the East Buttes area.

Hazard Areas

The City has identified landslide, flood, and wildfire hazard areas in the East Buttes area, as previously referenced in Figure 5 at the end of this section. Nine percent of the study area contains slopes designated as potential landslide hazards. Also, eight percent of the study area falls within the 100-year floodplain. These areas are concentrated in the lowlands surrounding the East Buttes. Forty-two percent of the study area is considered high-risk for wildfires. Designating an area high risk for flooding, landslide, or wildfire activity does not necessarily restrict or prohibit development. Areas of the East Buttes have already been developed within these potential hazard areas.

Zoning

The map in Figure 7, at the end of this section, displays City of Portland zoning in the study area. North of Foster Road, zoning is primarily single-family residential, with some multi-family residential, commercial and industrial zoning. Residential zoning throughout much of the study area is designated as R10, which allows one housing unit per 10,000 square feet. Denser residential development and multi-family housing is allowed in the northern and western parts of the study area.[12] In Pleasant Valley, in the southeast corner of the study area, residential land will be zoned R7 when individual property owners choose to annex into the City of Portland. Until that time, it is zoned for less-dense development, and for farming and agricultural uses. The study area also contains land zoned as open space (OS), including large areas atop Powell Butte and within the Willamette National Cemetery, and smaller areas scattered throughout the area's neighborhoods.

The City's zoning rules help prevent and mitigate some of the impacts of converting undeveloped natural landscapes to residential and commercial uses. The study area falls within the Johnson Creek Basin Plan District (the Plan District), which was created in 1991 to help protect Johnson Creek, its tributaries, and its surrounding landscape. Within the Plan District, the City identified specific sites with particularly valuable or important habitat and functional qualities that contribute or could contribute to protecting and improving Johnson Creek. In the *Johnson Creek Watershed Summaries of Resource Site Inventories*, which

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[12] City of Portland, Bureau of Planning. 2008. *Single Dwelling Zones.* Retrieved May 20, 2008, from http://www.portlandonline.com/planning/index.cfm?&a=64609&c=36238#R10

includes site inventories from the original 1991 *Johnson Creek Basin Protection Plan* and additional site inventories from the 1996 *Outer Southeast Community Plan* and the 1997 *Boring Lava Domes Supplement* to the *Johnson Creek Basin Protection Plan*, the City describes these areas and identifies the significant resource values they provide.[13]

Table 1 describes this information. The site description, in the left column of Table 1, shows the name of each unit inventoried in the Plan. The significant resource values, in the middle column of Table 1, describe the site's resources.[14] Although these site descriptions are now over ten years old and may be somewhat outdated, they indicate that there are many parcels of land within the East Buttes area, both publicly and privately owned, that harbor important natural resources.

Table 2. Descriptions of Important Sites in the Study Area Identified in the Johnson Creek Watershed Summaries of Resource Site Inventories, 1998

Site Description	Significant Resource Values
Site 14: I-205 East	Water, storm drainage, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient retention and removal, sediment trapping, interspersion.
Site 15: 106th-112th Unit	Water, storm drainage, scenic, fish and wildlife habitat, pollution and nutrient retention/removal, sediment trapping, recreation.
Site 16: Beggars-tick Marsh	Water, storm drainage, scenic, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient retention and removal, sediment trapping, recreation, education.
Site 17: 112th-117th Meadow	Water, storm drainage, scenic, fish and wildlife habitat and connection between Beggars-tick Marsh and Johnson Creek, pollution and nutrient retention and removal, sediment trapping, recreation.
Site 17.1: Johnson Creek (117th-122nd)	Water, storm drainage, nutrient retention, ground water recharge, retention of soils, microclimate amelioration, scenic amenities, recreation, and education.
Site 18: Leach Garden/Canyon	Water, storm drainage, scenic, fish and wildlife habitat, aesthetics, heritage, flood storage, pollution and nutrient retention and removal, sediment trapping, recreation, education.
Site 19: 127th – 131st	Water, storm drainage, fish and wildlife habitat, aesthetics, scenic, flood storage, pollution and nutrient retention and removal, sediment trapping

[13] City of Portland Bureau of Planning. 1998. *Johnson Creek Watershed: Summaries of Resource Site Inventories.* June.

[14] City of Portland Bureau of Planning. 1998. *Johnson Creek Watershed: Summaries of Resource Site Inventories.* June.

Site 20: Deardorf Road (West)	Water, storm drainage, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient retention and removal, sediment trapping.
Site 20.1: Johnson Creek at Canyon/ Deardorf Rd.	Water, storm drainage, scenic, fish and wildlife habitat and connection between Beggars-tick Marsh and Johnson Creek, pollution and nutrient retention and removal, sediment trapping, recreation.
Site 21: Deardorf Road (East)	Water, storm drainage, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient retention and removal, sediment trapping.
Site 21.1: Johnson Creek West of Bundy Park	Water, storm drainage, nutrient retention, ground water recharge, retention of soils, microclimate amelioration, scenic amenities, recreation, and education.
Site 22: Bundy Park Canyon	Water, storm drainage, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient removal, sediment trapping, recreation, education.
Site 22.1: Johnson Creek East of Bundy Park	Water, storm drainage, nutrient retention, ground water recharge, retention of soils, microclimate amelioration, scenic amenities, recreation, and education.
Site 23: Barbara Welch/Foster	Water, storm drainage, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient removal, sediment trapping.
Site 24: SW of Powell Butte (145th Ave. East)	Water, storm drainage, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient removal, sediment trapping.
Site 24.1: Johnson Creek SW of Powell Butte at 145th	Water, storm drainage, nutrient retention, ground water recharge, retention of soils, microclimate amelioration, scenic amenities, recreation, and education.
Site 25: South of Powell Butte	Water, storm drainage, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient removal, sediment trapping.
Site 26: SE of Powell Butte	Water, storm drainage, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient removal, sediment trapping.
Site 26.1: Tributary at Foster & Jenne Roads	Flood storage, storm drainage, filter and purification of water, food cover and territory for wildlife, ground water recharge, microclimate amelioration, sediment trapping, and air quality protection.
Site 27: Jenne Road-Northwest	Groundwater recharge, aesthetics, pollution and nutrient retention and removal, sediment trapping.
Site 27.1: Johnson Creek at Circle Avenue	Water, storm drainage, nutrient retention, ground water recharge, retention of soils, microclimate amelioration, scenic amenities, recreation, and education.

Site 27.2: Johnson Creek at Jenne & 174th	Water, storm drainage, nutrient retention, ground water recharge, retention of soils, microclimate amelioration, scenic amenities, recreation, and education.
Site 27OJ: Jenne Road-Southwest	Water, storm drainage, fish and wildlife habitat, aesthetics, flood storage, pollution and nutrient retention and removal, sediment trapping.
Site 29: Powell Butte	Water, storm drainage, aesthetics, scenic, pollution and nutrient retention and removal, sediment trapping, recreation, education, heritage.
Site 29.1: North Slope of Powell Butte	Wildlife habitat, ground water recharge and discharge, erosion control, water purification, storm drainage, microclimate amelioration, air and water quality protection, neighborhood livability, scenic amenities, geologic values, recreation, and education.
Site 30: Boring Lava Domes	Water, storm drainage, wildlife habitat, aesthetics, scenic, flood storage, pollution and nutrient retention and removal, sediment trapping.

Source: ECONorthwest, with data from City of Portland, Bureau of Planning. 1998. *Summaries of Resource Site Inventories.*

Many of the areas listed in the left column of Table 1 were subsequently designated with special status as "environmental overlay zones," under the City's zoning code. These zones primarily overlay land currently zoned as residential in the study area. A small portion of industrially-zoned properties have environmental overlays as well. The Environmental Protection overlay zone (marked on the zoning map with a "p") applies to 934 acres or 14 percent of the residentially-zoned land in the study area. This designation, which provides the most protection for natural resources, applies to areas that the City has determined contain "significant resources and functional values." The City rarely approves development in these areas.[15] An additional 1,074 acres or 16 percent of the residential land falls under the Environmental Conservation overlay zone (marked on the zoning map with a "c"). The purpose of this designation is to conserve important natural resources and functional values, while also allowing environmentally-sensitive urban development and mitigation for impacts to the resource.[16]

Since 1998, some of the lands zoned for environmental protection and environmental conservation have been developed while others remain in approximately the same condition as described in 1998. Some properties have

[15] City of Portland. "Chapter 33.430, Environmental Zones." *Title 33, Planning and Zoning, Zoning Code.* Section 33.430.010. Retrieved May 20, 2008, from http://www.portlandonline.com/shared/cfm/image.cfm?id=53343

[16] City of Portland. "Chapter 33.430, Environmental Zones." *Title 33, Planning and Zoning, Zoning Code.* Section 33.430.017 Retrieved May 20, 2008, from http://www.portlandonline.com/shared/cfm/image.cfm?id=53343

been purchased by the City of Portland, Metro, or otherwise afforded permanent protection. The map in Figure 8, at the end of this section, shows the current configuration of the environmental conservation and protection overlay zones within the study area.

In 2005, Metro established new requirements that local cities and counties must meet to protect, conserve, and restore significant riparian corridors and wildlife habitat. The requirements are housed in Title 13 Nature in Neighborhoods, of the Urban Growth Management Functional Plan. Metro adopted a regional inventory of significant natural resources as part of this program.

The City has recently refined the Title 13 regional inventory for Portland. The refined inventory is built on the science and inventory methodology Metro used, and incorporates updated GIS data and guidance from additional scientific studies.

The City's draft inventory identifies 2,690 acres of significant riparian corridors and wildlife habitat in the study area. Approximately 87% of these resources areas receive a relative rank of high or medium for riparian and/or upland wildlife habitat functions. Approximately 13% of the inventoried resource area is assigned a low relative rank, including areas of isolated habitat patches and developed floodplain. Figure 9, at the end of this section, reflects rankings within the study area.

Approximately 1,901 acres are within existing environmental overlay zones. Almost 800 acres of inventoried resources are outside the existing overlay zones and currently have no land use protections. Figure 10, at the end of this section, illustrates these unprotected areas.

6. Development

Development in the East Buttes area increased significantly over the recent past and is expected to continue this trend in the near future. Pressure to develop will increase as Portland's population and economic activity increase and easily developable land becomes less available.

Between 2002 and 2007, landowners in the study area filed 187 applications to the City of Portland to divide their land, often the first step towards development. Owners of 72 of these properties have filed for building permits. The map in Figure 11, at the end of this section, shows the location of these land divisions and new building permits. New land divisions amount to 267 acres, or 4 percent of the study area. New building permits within these divided areas amount to 64.5 acres, or 1 percent of the study area.

New development in the study area must follow guidelines for controlling stormwater runoff, as established in the *City of Portland Stormwater Management*

Manual.[17] Due to the area's steep topography, however, development in this area inevitably causes hydrologic changes. Many of these changes increase the risks of flooding and landslides and increase City permitting and inspection costs, described in more detail in Section II.

Given the stormwater-management challenges that new development in the area creates, and given the high quality and unique attributes of the area's natural resources, the City and Metro identified this as a promising area for land acquisition to protect natural resources. Metro acquired several parcels in the study area through its Natural Areas Programs, most notably lands at the southern base of Powell Butte. Similar purchases protect large parcels on the tops of the Boring Hills. The City of Portland acquired large portions of the floodplain near Powell Butte and just East of I-205 through its BES Johnson Creek Willing Seller Land Acquisition Program. The map in Figure 12 displays land acquired by both the City of Portland and Metro.

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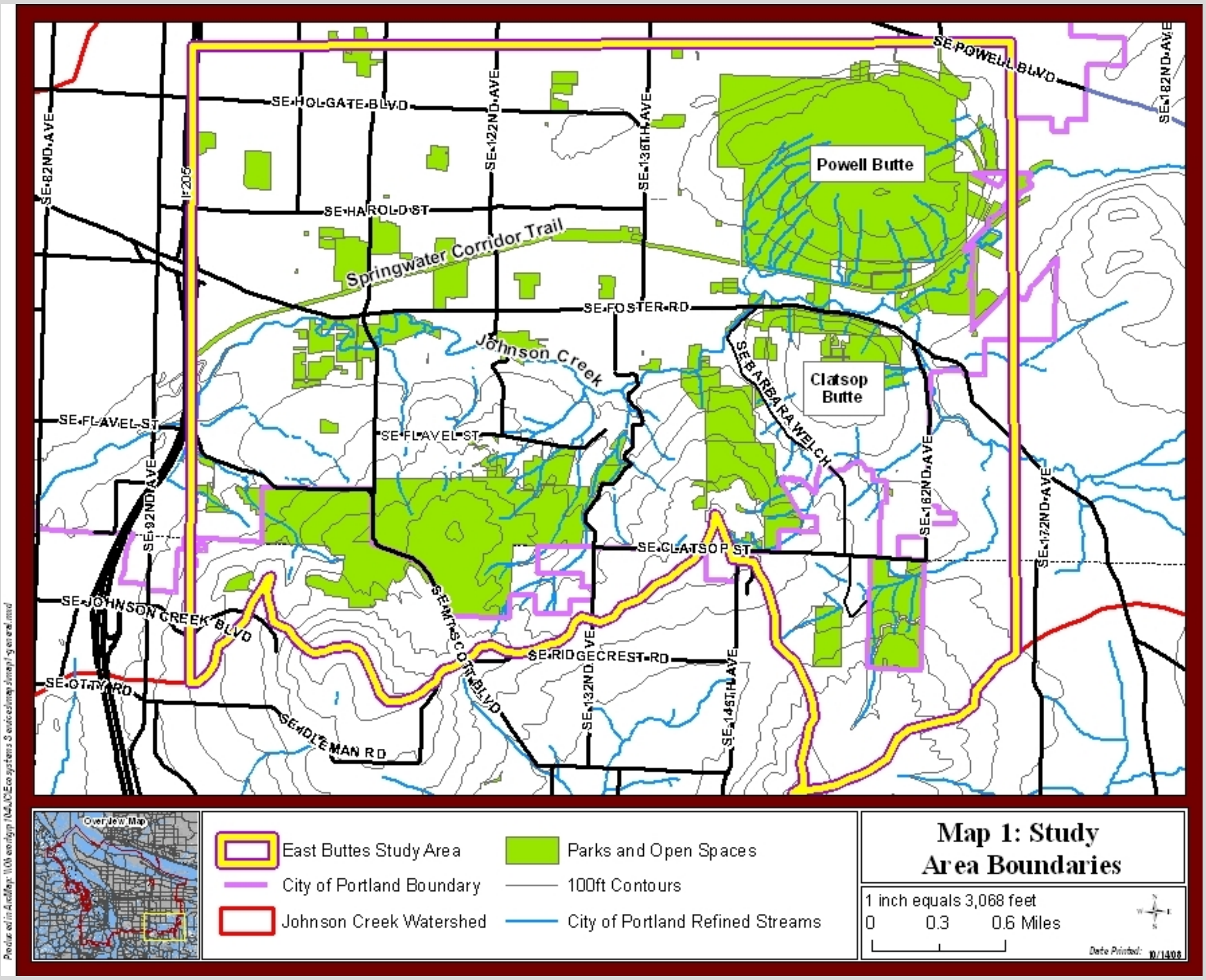
[17] City of Portland Bureau of Environmental Services. 2008. *City of Portland Stormwater Management Manual.*

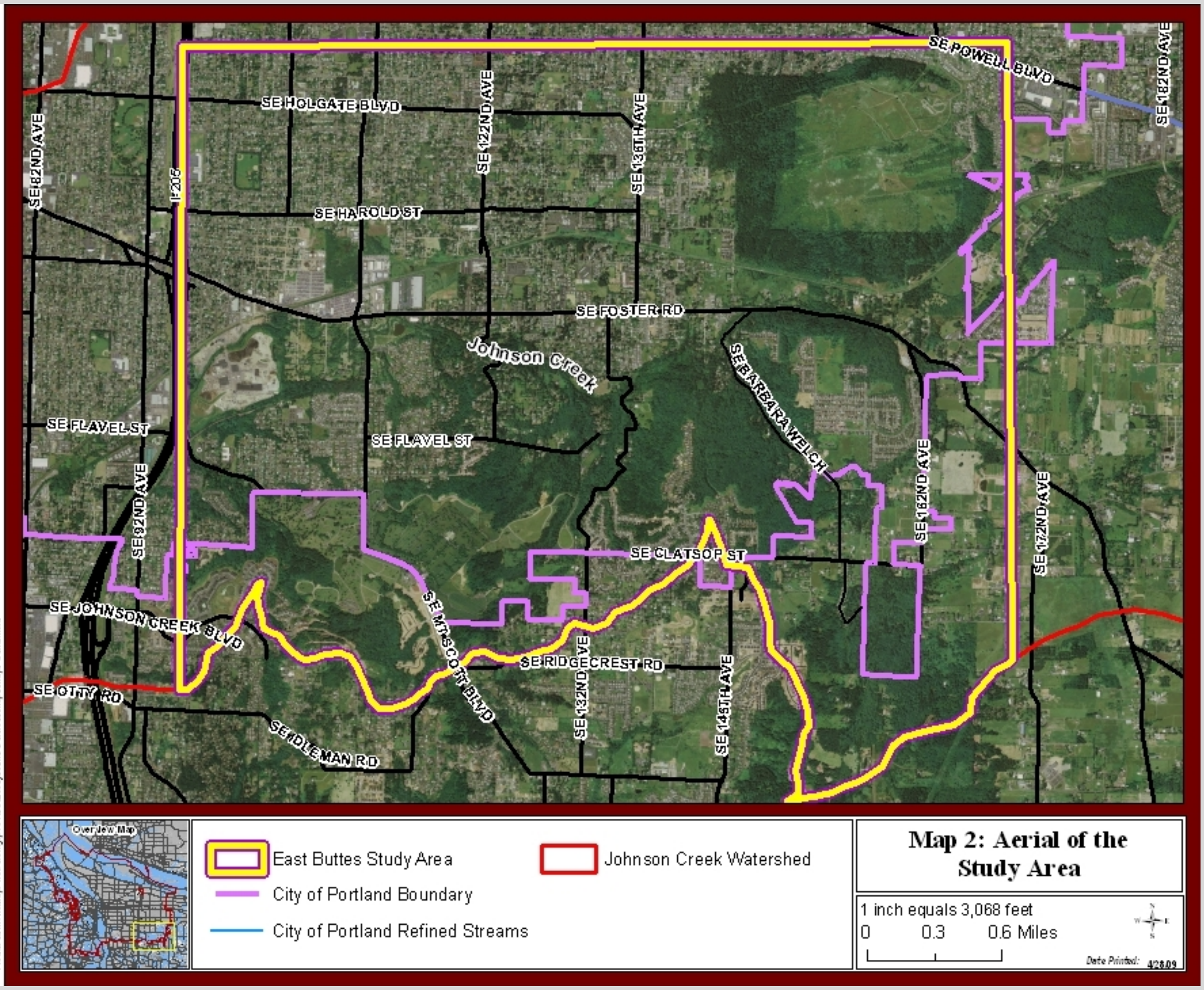
Figure 1. Boundaries of the East Buttes Study Area



Source: City of Portland, Bureau of Environmental Services

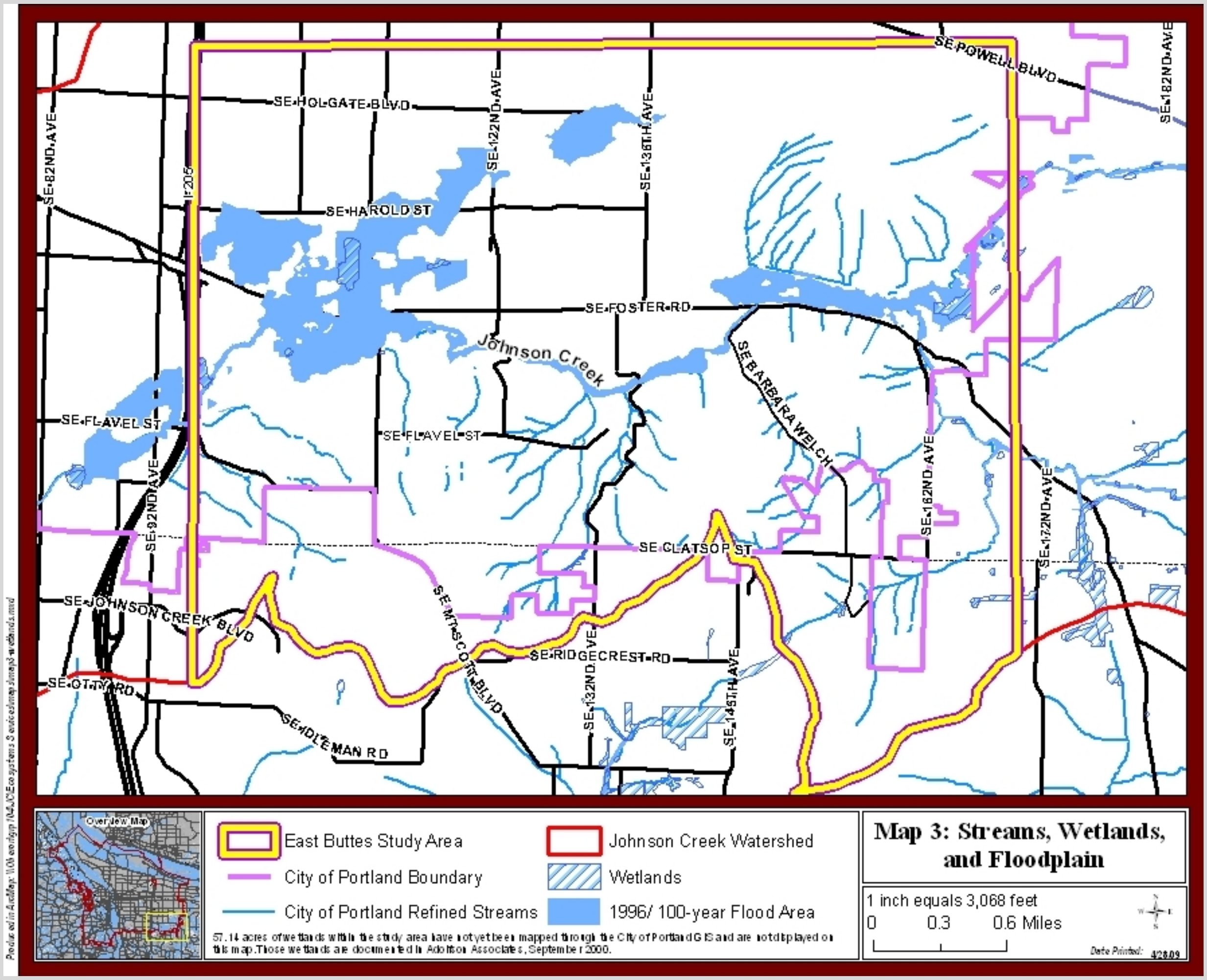
Note: "Refined streams" indicates that these data utilize the City of Portland refined inventory that is built upon the methodology utilized by Metro to refine its regional inventory of significant natural resources, and incorporates updated GIS data and scientific guidance.

Figure 2. Aerial Photo of the Study Area



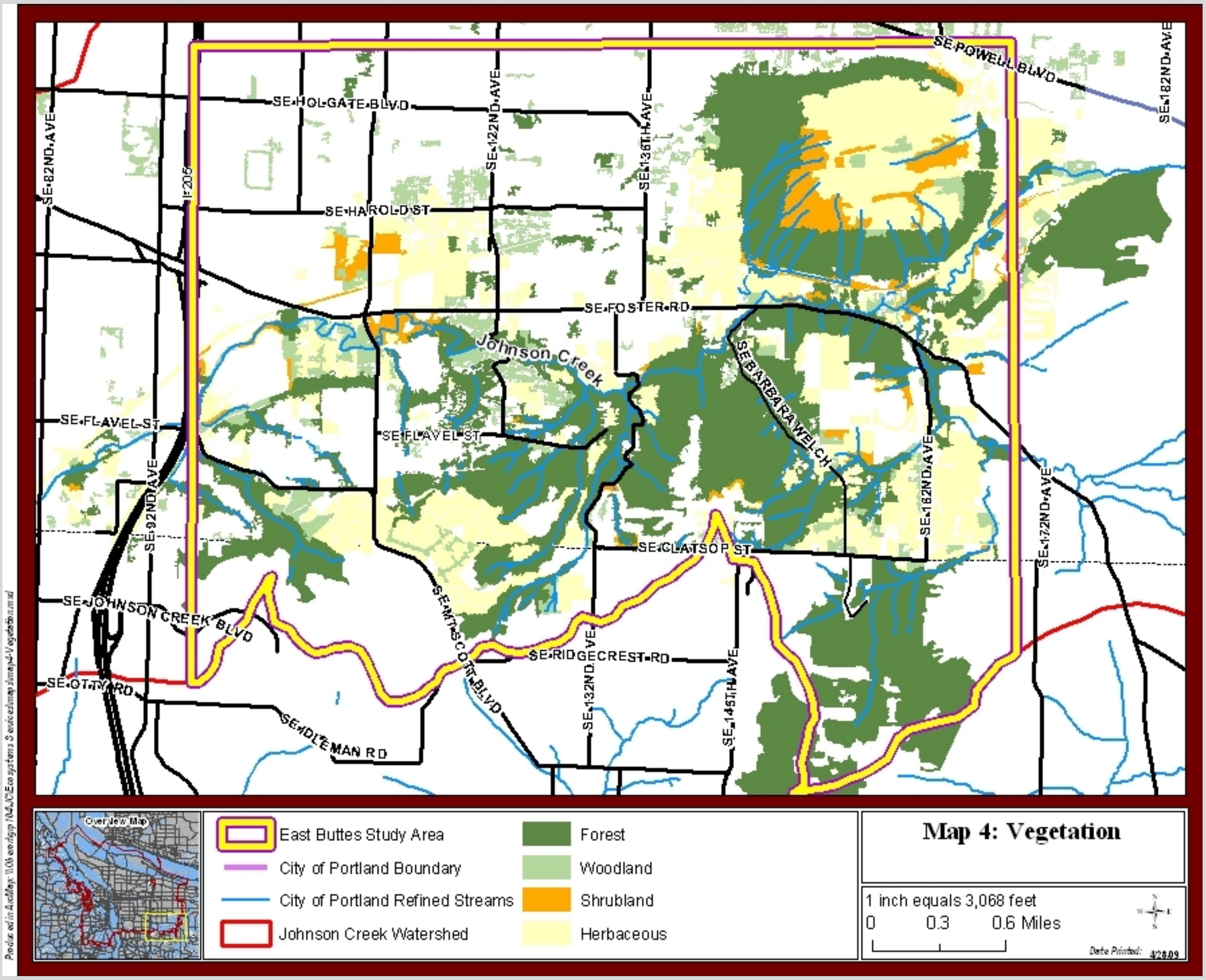
Source: City of Portland, Bureau of Planning and Sustainability

Figure 3. Stream, Wetlands, and Floodplains within the Study Area



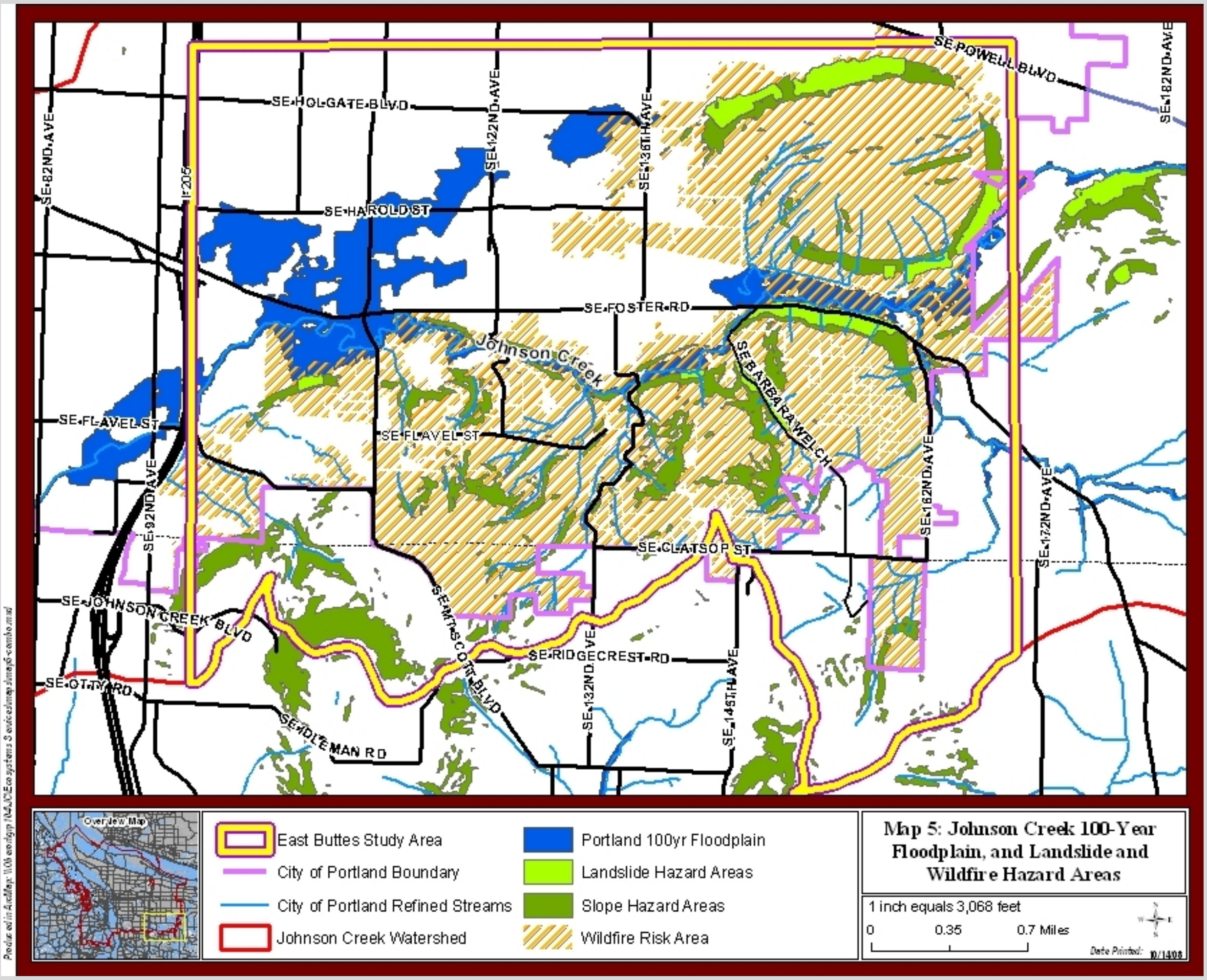
Source: City of Portland, Bureau of Planning and Sustainability

Figure 4. Vegetation Communities within the Study Area



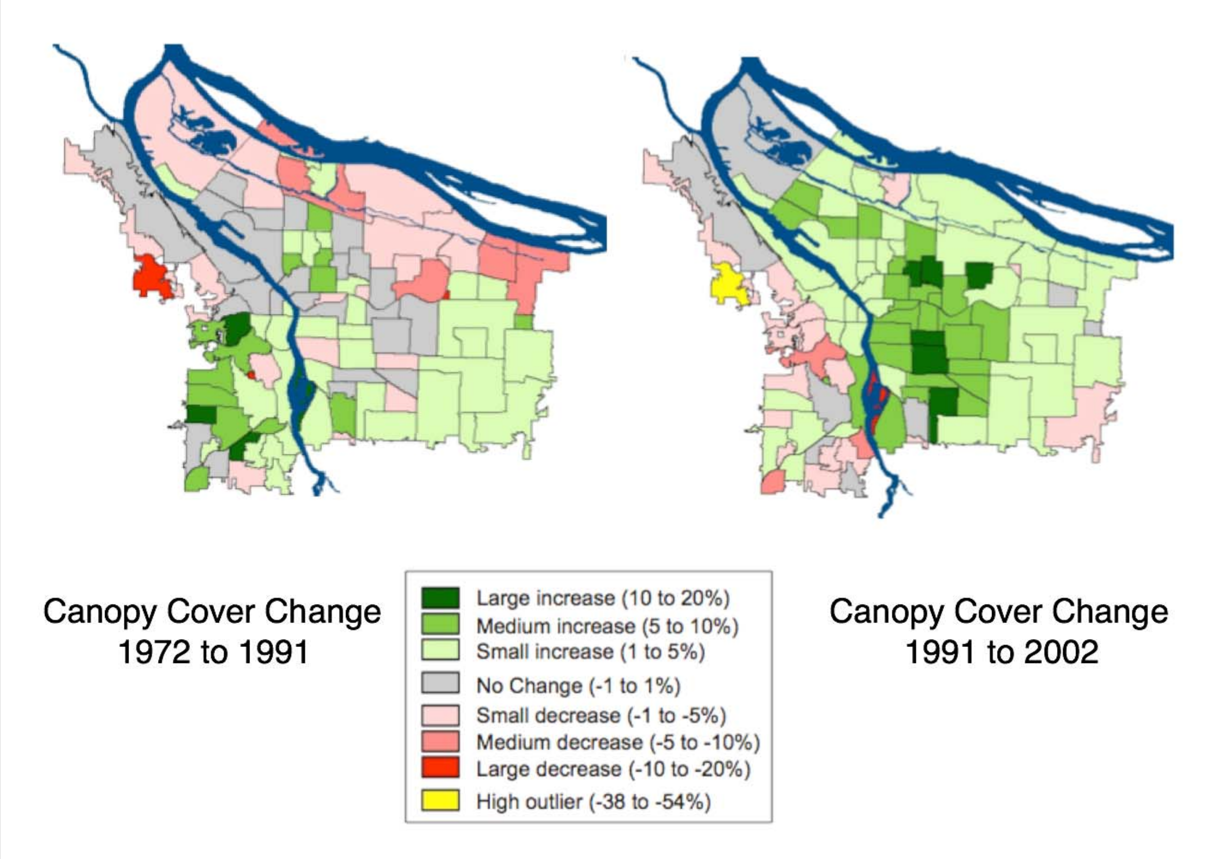
Source: City of Portland, Bureau of Planning and Sustainability

Figure 5. Landslide, Flood, and Wildfire Hazard Areas within the Study Area



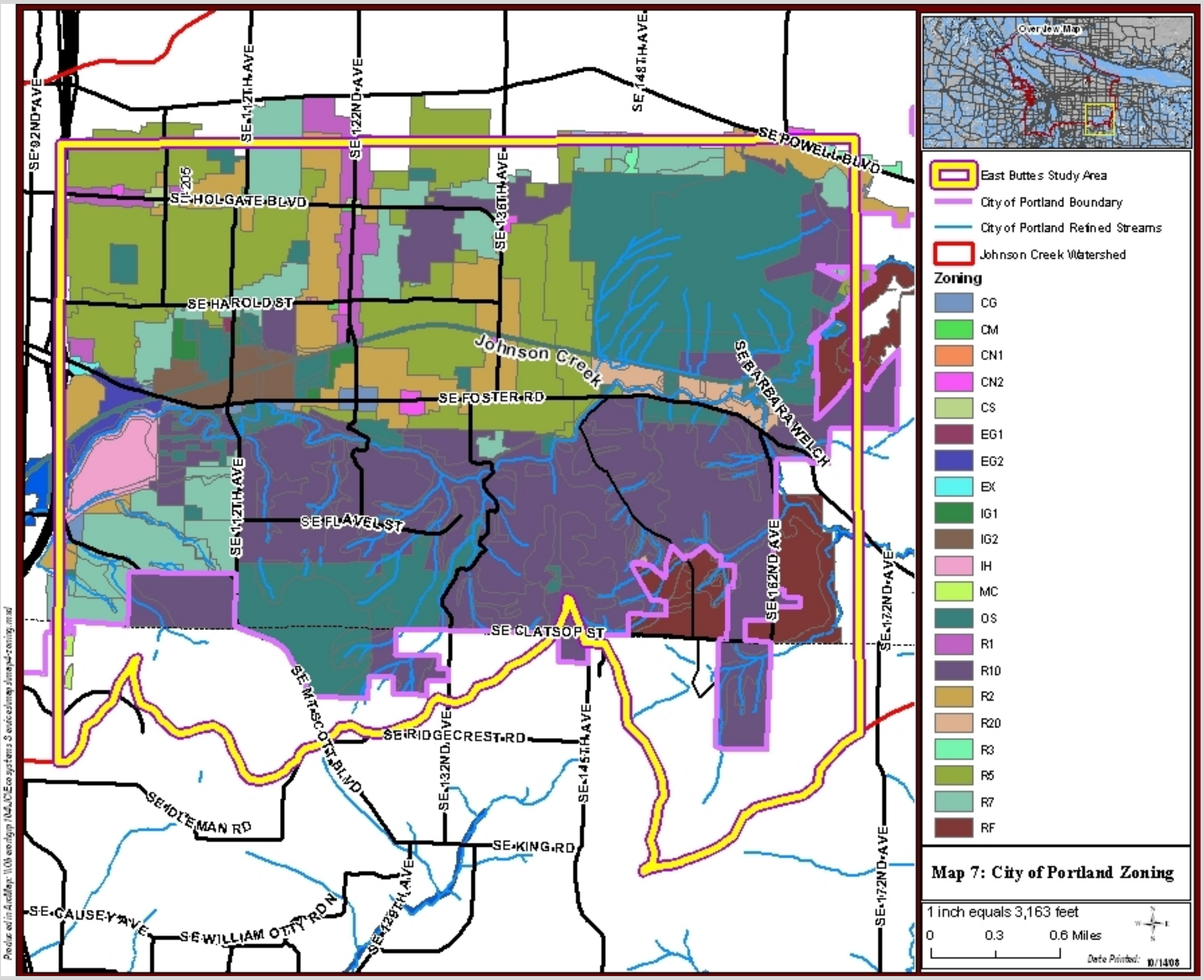
Source: City of Portland, Bureau of Environmental Services

Figure 6. Tree Canopy Coverage in Portland, 1972 to 1991, and 1991 to 2002



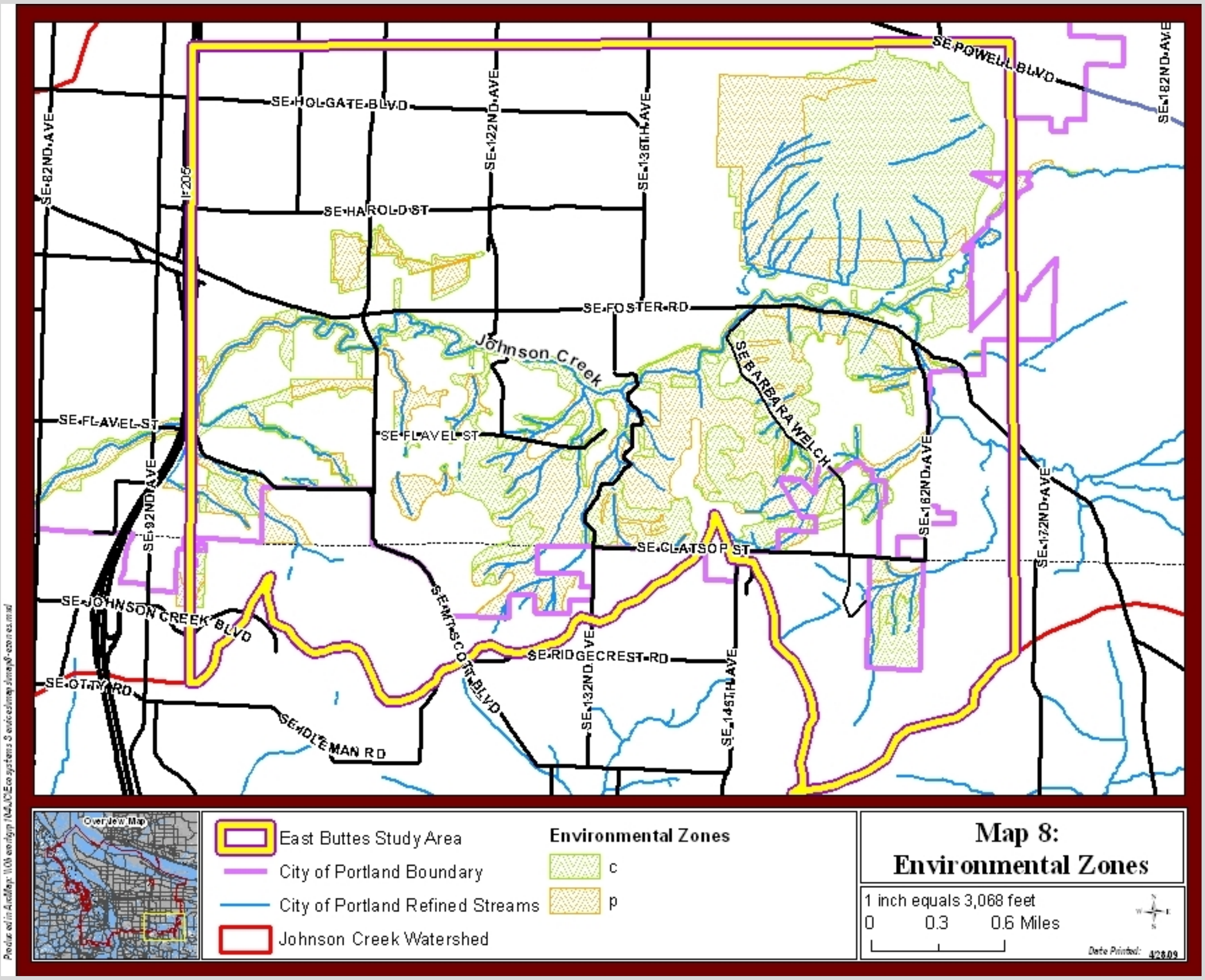
Source: Poracsky, J. and M. Lackner. 2004. *Urban Forest Canopy Cover in Portland, Oregon, 1972-2002: Final Report.* Portland State University, Geography Department, Cartographic Center. April.

Figure 7. City of Portland Zoning Designations within the Study Area



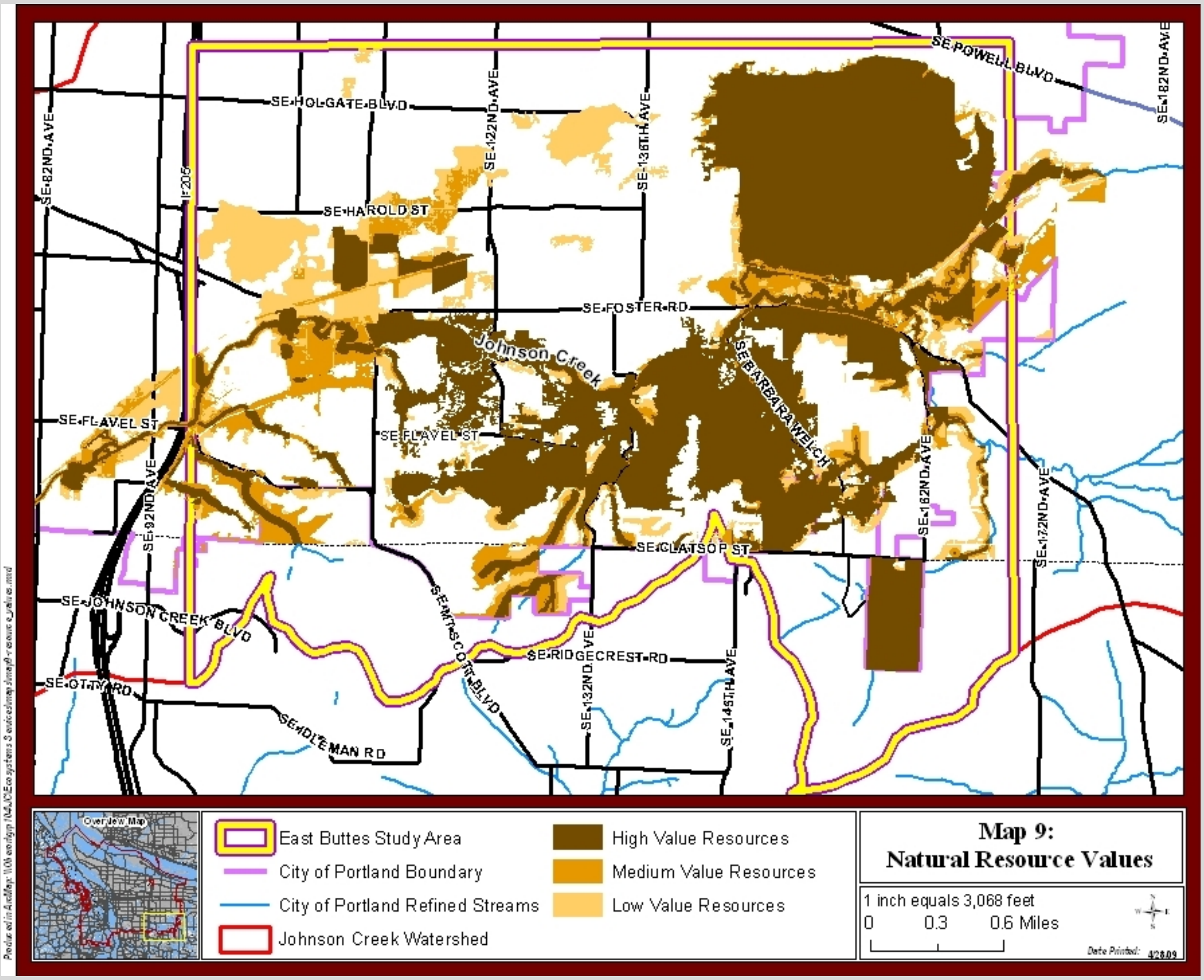
Source: City of Portland, Bureau of Environmental Services

Figure 8. Environmental Zones within the Study Area



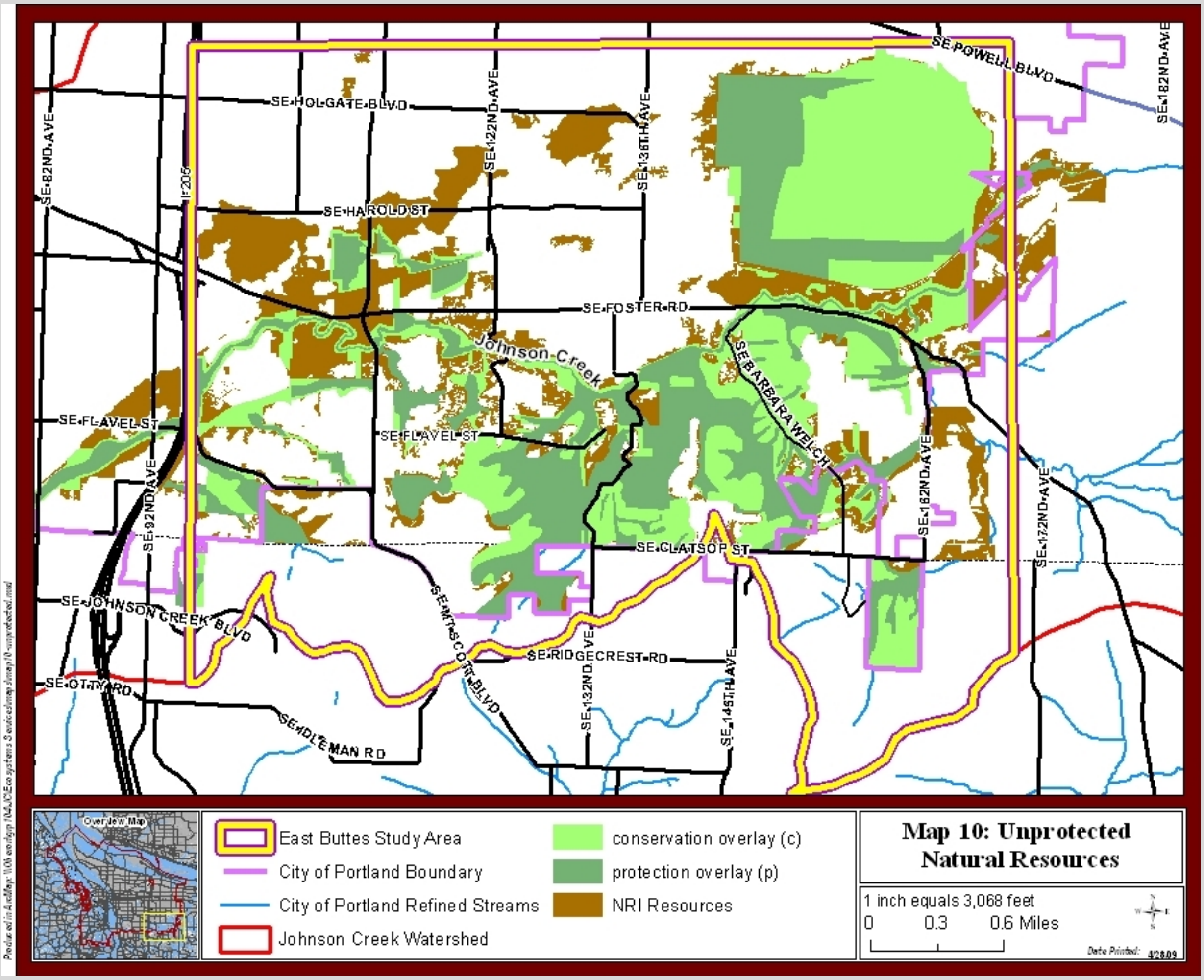
Source: City of Portland, Bureau of Environmental Services

Figure 9. Natural Resource Values within the Study Area



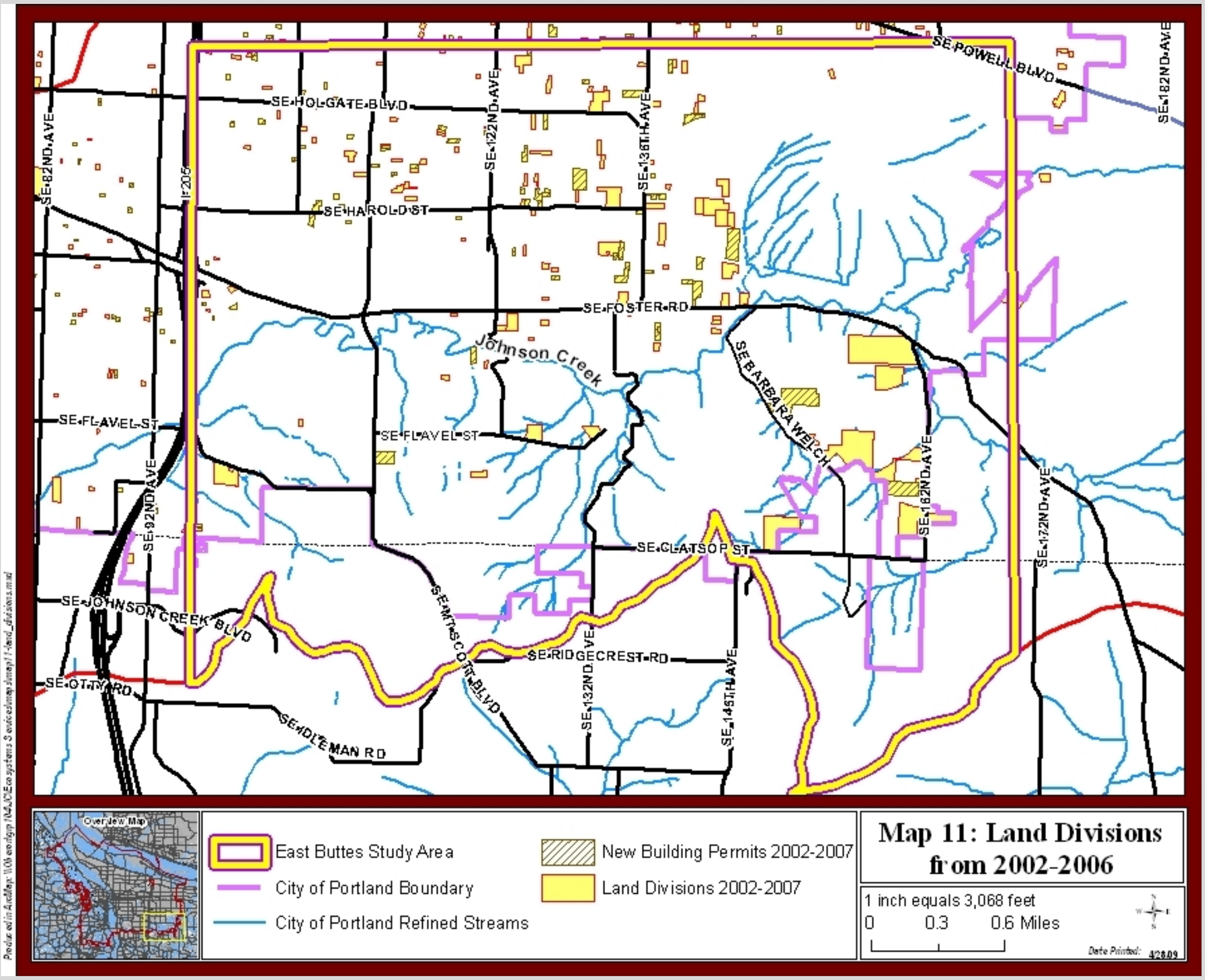
Source: City of Portland, Bureau of Planning and Sustainability

Figure 10. Unprotected Natural Resource Areas within the Study Area



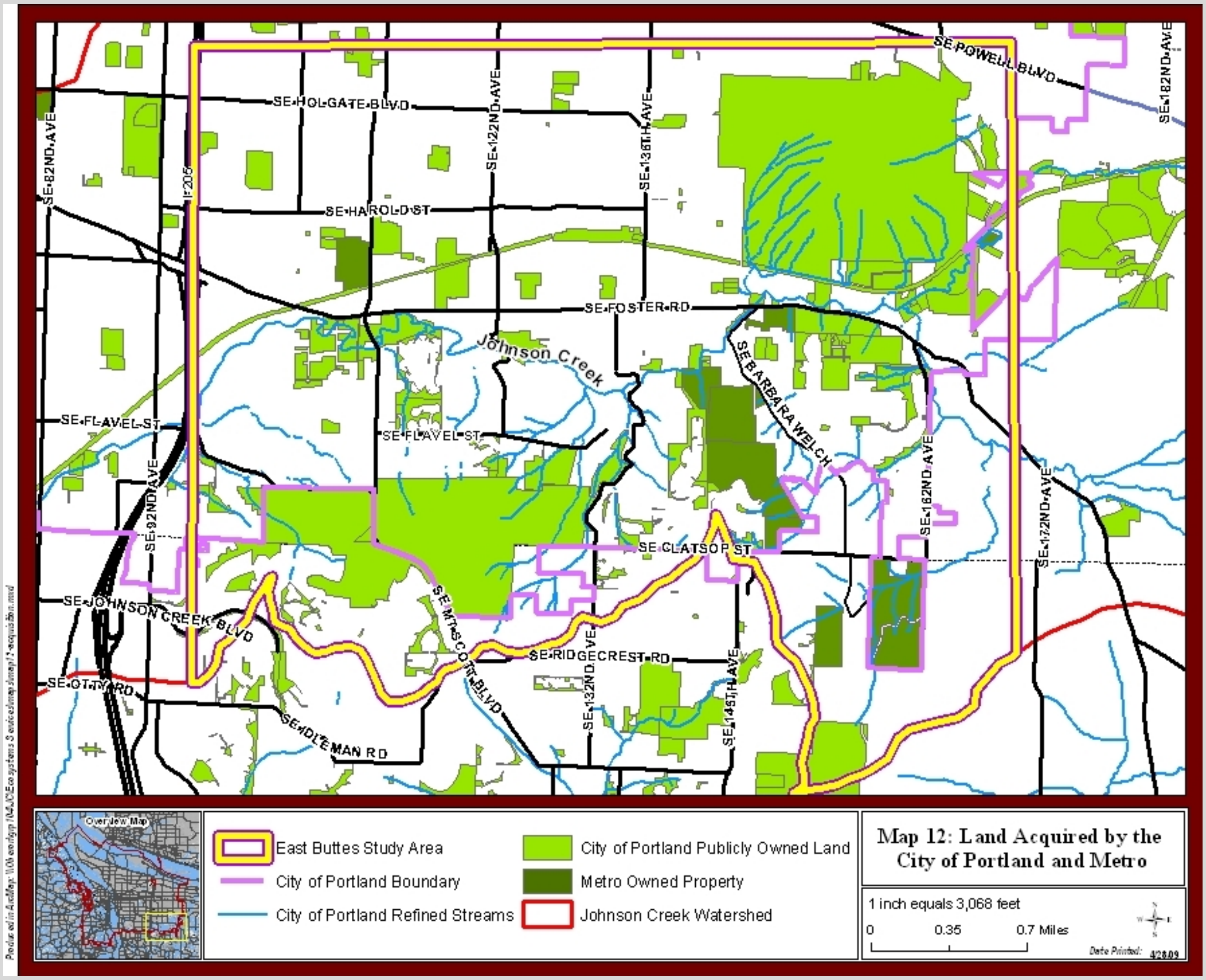
Source: City of Portland, Bureau of Planning and Sustainability

Figure 11. Land Divisions in the Study Area



Source: City of Portland, Bureau of Environmental Services

Figure 12. Land Acquired by the City of Portland and Metro within the Study Area



Source: City of Portland, Bureau of Environmental Services

II. Economic Arguments that Support Protecting Natural Resources in the East Buttes Area

Protecting natural resources in the East Buttes area will yield a range of economic benefits. These benefits form the basis of several economic arguments that support protecting the East Buttes' natural resources. This section presents four main arguments:

1. Avoiding increased flood and landslide risks to private property and commerce.
2. Reducing future public expenditures on stormwater management design, hazard mitigation, cleanup, and developing land-use guidelines that adequately addresses the area's risks of stormwater-generated flooding and landslides.
3. Protecting prior public investments in the Johnson Creek watershed.
4. Protecting the values of ecosystem services provided by the Butte's natural resources.

This section describes each of these arguments and, where possible, quantifies the associated economic benefits.

A. Avoiding Increased Flood and Landslide Risks to Private Property and Economic Commerce

As described in Section I-C, the East Buttes area's topography and drainage patterns pose risks to property and commerce due to the potential for flooding and landslides. Development, which increases impervious surface area, increases stormwater runoff and exacerbates these hazards.[18] In contrast, protecting at-risk properties and natural resources upstream from steeply-sloped or flood-prone areas can help control stormwater and minimize risks.[19]

Flooding

Johnson Creek has a long history of frequent flooding in several southeast Portland areas, including the Lents neighborhood and SE Foster Road. Flooding in these areas occurs, on average, every other year with heavy rains. Large

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[18] *See,* for example, Booth, D.B., B. Visitacion, and A.C. Seinemann. 2006. *Damages and Costs of Stormwater Runoff in the Puget Sound Region: Summary Report.* Puget Sound Action Team and University of Washington, Department of Civil and Environmental Engineering. August 30. Retrieved February 11, 2009, from http://www.psparchives.com/publications/our_work/stormwater/stormwater_resource/stormwater_management/SummaryReportPSATstormwaterFoundation_FINAL_08-30-06.pdf

[19] *See,* for example, Price George's County, Maryland, Development of Environmental Resources, Programs and Planning Division. 1999. *Low-Impact Development Design Strategies: An Integrated Design Approach.* June. Retrieved February 11, 2009, from http://www.epa.gov/nps/lidnatl.pdf

storms, such as those during February 1996, cause significant and widespread flooding and can create major damage including:

- Damage to homes, business, and roads.
- Failure of electrical systems.
- Health hazards from contacting contaminated water.
- Public safety problems.[20]

The 1996 flood was the seventh major flood in this area over the past 35 years.[21] The extent of this flood is displayed on the map in Figure 13, at the end of this section. A study of the damage caused by this flood—a flood statistically predicted to occur once every 25 years—found that in the stream reaches located within the present study area (from the I-205 bridge to SE 174th Ave), the costs incurred from damage to residential, commercial, and industrial properties was around $675,000. [22] Damage to roads and bridges in the study area amounted to another $7,150. US West and Portland General Electric spent about $39,000 to repair telephone lines and to shut down the sub-station in Lents. The study calculated additional costs for emergency services at 1 percent of the total costs incurred by residential, commercial, industrial, and public entities. For the study area this increases costs by $7,280.The total costs in the study area from this one flood event is over $728,000. Damage values at approximately $5.5 million, including damage to property and lost business during the flood, accrued downstream of the study area on Johnson Creek. These damages would have likely been less had the upstream ecosystems within the study area been able to retain more stormwater. Table 3 summarizes the costs associated with the 1996 flood both within and downstream of the study area.

Flooding occurs on a regular basis in this part of Portland, and several other studies describe the damages associated with floods in other years. Damages from the February 1994 flood within and downstream of the study area totaled about $394,617,[23] and from the November 1995 flood totaled $318,415.[24]

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[20] Flood and Landslide Mitigation Work Group. 1996. *City of Portland Flood and Landslide Hazard Mitigation Plan*. October.

[21] City of Portland. 2005. *Johnson Creek Watershed Characterization* [Draft]. March. Retrieved June 24, 2008, from http://www.portlandonline.com/shared/cfm/image.cfm?id=75912; City of Portland, Bureau of Planning. 1991. *Johnson Creek Basin Protection Plan.*

[22] Woodward Clyde Consultants. 1996. *Flood Damage Cost Estimate for Johnson Creek Flood Event, February 4-10, 1996.* City of Portland, Bureau of Environmental Services. April. Value adjusted to 2008 dollars.

[23] Economic Applications International, Inc. 1994. *Flood Damage Costs Calculations for Johnson Creek 5-Year Flooding Event, February 24, 1994.* May 2.

[24] Woodward Clyde Consultants. 1996. *Flood Damage Cost Estimate for Johnson Creek Flood Event, February 4-10, 1996.* City of Portland, Bureau of Environmental Services. April. Value adjusted to 2008 dollars.

Table 3. Summary Damage Within and Downstream of the Study Area from the 1996 Flood Event

Type of Risk	Economic Value
Within the study area	
Damaged homes and businesses	$674,669
Damaged roads and bridges	$7,150
Damage to utilities	$39,000
Emergency services (1% of total costs)	$7,280
Estimate of damage within study area:	*$728,099*
Downstream of the study area	
Damaged homes and businesses	$1.8 million
Lost business during and after flood	$2.2 million
Damaged parks	$51,000
Emergency services (1% of total costs)	$41,000
Estimate of damage downstream of study area:	*$5.4 million*

Source: ECONorthwest, with data from Woodward Clyde Consultants. 1996. *Flood Damage Cost Estimate for Johnson Creek Flood Event, February 4-10, 1996.* City of Portland, Bureau of Environmental Services. April. Value adjusted to 2008 dollars.

Landslides

A study of landslide hazards in the Portland area after the 1996 storm found that human actions contributed to 76 percent of the slides surveyed.[25] Damage and associated economic costs from landslides can include:

- Broken water mains and sewer pipes.
- Degraded road surfaces and damaged bridges and other transportation infrastructure.
- Siltation of streams and rivers, including threatened or endangered fish habitat, and blockage of City culverts.
- Destroyed homes and businesses and disrupted economic activities.[26]

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[25] Burns, S., W. Burns, D. James, and J. Hinkle. 1998. *Landslides in the Portland, Oregon Metropolitan Area Resulting from the Storm of February 1996: Inventory Map, Database and Evaluation*. Metro. August 27.

[26] Wang, Y., R.D. Summers, and R.J. Hofmeister. 2002. *Landslide Loss Estimation Pilot Project in Oregon*. State of Oregon, Department of Geology and Mineral Industries. Open-File Report No. O-02-05. Retrieved October 7, 2008, from http://www.oregongeology.com/sub/Landslide/O0205.pdf

Although several studies have characterized the landslide risk and described landslide mitigation measures in Portland, we are unaware of any studies that quantify damages associated with landslides in the East Buttes area. Metro, however, estimates that approximately 20 percent of the City-wide damages associated with the 1996 floods could be attributed to landslide losses.[27] The City of Portland estimates that in an average year, it spends approximately $375,000 to $550,000 on landslide-related costs.[28] These costs are not broken down by region of the city, so there is no way to know what percent of these expenditures are related to landslides in the East Buttes area.

Acquiring properties in flood zones and in slope- and landslide-hazard areas is the most effective means of avoiding future flooding and landslide damage and the associated economic costs. Additional benefits can come from protecting upland natural resources and maintaining natural stormwater-management capabilities, which help reduce flooding and landslide hazards.[29] Given the area's topography and hydrology patterns, developing these areas and increasing the amounts of impervious surfaces upstream and on slopes will have the opposite effect.

B. Avoiding Increased Public Expenditures on Mitigation, Cleanup, and Land Use Permitting

Given the lack of stormwater infrastructure, poor infiltration, and the current zoning and development expectations, there are few technically feasible options for meeting stormwater management and drainage requirements in the East Buttes area. Stormwater runoff from existing developments in and upslope of hazard areas can overwhelm drainage ways, flood roads, and inundate streams and rivers. Mitigating current problems, cleaning-up damage from erosion and flooding, and developing permitting guidelines to address these problems, takes significant amounts of City staff time and budget.

There are several locations in the study area that regularly experience erosion, flooding, and stormwater management problems. The map in Figure 14, at the

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27 Metro. 1999. *Regional Hazard Mitigation Policy and Planning Guide: Reducing Disaster Losses.* June.

28 Wang, Y., R.D. Summers, and R.J. Hofmeister. 2002. *Landslide Loss Estimation Pilot Project in Oregon*. State of Oregon, Department of Geology and Mineral Industries. Open-File Report No. O-02-05. Retrieved October 7, 2008, from http://www.oregongeology.com/sub/Landslide/O0205.pdf

29 *See* City of Portland, Bureau of Buildings. 1998. *Flood and Landslide Mitigation Plan Progress Report.* March.; Wang, Y., R.D. Summers, and R.J. Hofmeister. 2002. *Landslide Loss Estimation Pilot Project in Oregon*. State of Oregon, Department of Geology and Mineral Industries. Open-File Report No. O-02-05. Retrieved October 7, 2008, from http://www.oregongeology.com/sub/Landslide/O0205.pdf; Burns, S., W. Burns, D. James, and J. Hinkle. 1998. *Landslides in the Portland, Oregon Metropolitan Area Resulting from the Storm of February 1996: Inventory Map, Database and Evaluation.* Metro. August 27; and Flood and Landslide Mitigation Work Group. 1996. *City of Portland Flood and Landslide Hazard Mitigation Plan*. October.

end of this section, shows the location of five of these areas. Many of the problems in these five locations stem directly from stormwater running off of impervious surfaces in developed areas.

- Southeast Barbara Welch Boulevard is located in an area without adequate stormwater-management alternatives. The road occupies a steeply-sloped ravine with drainages on both sides of the road. Stormwater runoff from upland developments frequently exceeds the capacity of the drainages, which overflow onto the road. The photos in Figure 15, at the end of this section, show the road in December 2007 with approximately one to two inches of water flowing over its surface. Given the topography of the ravine, the drainage ditches cannot be expanded. As a result, this area experiences frequent flooding, saturated soils, and erosion and sediment transport problems.
- The south side of SE Foster Road along Clatsop Butte is another problem area. Drainages off the Butte funnel stormwater to Johnson Creek. These drainages, however, frequently become overwhelmed and flood SE Foster Road, carrying sediment and debris that can block traffic.
- The area around SE 162nd Street and SE Foster Road represents another area where stormwater, periodic flooding, and erosion pose problems for City stormwater managers.
- Developments near SE Deardorf Road funnel stormwater runoff into drainages that cut into hillsides, causing erosion and sedimentation before reaching Johnson Creek.
- Drainages along the west side of Powell Butte produce significant and ongoing sedimentation of the Springwater Corridor Trail.

The City keeps track of some of the costs related to repairing and reconstructing stormwater controls. Table 4 reports the results of a preliminary compilation of some of the City's costs for three of the problems locations discussed above. The costs include some, but not all of the cost of staff time from mid-1997 through 2008 spent cleaning up erosion and sedimentation, and repairing and reconstructing stormwater facilities and soil-disposal costs.

Table 4. Partial Costs of Soil Disposal and City Staff Time Spent on Cleaning, Repairing and Reconstructing Stormwater Controls in the Clatsop Butte Area, Mid-1997 to 2008

Location Where Costs Accrued		Cost
SE 162nd Street		$72,561
SE Barbara Welch Road		$97,534
SE Foster Road		$60,712
	Subtotal	$230,807
	Administration and Other Costs	$134,161
	Total	**$364,968**

Source: City of Portland's Hanson Database. Costs are in nominal dollars, not adjusted for inflation, because totals represent costs accrued between 1997 and 2008 and values for individual years were not available.

In some cases, effective stormwater-management controls can be designed but are deemed too expensive, given the area's poorly-drained soils and steep topography. As a result, many proposed developments proceed, with lower-cost and less effective management alternatives. This typically results in excessive stormwater flows, erosion, sedimentation and other problems.

In some particularly challenging locations, City staff spend considerable time and budget working with developers, designing stormwater-management facilities, and developing mitigation plans that will more effectively manage stormwater. The Waterleaf development on Clatsop Butte is one such example. The site posed stormwater-management challenges given the area's topography, the quality of the site's natural resources, and existing drainage patterns. City staff spent many hours working with the developer and exploring stormwater-management alternatives. The City typically does not track staff time and other costs of working with developers to manage stormwater in problem areas. A conservative estimate of the cost of City staff time spent on the Waterleaf development, however, is over $42,000.[30] In the end, the site proved too difficult to develop and the City purchased the site from the developers.

Continued development of the East Buttes' natural resources in these problem areas will increase City costs of planning stormwater controls and cleaning up stormwater-related problems. Resource protection programs that identify hazard areas where stormwater management is not technically or economically feasible, and therefore should not be developed, can help reduce City costs associated with these efforts. Also, protecting natural resources upslope and upstream from these problem areas would help avoid directing additional runoff to areas where stormwater cannot be managed.

30 Personal communication with A. Young, City of Portland, Bureau of Environmental Services.

C. Protecting Prior Investments in the Johnson Creek Watershed

Public and non-profit entities have invested millions of dollars restoring the Johnson Creek watershed. These restoration efforts primarily address three issues: flood mitigation, protecting or restoring habitat for threatened or endangered fish, and improving water quality, which includes moderating water temperatures during warm weather and filtering pollutants. Other investments in the watershed include improved recreational access such as the Springwater Corridor Trail.[31]

Actions upstream in the watershed can threaten the quality and stability of previous restoration or recreation investments. Upstream development in problem areas of the East Buttes promotes flooding, erosion, siltation and other stormwater-related problems, can increase toxins, and threatens restoration project investments. For example, increasing areas of impervious surface upstream will direct more stormwater runoff more quickly to Johnson Creek, which could exacerbate the Creek's flooding problem and washout bank stabilization or habitat projects. Protecting the area's important natural resources upstream in the East Buttes area can help minimize negative consequences downstream.

The City of Portland, Metro, the Johnson Creek Watershed Council, Reed College and the 40-Mile Land Trust, among other groups, invest in projects that protect and enhance the watershed's health and recreational access. These restoration investments often occur as part of a larger protection effort that includes purchasing and restoring important habitats. The restoration and recreation project and land acquisition investments at risk in the study area include:

- The 60-acre East Lents Floodplain Restoration project is currently under construction and expected to be completed by 2011. This project will address flooding, habitat, and water-quality issues in the watershed. When complete, the project will add flood storage to the floodplain. To date the City of Portland has spent over $8 million acquiring land in this area. Project funding includes over $2.7 million from the Federal Emergency Management Agency and approximately $900,000 from the City of Portland.[32]

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[31] For details on restoration efforts in the Johnson Creek watershed and associated investments in recreational access, *see* City of Portland Bureau of Environmental Services. 2008. *Johnson Creek Watershed.* Retrieved October 6, 2008, from http://www.portlandonline.com/BES/index.cfm?c=32201; Johnson Creek Watershed Council.2008. *Johnson Creek Watershed Council.* Retrieved October 6, 2008, from http://www.jcwc.org; and Metro Regional Government. 2008. *Johnson Creek and Watershed.* Retrieved October 6, 2008, from http://www.oregonmetro.gov/index.cfm/go/by.web/id/26778

[32] City of Portland, Bureau of Environmental Services. 2008. *East Lents Floodplain Restoration Project.* Retrieved October 6, 2008, from http://www.portlandonline.com/BES/index.cfm?&c=46540

- Floodplain restoration in the Tideman Johnson Park area was completed in 2006 and added 35 acre-feet of flood storage. It included habitat improvements and stream bank and floodplain restoration.[33] The estimated costs of restoration to date are $3.5 million.
- The Kelley Creek Confluence project was the first phase of the East Powell Butte Restoration Project. It was completed in 2004 and restored six acres of salmon habitat at the confluence of Johnson Creek and Kelley Creek.[34] The project cost $1.3 million to construct and $653,000 to acquire the land. It added 13 acre-feet of flood storage.
- The 38-acre Schweitzer project, completed in 2007, is the largest component of the East Powell Butte Restoration Project. It cost approximately $1.4 million to acquire the land and $5 million to build the project. The project addresses flooding, habitat, and water-quality issues.[35] The project added 74 acre-feet of flood storage to the floodplain.
- The Brookside wetland, a 14-acre project, was the City of Portland's first major flood-mitigation project in the watershed.[36] It was completed in 1997. The project cost $3.4 million to construct and $739,000 to acquire the land.
- The Johnson Creek Watershed Council sponsors annual Winter and Summer Watershed Wide Events, where volunteers remove invasive species and trash, plant native species, and perform other restoration efforts. These events draw hundreds of volunteers and their cumulative and on-going efforts promote significant improvements in the Johnson Creek watershed.[37] In 2007, 475 people volunteered for the events, cleaning up and restoring locations within the East Buttes study area and downstream.[38]

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[33] City of Portland, Bureau of Environmental Services. 2008. *East Lents Floodplain Restoration Project.* Retrieved October 6, 2008, from http://www.portlandonline.com/BES/index.cfm?&c=46540

[34] City of Portland, Bureau of Environmental Services. 2008. *East Lents Floodplain Restoration Project.* Retrieved October 6, 2008, from http://www.portlandonline.com/BES/index.cfm?&c=46540

[35] City of Portland, Bureau of Environmental Services. 2008. *East Powell Butte Restoration Project: Brownwood Phase.* Retrieved October 6, 2008, from http://www.portlandonline.com/BES/index.cfm?c=33213&a=158335

[36] City of Portland, Bureau of Environmental Services. 2008. *Johnson Creek: Projects: Completed Projects.* Retrieved October 8, 2008, from http://www.portlandonline.com/BES/index.cfm?c=33213&a=106235

[37] Johnson Creek Watershed Council. 2008. *Johnson Creek: The State of the Watershed.* Spring. Retrieved October 6, 2008, from http://www.jcwc.org/pdf/JCWC_SoW2008Spring.pdf

[38] Johnson Creek Watershed Council. 2007. *2007 Annual Report.* Retrieved October 8, 2008, from http://www.jcwc.org/pdf/JCWC_AnnualReport2007.pdf

- Recent Metro purchases in two target area, East Buttes and the Johnson Creek Watershed, help safeguard water quality and protect fish and wildlife habitat.[39] Supported in part by two successive bond measures for habitat acquisition, Metro's expenditures on habitat purchase and protection throughout the region exceeds $360 million. Data on the portion of these funds spent within the study area are unavailable.
- Currently Portland Parks and Recreation spends an estimated $12,127 per year for maintenance on the Springwater Corridor Trail in the study area.[40] In addition, it will cost about $528,900 to resurface the existing chip seal trail with asphalt.[41] The existing chip seal surface has exceeded its life span and needs to be replaced. It is assumed that maintenance costs and the need to replace the trail surface will increase with more development in the area and increased used of the trail.

The costs of restoration and recreation trail projects that can be quantified (i.e., partial costs) that are at risk from uncontrolled stormwater in the East Buttes area total $27.8 million. Given that development costs were unavailable for all projects, this figure underestimates the total value at risk.

D. Protecting the Values of Ecosystem Goods and Services

The natural resources of the East Buttes study area include upland forests and meadows that cover the butte tops, and lowland wetlands and forested riparian areas surrounding Johnson Creek and its tributaries. These resources contain a range of ecosystems that provide an array of ecosystem goods and services. These ecosystem goods and services are important to people, and hence, have economic value.[42] Their economic importance may arise when they are extracted, as when people catch fish, or when they remain in place, as when people enjoy a cool walk next to a stream on a hot day. In some cases, ecosystem goods and services can be directly measured and their values quantified. In other cases, the values have not been quantified, but that does not mean that they do not have value; instead, the paucity of estimates indicates that measuring the economic value of some ecosystem goods and services can be exceedingly difficult.

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[39] Metro Regional Government. 2008. *Acquiring Natural Areas.* Retrieved October 8, 2008, from http://www.oregonmetro.gov/index.cfm/go/by.web/id=18198 accessed July 11, 2008.

[40] This estimate assumes that the cost of park maintenance for one year is approximately $55,124 and the trail within the study area is 22 percent of the total area maintained by Parks. Parks maintains the sections in Portland and from SE Palmblad to Boring, OR.

[41] This estimate assumes that the trail within the study area is about 21,156 feet long and about 10 feet wide, or 211,560 square feet. The asphalt treatment is $2.50 per square foot to replace.

[42] De Groot, R., M. Wilson, and R. Boumans. 2002. "A Typology for the Classification, Description and Valuation of Ecosystem Functions, Goods and Services." *Ecological Economics* 41: 393-408.; Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being.*

When Established Markets Exist

Economists describe economic benefits of ecosystem goods and services using various methods. Established markets exist for some benefits, such as increases in the supply of goods (e.g., commercial harvests of fish). In these cases, market prices serve as a measure of the economic benefit of actions that protect or increase the supply of the good. However, factors such as externalities (e.g., when prices do not include pollution impacts) or government intervention (e.g., when subsidies artificially elevate prices) can distort market prices.

When Markets Do Not Exist: Benefit Transfer

Measuring the economic significance of benefits for which markets do not exist, such as cultural amenities or the value of an endangered species, is more challenging. Economists have developed techniques that can approximate the economic values of some of these benefits. These techniques have been tested and improved over decades, with results and methods vetted through academic journals and scholarly conferences.[43]

Where possible, economic information on the benefits of ecosystem goods and services presented in this report is based on studies conducted in the East Buttes study area itself. Often, however, studies have not been completed in the study area, but are available from research on the value of ecosystem services in areas that have similar characteristics (e.g. topography, vegetation, habitat features). In many cases, we can apply these values to the study area using a technique called benefit-transfer (BT). The BT method measures the values of ecosystem services at a site based on the results of economic studies conducted elsewhere.[44] For example, a BT analysis may calculate the values of water-quality services of riparian areas in Portland, based on studies conducted on riparian areas in Denver, Colorado. Where applicable, a BT analysis may save both time and money. But the applicability of a BT analysis diminishes as differences increase between the study area and the reference site(s). To the extent that the differences matter, values measured at the reference site(s) may not accurately reflect values in the study area. Given this constraint, the BT method is better suited to providing *insights* into the appropriate range of values for particular services, rather than precise measures of values. A number of economists and government agencies describe the basic steps in a BT study and the criteria to

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[43] For more information on the methods of measuring economic benefits that are not traded in markets see, The National Research Council. 2004. *Valuing Ecosystem Services: Toward Better Environmental Decision-Making*. Committee on Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems, National research Council; Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being*; and Barbier, E.B., et al. 1997. *Economic Valuation of Wetlands*. Ramsar Convention Bureau, Department of Environmental Economics and Environmental Management, University of York, Institute of Hydrology, IUCN-The World Conservation Union.

[44] King, D.M. and M. Mazzotta. 2000. "Methods, Section 8: Benefit Transfer Method." *Ecosystem Valuation.* Retrieved July 14, 2008, from http://www.ecosystemvaluation.org/benefit_transfer.htm

consider when selecting studies for a BT analysis.[45] The major steps in a BT study are:

- Step 1: Identify the environmental good or service at issue.
- Step 2: Identify affected stakeholders.
- Step 3: Review existing, relevant studies.
- Step 4: Assess the transferability of results from the study area to the reference site, taking into account the affected good or service and stakeholders.

Major factors or criteria to consider when assessing the transferability of results between the reference site(s) and the study area are:

- Evaluate the quality of the research conducted at the reference site(s).
- Seek similar environmental goods or services at the reference site(s) and the study area.
- Seek similar population and stakeholder characteristics at the reference site(s) and the study area.
- Seek similar baseline measures and magnitude of changes of environmental goods or services at the reference site(s) and the study area.
- Account for different values calculated using different valuation methods.

Given the challenges of measuring the full economic values of ecosystem services, as described above, we conclude with some certainty that the economic benefits described in this subsection likely underestimate, perhaps significantly in some cases, the complete economic benefits provided by the natural resources of the East Buttes area. Figure 16, at the end of this section, illustrates one reason why this is likely to be true: the process of quantifying and monetizing benefits does not capture the value of all the ecosystem goods and services produced by the natural resources found within the East Buttes area. With just a few exceptions, the benefits presented in this section fall within the smallest circle in Figure 16. There is sufficient information to allow us to assign a dollar value to just a small subset of the total universe of ecosystem goods and services. Other ecosystem goods and services, such as pollination, nutrient cycling, food

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[45] *See,* for example, Desvouges, W.H., M.C. Naughton, and G.R. Parsons. 1992. "Benefit Transfer: Conceptual Problems in Estimating Water Quality Benefits Using Existing Studies." *Water Resources Research* 28 (3): 675-683;. Boyle, K.J. and J.C. Bergstrom. 1992. "Benefit Transfer Studies: Myths, Pragmatism, and Idealism." *Water Resources Research* 28 (3): 657-663; Brouwer, R. 2000. "Environmental Value Transfer: State of the Art and Future Prospects." *Ecological Economics* 32: 137-153; and U.S. Environmental Protection Agency, Office of the Administrator. 2000. *Guidelines for Preparing Economic Analyses*. Report No. EPA 240-R-00-003. Retrieved July 14, 2008, from http://yosemite.epa.gov/ee/epa/eermfile.nsf/vwAN/EE-0228C-07.pdf/$File/EE-0228C-07.pdf

production, and spiritual fulfillment, provide society with additional benefits, but resist quantification in physical, and thus monetary terms. Yet other benefits might be theorized to exist, but cannot be identified and verified. Finally, there are potentially other valuable ecosystem goods and services that science does not currently allow us to recognize.

The following eight sub-sections discuss the values of some of the ecosystem goods and services provided by the natural resources in the East Buttes area. Each sub-section describes how development and disturbance of the East Buttes' natural resources affects the ability of the ecosystem to provide each good or service. Table 5, at the end of the section, summarizes the economic values from each of the eight ecosystem services identified.

1. Water Storage and Release

Vegetation and soils of the East Buttes area have evolved over thousands of years to regulate the flow of water from the Butte tops to the floodplains of Johnson Creek and its tributaries. Both upland forest ecosystems and lowland riparian ecosystems serve important functions in flood control and aquifer storage and release in the study area. In upland areas, the forests that cover the hill slopes help slow rainwater before it hits the ground, reducing its erosive potential and facilitating infiltration and groundwater recharge. Precipitation that infiltrates into the ground in upland areas feeds springs that provide cool inflows of water into Johnson Creek and its tributaries throughout the year. When more rainwater infiltrates in upland areas, less is available to run off the surface of the steep Butte slopes, which reduces the risk of flooding downstream. In lowland areas, riparian ecosystems also provide vital areas for storage and gradual release of flood waters during storm events.

Increasing impervious surface and decreasing vegetative cover negatively affects hydrological conditions by increasing the quantity and rate of stormwater runoff flowing from upland areas into Johnson Creek and its tributaries. This, in turn, causes more frequent and severe flooding events. As discussed in Section II.A, economic studies of the flood damage in the Johnson Creek watershed demonstrate that flood events result in considerable public and private costs. The 1996, 1995, and 1994 flood events caused a total of about $6.1 million, $318,000, and $395,000 respectively in flood damage within and downstream of the study area.[46] These costs do not include damages to ecosystems from more frequent and severe flooding events. Flooding also scours the stream channel, promote bank erosion, and damages wildlife habitat, limiting the capacity of the ecosystem to function properly, and thus reducing the value of many other goods and services.

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[46] Woodward Clyde Consultants. 1996. *Flood Damage Cost Estimate for Johnson Creek Flood Event, February 4-10, 1996.* City of Portland, Bureau of Environmental Services. April. Values adjusted to 2008 dollars.

If the East Buttes area loses more trees and gains more impervious surfaces, the costs of flooding, both within and downstream of the study area, would undoubtedly increase. The economic benefits of the natural flood controls described above will likely increase in the future, as climate change is expected to increase the frequency and intensity of storm events in the Pacific Northwest.[47] This means that damages caused by the 1996 storm event will be more likely to occur in any given year, and storms capable of causing greater damage will also occur with greater frequency.

In addition to controlling flooding, the ecosystem's ability to store and release water has implications for the quality and quantity of water in Johnson Creek and its tributaries throughout the year. Johnson Creek is on the state's 303(d) list as water quality limited for temperature. As impervious surface increases and vegetation decreases, less water infiltrates into the ground to recharge aquifers and reduce water temperature. This, in turn, reduces the flow of cool water feeding Kelley and Johnson creeks, especially during the warm and dry summer months. Sustaining cool flows and pools throughout the year are essential to maintaining and enhancing populations of sensitive, threatened, and endangered fish, such as the cutthroat trout found in Kelley Creek.

Many studies have attempted to quantify the value of streamflows for resident and anadromous fish populations in the Pacific Northwest. One study found that the economic value of improved streamflows to enhance salmon populations in northern California ranges from $49 to $79 per acre-foot.[48] A study in Montana found that households were willing to pay between $5 and $49 per household per year, with an average of $21 per household per year to increase streamflow during the summer months in five rivers to maintain trout populations, wildlife, and plants. Higher values were associated in part with respondents who lived closer to or actively used the rivers.[49] Another illustration of the value of streamflow comes from prices paid by public and private entities in Oregon to purchase water for environmental purposes. One study, which included transactions between 1990 and 2003, found that the median price paid for water for environmental purposes was $22 per acre-foot per year.[50] The actual benefit

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[47] Madsen, T. and E. Figdor. 2007. *When it Rains, it Pours: Global Warming and the Rising Frequency of Extreme Precipitation in the United States.* Environment America Research & Policy Center and Frontier Group. December.

[48] Jaeger, W.K. and R. Mikesell. 2002. "Increasing Streamflow to Sustain Salmon and Other Native Fish in the Pacific Northwest." *Contemporary Economic Policy* 20(4): 366-380. Values adjusted to 2008 dollars.

[49] Duffield, J.W. 1992. Total Valuation of Wildlife and Fishery Resources: Applications in the Northern Rockies. In *The Economic Value of Wilderness: Proceedings of the Conference.* U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. General Technical Report, SE-78. Values adjusted to 2008 dollars.

[50] Brown, T.C. 2004. *The Marginal Economic Value of Streamflow from National Forests.* Discussion Paper. Fort Collins, CO: U.S. Forest Service, Rocky Mountain Research (Continued next page).

associated with increased stream flow is site specific, depending upon the value to society of protecting the particular fish species found in the particular stream, and the effectiveness of increased stream flows on increasing fish populations. In the streams surrounding the East Buttes, it is likely that stable, cooler flows, especially during the summer months would benefit resident and migratory fish. To quantify the total value of these flows, however, more information is needed on the quantity of flow produced from the ecosystem and the resulting benefit of those flows on the populations of resident and migratory fish.

2. Habitat for Aquatic and Terrestrial Species

The riparian ecosystems surrounding Johnson and Kelley Creeks provide habitat for regionally significant fish species, including coho and Chinook salmon, cutthroat trout, rainbow and steelhead trout, and lamprey. Federal regulations designate Johnson Creek as critical habitat for several salmonid species. Kelley Creek, a tributary to Johnson Creek that lies partly within the study area, provides particularly important habitat for cutthroat trout. During 2002 and 2003, field surveys of fish abundance and distribution in Portland's streams, Oregon Department of Fish and Wildlife (ODFW) biologists observed the largest cutthroat trout individuals found in the Johnson Creek watershed in Kelley Creek, along with several trout redds.[51,52] In spring 2008, ODFW repeated their surveys of Johnson Creek, Crystal Springs, and Kelley Creek. They found Chinook from Crystal Springs to Kelley Creek, verifying that Chinook pass through the Johnson Creek system. They also found numerous coho in Johnson Creek. In addition, the Johnson Creek watershed was the only watershed in the Portland area in which lamprey were found during ODFW's 2003 field survey, and they were found in particular abundance in Kelley Creek. These findings led ODFW's biologists to conclude that Kelley Creek provides high-quality habitat for aquatic species among the creeks in the Portland area, and should be given a high-priority for protection.

The upland forest and meadow ecosystems of the East Buttes provide a unique assemblage of habitats not common in the Portland metropolitan area. Upland meadow ecosystems, like that found at the top of Powell Butte, are increasingly scarce in Portland, and provide exceptional habitat for birds and small mammals. The ecotones, or areas where two ecosystems meet, which occur as the elevation increases on the East Buttes and forests give way to meadows, support especially

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(Continued from previous page) Station. December 28. Value adjusted to 2008 dollars.

[51] Tinus, E.S., J.A. Koloszar, and D.L. Ward. 2003. *Abundance and Distribution of Fish in City of Portland Streams.* City of Portland, Bureau of Environmental Services, Endangered Species Act Program and Oregon Department of Fish and Wildlife. December.

[52] A redd is a nest of fish eggs covered with gravel. Streamnet. 2002. *Public Outreach: Glossary of Fish Related Terms.* March 5. Retrieved February 11, 2009, from http://www.streamnet.org/pub-ed/ff/glossary/glossaryfish.html

diverse populations of wildlife. For example, the grassland-forest ecotones atop Powell Butte provide valuable habitat for wildlife, potentially supporting greater densities of wildlife than other habitat types.[53] Theses upland forests and meadows provide foraging, perching, roosting, and nesting habitat for hawks, falcons, owls, and bats. The highest elevations of the East Buttes provide important stopover habitat for migratory neotropical songbirds, which are on the decline in the Portland metropolitan area as suitable habitat becomes more limited. The lowland forests and riparian ecosystems along Johnson Creek also provide nesting habitat for birds, as well as forage and cover for a variety of amphibians, reptiles and small mammals.

The habitat provided by the East Buttes ecosystems is also significant for its connectivity. Unlike many areas throughout the region, large areas of forests in the study area remain intact, connecting different kinds of habitat. For example, natural connections remain between the riparian habitat surrounding Johnson Creek, protected natural areas in the City such as Beggars-tick Wildlife Refuge in the northeastern part of the study area, and other natural areas to the east and south, extending all the way to the foothills of the Cascade Mountains. Because of this connectivity the area's ecosystems support high levels of biodiversity of wildlife, particularly wildlife that depend on unique microclimates and large undisturbed areas.

Protecting upland and riparian habitat for neotropical migratory birds produces both use and non-use benefits. A review of several studies that quantified value of wetlands found that people's willingness to pay for habitat provided by wetlands averaged about $460 per acre of wetland per year.[54] Multiplied by 72.49 acres of wetland habitat, the study area yields an annual value of about $33,000 for this habitat.

People also value habitat for the bird-watching opportunities it provides. Habitat throughout the study area contributes to supporting the migratory bird population throughout Portland. Several spots in the study area, including Powell Butte Nature Park and Beggars-tick Marsh, are especially popular among birdwatchers and draw people from throughout the Portland metropolitan area. In Oregon, 35 percent of the population surveyed in a 2001 study by the U.S. Fish and Wildlife Service participated in bird watching. A 2003 study by Oregon Parks and Recreation found that across the state, 29 percent of residents participated in bird watching. Participation was lower for the region that includes the Portland metropolitan area, where 20 percent of residents

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[53] City of Portland, Bureau of Planning. 1998. *Johnson Creek Watershed: Summaries of Resource Site Inventories*. Pg. 1-103.

[54] Woodward, R.T. and Y.S. Wui. 2001. "The Economic Value of Wetland Services: a Meta-Analysis." Ecological Economics 37 (2): 257-270. Value adjusted to 2008 dollars.

participate in bird watching.[55] The average net economic value—that is, the value participants perceive the experience is worth to them, minus the expenses they incur to participate—among those surveyed for a day of bird watching was $41.[56] Assuming that 20 percent of the population in the Portland metropolitan area—approximately 400,000 people—participated in just one day of bird watching per year, the net economic value of that activity would be $16.4 million per year. Data are unavailable to determine exactly what percent of bird watching activity is made possible by the habitat of the East Buttes area, but we know it provides important regional habitat for neo-tropical migratory birds. Supposing 25 percent of bird watching occurs within the East Buttes Study area, or makes possible bird watching opportunities elsewhere in the region by supporting greater bird populations, the value attributable to the East Buttes would be $3.3 million per year.

Protecting the integrity of aquatic and riparian habitat in Johnson Creek and its tributaries would likely contribute to sustaining and enhancing fish populations, including resident trout and anadromous salmonids. The economic value of salmon populations in the literature varies dramatically, a reflection of the uncertainty inherent in valuing such a resource. The most relevant research to the study area is a 1993 study that calculated the household willingness to pay for each additional fish caught on the Willamette and Clackamas rivers at $3.60 per fish.[57] To the extent that Johnson Creek and its tributaries contribute additional salmon to the Willamette River, this value would directly apply. Another study that surveyed Oregon residents found that each household would be willing to pay $3.50 per month to improve salmon runs.[58] Similarly, data from a national survey indicate that households' willingness to pay to protect the cutthroat trout, a species found in Johnson and Kelley creeks, is $21 per household (a one-time payment).[59]

We illustrate the potential value of the aquatic habitat in the East Buttes area by describing the value of anadromous fish reared in Johnson and Kelley creeks,

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[55] Oregon Parks and Recreation Department. 2003. *2003-2007 Oregon Statewide Comprehensive Outdoor Recreation Plan.* January. Retrieved February 11, 2009, from http://www.prd.state.or.us/images/pdf/scorp_00_complete.pdf

[56] La Rouche, G.P. 2003. *Birding in the United States: A Demographic and Economic Analysis: Addendum to the 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation.* Report No. 2001-1. U.S. Fish and Wildlife Service, Division of Federal Aid. Value adjusted to 2008 dollars.

[57] Berrens, R., O. Bergland, and R. M. Adams. 1993. "Valuation Issues in an Urban Recreational Fishery: Spring Chinook Salmon in Portland, Oregon." *Journal of Leisure Research* 25(1): 70-83. Value adjusted to 2008 dollars.

[58] Helvoigt, T., and C.A. Montgomery. 2003. *Trends in Oregonians' Willingness to Pay for Salmon*. Corvallis, Oregon, Oregon State University: Working Paper.

[59] Richardson, L., and J. Loomis. 2009. "The Total Economic Value of Threatened, Endangered and Rare Species: An Updated Meta-Analysis." *Ecological Economics* doi: 10.1016/j.ecolecon.2008.10.016.

and the value that people place on protecting the resident cutthroat trout. The value anglers place on an additional fish caught in the Willamette River and the value households place on protecting cutthroat trout are separate and additive measures of the total value. Calculating the former requires data on the number of additional fish caught each year in the Willamette, and originating from these creeks, however, the data on anadromous fish numbers are insufficient to complete this calculation. The value of the cutthroat trout in Johnson and Kelley creeks can be calculated using the total number of households in the Portland metropolitan area (defined here as the 2007 Portland-Vancouver Metropolitan Statistical Area), or 833,728 households.[60] If just 10 percent of these households were aware of the cutthroat trout and interested in ensuring their continued survival in these creeks, the collective value the households place on protecting their habitat could approach $1.7 million.[61] This is likely a conservative estimate, as 10 percent is probably a low approximation of the households within the Portland metropolitan area willing to pay to ensure the continued survival of the cutthroat trout. Also, households outside the Portland metropolitan area are likely to be willing to pay to protect cutthroat trout habitat in Johnson and Kelley creeks.

Another indication of the regional population's willingness to pay to protect fish in the Metro area comes from the passage of two Metro bond measures, in 1995 and again in 2006, to acquire natural areas to improve water quality and protect fish and wildlife habitat. The 1995 measure provided $135 million to purchase and protect natural areas throughout the region, and the 2006 measure secured an additional $227.4 million to expand the program.[62] The bond measures provide many benefits beyond fish protection, like recreational opportunities, so the bond amounts overstate the public's collective willingness to pay for protecting just fish. They may also understate it, as it is impossible to know how much above the bond measures' value the public may have been willing to pay for natural area protection, if given the opportunity.

3. Nutrient and Pollutant Filtration

Upland and riparian forest ecosystems support vegetation, soils, and microorganisms that help filter pollutants from both the air and water, improving environmental quality. Vegetation helps filter and assimilate pollutants from stormwater runoff, which picks up contaminants as it flows over

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[60] U.S. Department of Commerce, Census Bureau. 2008. "Households by Type in the Portland-Vancouver-Beaverton, OR-WA Metropolitan Statistical Area." *2007 American Community Survey 1-Year Estimates.* Retrieved October 10, 2008, from http://www.factfinder.census.gov

[61] 833,728 * 0.10 = 83,373 * $21 = $1,750,833

[62] Metro. 2009. *2006 Natural Areas Bond Measure.* Retrieved February 20, 2009, from http://www.oregonmetro.gov/index.cfm/go/by.web/id=16894 and Metro. 2009. *1995 Natural Areas Bond Measure.* Retrieved February 20, 2009, from http://www.oregonmetro.gov/index.cfm/go/by.web/id=14319

soil and impervious surfaces. Vegetation helps improve water quality as runoff flows into the streams, creeks, and ponds within the study area, and in turn improves aquatic and riparian habitat for the species that depend on it and enhances the aesthetic qualities of the stream (e.g., by preventing algae blooms that can result from excessive nutrients). Trees help to remove pollutants such as ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter from the air. Filtering these pollutants from the air reduces smog and acid rain, and may help mitigate the effects of global warming. This air purification service provides benefits to human health, as well as the health of other organisms.

Reductions in vegetation and increases in impervious surfaces will result in a decrease in water quality in Johnson Creek and its tributaries.[63] Economic studies link declines in water quality with reductions in the value of property and streamside and in-stream recreation, as well as increased costs of water treatment. For example, a recent study of a Maryland watershed found that a one-unit (mg/L) increase in total suspended solids (TSS) reduces average housing prices within the watershed by $1,086 and a one-unit (mg/L) increase in dissolved inorganic nitrogen, reduces average housing prices in the watershed by $17,642.[64] The differences in housing values and watershed characteristics would likely cause this number to be different in the Portland area, but we provide it here as an illustration.

Preserving existing vegetation, especially trees, helps maintain air-quality benefits including filtering pollutants. American Forests, a national non-profit conservation and research organization, estimates the value of the pollutant-removal services that trees provide. They calculate this value based on the amount of pollutants removed by trees, and on the health care costs associated with treating pollutant-related respiratory ailments. American Forests calculates the avoided health care costs per pound of pollutant removed: approximately $3.00 per pound of ozone (O_3), $0.75 per pound of sulfur dioxide (SO_2), $3.00 per pound of nitrogen dioxide (NO_2), $2.00 per pound of particulate matter less than 10 microns in size (PM_{10}), and $0.43 per pound of carbon monoxide (CO) removed.[65]

An analysis completed by Portland Parks and Recreation estimates the per-pound value of pollutant removal by trees, based on avoided regulatory compliance costs, at $0.94 per pound for O_3, $1.88 per pound for SO_2, $0.94 per pound for NO_2, $1.67 per pound for PM_{10}, and $0.35 per pound for volatile

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[63] House, M.A. 1993. "Urban-Drainage Impacts on Receiving Water Quality." *Water Science and Technology* 27(12): 117-158.

[64] Poor, P.J., K.L. Pessagno, and R.W. Paul. 2007. "Exploring the Hedonic Value of Ambient Water Quality: A Local Watershed-Based Study." *Ecological Economics* 60(2007): 797-806.

[65] American Forests. 2001. *Regional Ecosystem Analysis for the Willamette/Lower Columbia Region of Northwestern Oregon and Southwestern Washington State.* October.

organic compounds (VOCs).[66] This analysis also found that in total, Portland's public trees—street trees and park trees—produce $770,150 in air quality benefits annually, which equates to approximately $1 per tree. The study did not include trees on private property, which also provide air quality improvements, and are numerous in the study area.

Data on the amount of pollutants assimilated by trees in the study area are not available. In a 2001 analysis, however, American Forests calculated the value of this service for trees within the Portland urban growth boundary at approximately $4.8 million per year. Although the acres of tree canopy within the urban growth boundary have almost certainly changed since 2001, for illustrative purposes, we use this value as a basis for an analysis of the pollutant-removal services provided by trees in the study area. The tree canopy of the study area represents about 5 percent of the total canopy within Portland's urban growth boundary,[67] and so the value of the air-pollutant-assimilation capacity of these trees is estimated at approximately $240,000 per year.[68]

4. Soil Retention and Erosion Control

The East Buttes' steep slopes are prone to erosion. The native vegetation covering the Buttes, however, helps retain soil and maintain the integrity of the steep slopes in several ways: the forest canopy intercepts and slows rainwater velocity which reduces its erosive potential and helps it infiltrate into the ground, vegetation absorbs precipitation, and tree roots and underbrush help stabilize the soil. Removing vegetation, increasing impervious surfaces on or above the slopes, and building near the slopes can increase stormwater runoff that destabilizes the soil, leading to increased erosion and landslides. Increased erosion results in a myriad of localized and downstream impacts, including impaired water quality, loss of habitat, and damage to public and private property and infrastructure.

Reducing soil erosion, by carefully managing development and limiting the disturbance of steep slopes that are prone to landslides, can yield economic benefits in the form of avoided costs associated with increased sedimentation of local water bodies, and damage to private and public infrastructure created by erosion and landslides. One economic study of the offsite benefits of reducing

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[66] Portland Parks and Recreation, City Nature Urban Forestry. 2007. *Portland's Urban Forest Canopy: Assessment and Public Tree Evaluation.* October. Retrieved June 24, 2008, from http://www.portlandonline.com/shared/cfm/image.cfm?id=171829

[67] There are 42,931 acres of forest canopy within the Portland urban growth boundary, and 1,858 acres of tree canopy within the study area. (1,858 / 42,931 = 0.046 or 4.6%)

[68] 0.04 * $4,800,000 = $192,000

soil erosion found that the benefits attributable to preventing soil erosion in the Pacific region about $4 per ton.[69]

A measure of the tons of sediment that are washed into local waterways each year is needed to calculate the economic benefits of controlling erosion in the study area. This data is not available. However, based on the remaining acres of developable land in the study area, and using the Revised Universal Soil Loss Equation (RUSLE) for disturbance of soils, we can estimate that if all undevelopable areas were to develop, soil loss would amount to about 10,005[70] tons per year. This estimate assumes that conservation measures are equivalent to bare land and that stormwater best management practices (BMPs) are about 75 percent effective (this is a best professional estimate of the current anticipated effectiveness of BMPs). Multiplied by the City of Portland's average annual cost per ton for soil disposal ($32), plus overhead (20 percent) and condition assessment charges ($8,000 per year)[71], the cost per ton to dispose of the soil would amount to approximately $37,615 per year for full development of currently undeveloped areas. It should be noted that RUSLE is based on use in agricultural, not urban areas. Like most models, RUSLE has its limitations and is based on the best professional judgment of the person populating the model. The data generated from the model are not based on actual monitoring data.

5. Local Climate Regulation

The tree canopy, vegetation, and flowing water provided by riparian and upland forest ecosystems support many functions that help regulate local climate. Tree canopy provides shade to residential and commercial structures, shielding against solar radiation. Evapotranspiration of vegetation naturally cools the air. These effects offset the urban-heat-island effect, and act as a natural air conditioner, reducing the demand for energy required to cool residential and commercial structures. Trees also block wind, which can contribute to increased demand for heating during the winter months. Development and site disturbance generally reduce tree canopy cover, exposing buildings to the elements, including more direct sunlight and wind. This increases the demand for air conditioning during the summer months and for heating during the winter months. Development also contributes to the urban-heat-island effect by increasing the coverage of impervious surfaces and adding structures that absorb solar radiation during the day and radiate warmth during the night, keeping temperatures abnormally high.

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[69] Ribaudo, M.O. 1986. *Reducing Soil Erosion: Offsite Benefits*. U.S. Department of Agriculture, Economic Research Service. Agricultural Economic Report No. 561. September. Value adjusted to 2008 dollars.

[70] Personal Communication with F. Wildensee and A. Young. City of Portland, Bureau of Environmental Services. July 14, 2008**.**

[71] Personal communication with S. Hazzard and A. Young, , City of Portland, Bureau of Environmental Services. *Stormwater Residual Costs for Johnson Creek.* June 30, 2008.

Protecting natural vegetation helps household and businesses avoid energy costs. A study by American Forests focusing on the Portland metropolitan area found that households spend an average of $122 per home on air conditioning per year. The analysis showed that tree canopy can reduce home cooling costs, saving each household an average of $13 per year.[72] American Forests assumes, based on local data, that approximately 15 percent of the households in the Portland area have air conditioning units. Applying this savings to 15 percent of the approximately 8,529 single-family houses in the study area, or about 1,279 households, indicates that protecting tree canopy in the study area would collectively save the area's residents about $16,000 per year.[73] This value is probably an underestimate of the total value society derives from the ecosystem's thermal regulation function, as the study that estimated $13 per household per year did not calculate the savings tree canopy can provide businesses and multi-family housing. While estimates are not available for these kinds of structures, it is likely that they would also save on cooling costs, though there is insufficient information to determine whether the amount would be more or less than an individual household.

Another way to look at the value provided by the ecosystem's regulation of local climate comes from an analysis by Portland Parks and Recreation of the value of Portland's trees. This study quantified how street trees affect household energy usage, and found that every tree produced energy savings of $3 per year.[74] Although the number of trees in the study area is not known at this time, this figure could be used to estimate the total value of energy savings.

Tree canopy may also reduce the demand for heating in the winter by blocking wind. Neither of these studies investigated whether Portland's trees contributed to lower heating bills in the winter; however, studies show that wind protection provided by trees can provide benefits by reducing demand for heating, especially in the mid- and northern-latitudes.[75]

6. Global Climate Regulation

The woody biomass of the area's forests, woodlands, meadows, and other natural resources contains a substantial amount of stored carbon, and continues sequestering additional carbon dioxide each year. Development and disturbance

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[72] American Forests. 2001. *Regional Ecosystem Analysis for the Willamette/Lower Columbia Region of Northwestern Oregon and Southwestern Washington State.* October. Values adjusted to 2008 dollars.

[73] 10,209 * 0.15 = 1,531 households * $13 = $16,841

[74] Portland Parks and Recreation, City Nature Urban Forestry. 2007. *Portland's Urban Forest Canopy: Assessment and Public Tree Evaluation.* October. Retrieved June 24, 2008, from http://www.portlandonline.com/shared/cfm/image.cfm?id=171829

[75] McPherson, G. and J.R. Simpson. 1995. "Shade Trees as a Demand-Side Resource." *Home Energy Magazine Online.* March/April. Retrieved June 25, 2008, from http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/95/950307.html

that reduce forest and vegetation cover not only reduce the ecosystem's ability to store additional carbon, but clearing, burning, or decomposing brush and trees releases sequestered carbon back into the atmosphere, contributing to overall carbon emissions and to human-caused global warming.

There are currently 2,013 acres of tree canopy in the East Buttes area, which represents about 5 percent of the tree canopy within the Portland urban growth boundary. Using estimates calculated by American Forests for the entire area within the Portland urban growth boundary (about 12,516 tons per year), we estimate that protecting the canopy within the study area sequesters approximately 626 tons of carbon each year.[76] Currently, carbon dioxide is traded on several markets throughout the world, which set a price on each ton of carbon emitted or sequestered. As of July 2008, carbon dioxide traded on the Chicago Climate Exchange, the U.S. market for carbon dioxide, at about $4 per ton. In places where government regulations restrict the emissions of carbon dioxide, such as in Europe, carbon dioxide trades for about $40 per ton.[77] This latter value is consistent with the prices at which western electrical utilities expect carbon dioxide to trade once mandatory emissions restrictions come into effect in the United States.[78] At $40 per ton, the value of the carbon sequestered each year by the trees in the study area is $91,896.[79]

7. Scenic and Aesthetic Amenities

The forested hillsides and riparian lowlands of the East Buttes provide extensive scenic and aesthetic amenities for local and distant residents, as well as for visitors to the area's parks and trails. Property owners in the immediate area benefit directly from the surrounding amenities that the natural landscape provides, while residents farther away benefit from the views provided by the forested backdrop on the cityscape.

Development and disturbance of the East Buttes would reduce the area's scenic and aesthetic qualities, and would degrade the views of the Buttes' undisturbed slopes from afar. Research on property values in Portland found that a property's proximity to natural areas affects its value: values typically increase as the distance between a park or natural area and a property decreases, and as the quality of the natural resources surrounding a property increases. For example,

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[76] 12,516 * 0.04 = 500.64

[77] Price for a tonne of carbon dioxide on the European Climate Exchange on July 28, 2008. Retrieved July 28, 2008, from http://www.europeanclimateexchange.com/

[78] Western Regional Transmission Expansion Partnership Economic Analysis Subcommittee. 2007. Benefit-Cost Analysis of Frontier Line Possibilities: Final Report. April 27. Retrieved October 19, 2007, from http://www.ftloutreach.com/images/FTL_Econ_Analysis_Final_Report_4-27-07.doc.

[79] 626 tons of carbon is equivalent to 2,297 tons of carbon dioxide (626 * 3.67 = 2,297). This calculation is required because the Chicago Climate Exchange trades in tons of carbon dioxide, while carbon sequestration is measured in terms of tons of carbon. 1,835 tons * $40/ton = $91,896.

one study found that property values for homes within 1,500 feet of an urban park are on average approximately $4,000 greater than similar properties farther away from the park, and values for homes within 1,500 feet of a natural area park are on average approximately $36,000 greater.[80] The strength of this study is that the researchers calculated amenity values for local parks that, as described, are similar to the types of parks and natural areas found in the East Buttes area.

There are 9,882 single-family residential households within 1,500 feet of public open spaces in the study area. We estimate that these open spaces improve property values for the surrounding residential properties by approximately $39.5 million, compared with the values of properties further from the parks.[81] We calculate this value using the lower contribution to value that an urban park provides, or $4,000 per household. To the extent that some of the households in the study area are near natural-area parks (such as Powell Butte Park), which can increase property values by $35,000 per residential property, this estimated value likely significantly underestimates the beneficial impact of these parks on property values.

Developing new parks in the East Buttes area may increase values for surrounding properties. Note, however, that the study from which we selected values focused on the relationship between proximity to an *existing* park and value, but not the extent to which establishing new parks increases value. The actual change in property values that would materialize from a new park would depend on the extent to which the park changes the amenities available to nearby residents (for example, by improving access, adding trails, etc.).

Another recent study that investigated the effect of tree canopy cover on property values in Portland found that, in areas where tree canopy coverage is low, an increase in coverage increases property values. [82] Many areas in the northern portion of the East Buttes area have low canopy coverage. The study also found that increasing the canopy cover in heavily-forested areas decreases property values. Areas that exhibited this relationship were found primarily in southwest and northwest Portland, but some heavily forested areas in the study area may fall into this category. This suggests that an increase in trees in the less-forested northern sections of the study area would likely increase property values, while an increase in tree canopy in the southern section of the study area may actually decrease property values.

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[80] Lutzenhiser, M. and N.R. Netusil. 2001. "The Effect of Open Spaces on a Home's Sale Price." *Contemporary Economic Policy* 19(3): 291-298. Values adjusted to 2008 dollars based on the Case-Shiller Housing Price Index for Portland, Oregon.

[81] $4,000 * 9,882 = $39,528,000

[82] Netusil. N., S. Chattopadhyay, and K. Kovacs. 2008. *Estimating the Demand for Large Patches of Tree Canopy: A Second-Stage Hedonic Price Analysis in Portland, Oregon.* Under Review.

8. Recreational Opportunities

The area's ecosystems provide a range of recreational opportunities. Local residents, as well as visitors, visit the area's parks and trails for hiking, biking, wading, fishing, wildlife viewing, picnicking, and relaxing. Over nine miles of trails cover Powell Butte Nature Park and connect with the Springwater Corridor Trail. These trails are open to pedestrians, bikes, and in some areas, horseback riders. People from across the Portland metropolitan area use the Springwater Corridor Trail, which runs through the center of the study area loosely following Johnson Creek. Portland Bureau of Transportation's traffic counts where the Springwater Trail crosses 122nd Avenue indicate that approximately 400 people use the trail on bicycle each day within the study area. Additional people enjoy the trail on foot, although specific counts are not available within the study area.

Numerous opportunities for new trail development abound in the study area, including the proposed East Buttes Powerline Corridor Trail, the East Buttes Trail, and the Scouter Mountain Trail. All of these proposed trails traverse the East Buttes area and would provide connections to other trails in the region.[83]

Development in the East Buttes area that cuts off public access from one point to another on the planned routes could threaten the completion of these proposed trails. Development or disturbance that changes the natural character that draws may of the trail users to the area could also negatively impact the quality of the trail experience for some. A 2005 study of the value of different recreation activities on public lands found that in the Pacific Northwest region, the net economic value associated with hiking, mountain biking, picnicking, and general recreation is $25, $50, $69, and $35, respectively, per person per activity day.[84] Studies are unavailable for the economic value of regional trails in the Portland metropolitan area, Oregon, or the Pacific Northwest. A study of a regional trail in Virginia, however, found that the net economic value associated with hiking was $39 per person per trip.[85] A similar analysis of an urban regional trail outside Washington D.C. primarily used for biking and walking found a net economic value of $10 to $14 per person per trip.[86] The characteristics of this trail that most

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[83] Portland Parks and Recreation. 2006. *Recreational Trails Strategy: A 20-Year Vision for Portland's Regional Trail System.* June. Retrieved June 25, 2008, from http://www.portlandonline.com/parks/index.cfm?c=42627&a=120478

[84] Loomis, J. 2005. *Updated Outdoor Recreation Use Values on National Forests and Other Public Lands.* U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. General Technical Report No. PNW-GTR-658. October. Values adjusted to 2008 dollars.

[85] Bowker, J.M., J.C. Bergstrom, and J. Gill. 2007 "Estimating the Economic Value and Impacts of Recreational Trails: A Case Study of the Virginia Creeper Rail Trail." *Tourism Economics* 13(2): 241-260. Value adjusted to 2008 dollars.

[86] Bowker, J.M., J.C. Bergstron, J. Gill, and U. Lemanski. 2004. *The Washington & Old Dominion Trail: An Assessment of User Demographics, Preferences, and Economics.* Final Report. Virginia Department of Conservation, U.S. Department of Agriculture, Forest Service, University of Georgia, Department

closely match those of the Springwater Corridor Trail where biking and walking for recreation and fitness, and the users come mostly from the local area. Applying the higher value (the economic value bikers ascribe to their activity is generally higher than the economic value walkers ascribe to their activity) to the approximately 146,000 bike trips per year on the trail generates a net economic value of about $2 million per year.[87] A lack of information available on recreation participation levels for the other trails and parks in the study area limits our ability to calculate the full value of recreation associated with the natural resources in the study area.

Table 5. Summary Table of Illustrative Values of Ecosystem Services

Ecosystem Service	Valuation Technique	Illustrative Value
Water storage and release	Avoided costs associated with reduced flooding within and downstream of the study area	$6.1 million
	Value of increased streamflows to support salmonid habitat	Unquantifiable at this time
Habitat for aquatic and terrestrial species	Annual willingness to pay to protect habitat provided by wetlands	$33,000
	Annual consumer surplus associated with birdwatching in the study area	$3.3 million
	Willingness to pay to protect cutthroat trout	$1.7 million
Nutrient and pollutant filtration	Annual avoided healthcare costs associated with the pollutants assimilated by trees	$240,000
Soil retention	Avoided costs associated with sedimentation off newly developed areas	$37,615
Local climate regulation	Annual avoided costs associated with cooling residential households in the study area	$16,000
Global climate regulation	Annual market value[a] of sequestered carbon	$91,896[a]
Scenic and aesthetic amenities	Increased property values associated with proximity to parks and tree canopy	$39.5 million
Recreational opportunities	Annual consumer surplus associated with biking on the Springwater Corridor Trail within the study area.	$2 million

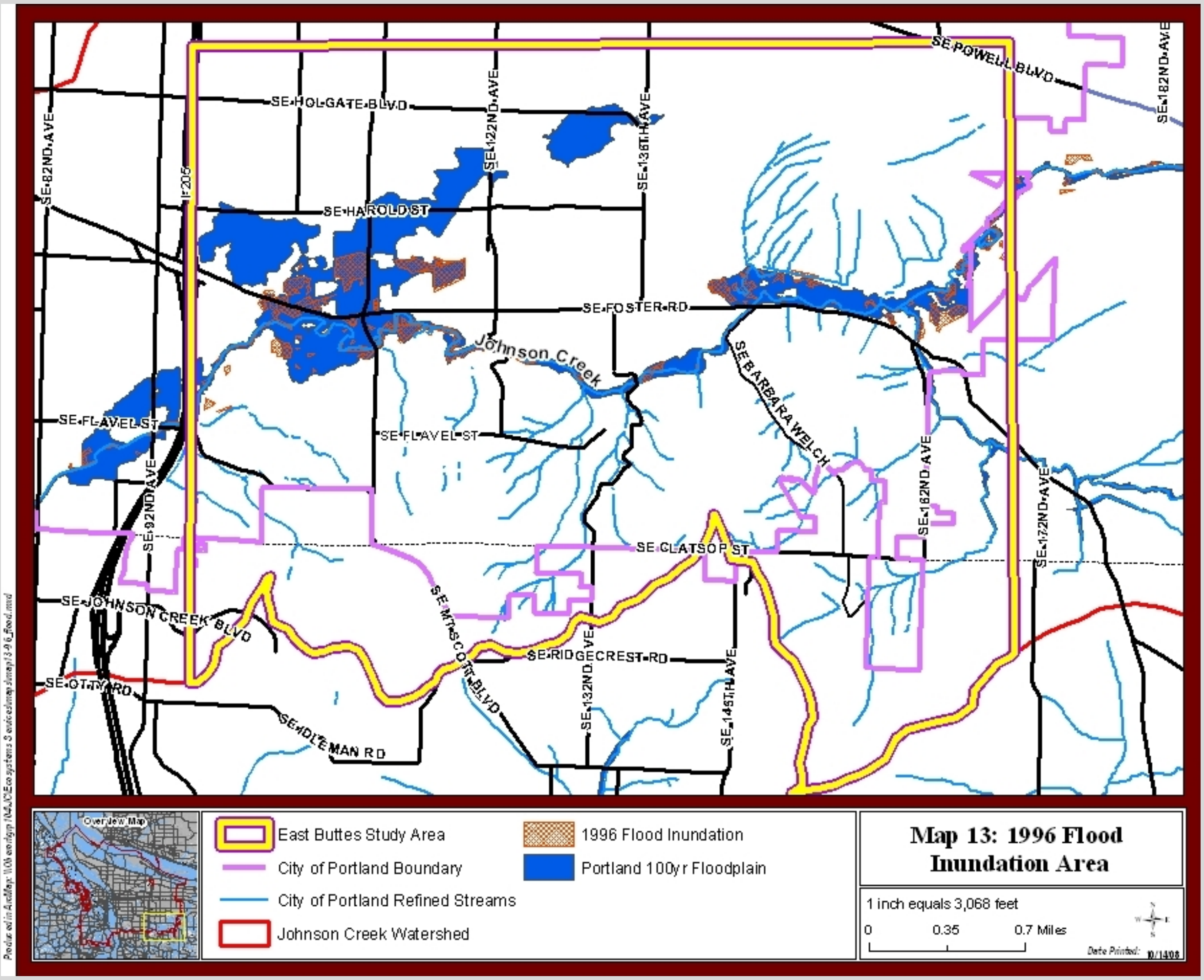
Source: ECONorthwest

[a] Predicted market value if carbon dioxide emissions become regulated.

of Agricultural and Applied Economics, and U.S. Department of the Interior, National Parks Service. December 9. Values adjusted to 2008 dollars.

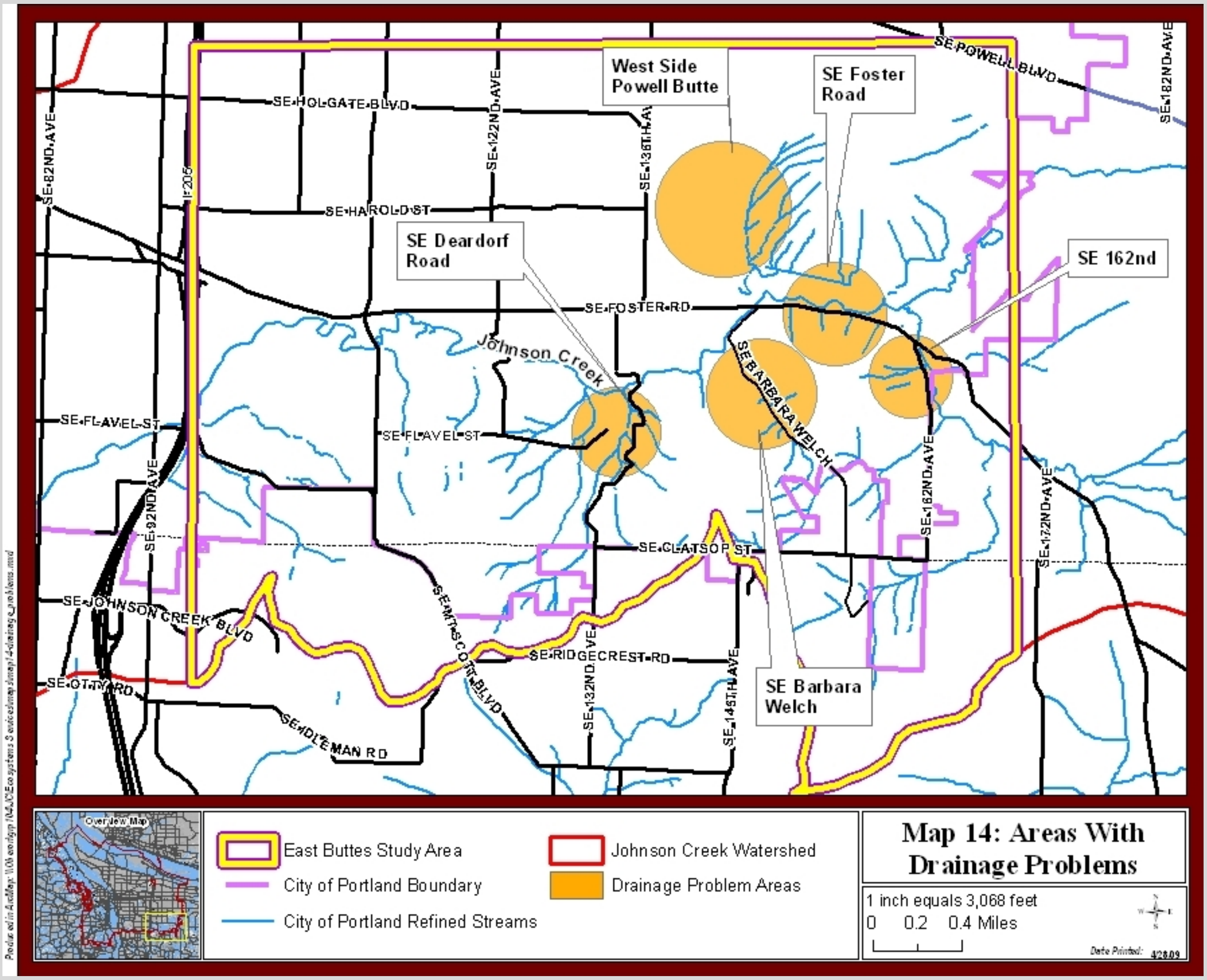
[87] 400 * 365 = 146,000 * $14 = $2,044,000

Figure 13. 1996 Flood Extent



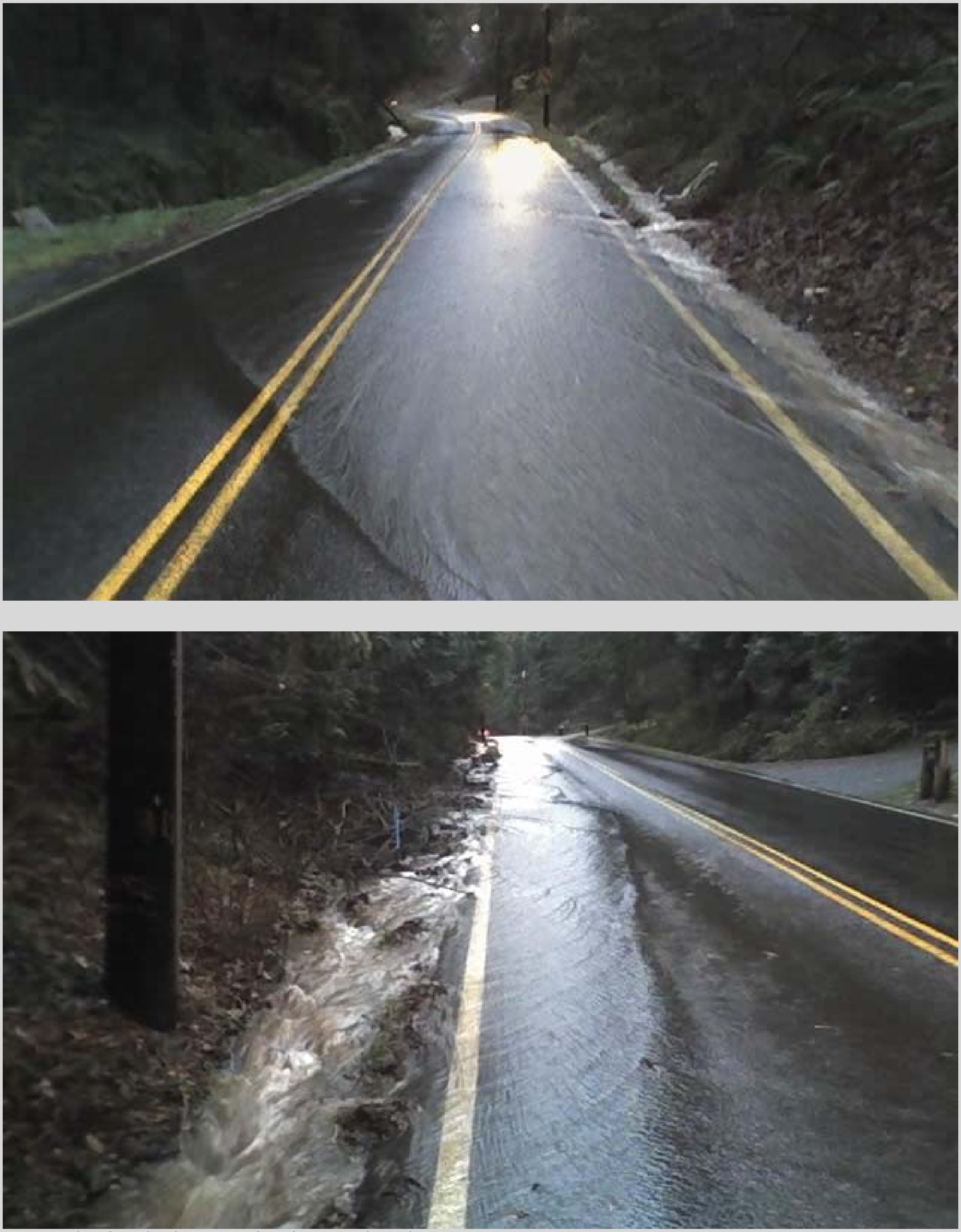
Source: City of Portland, Bureau of Environmental Services

Figure 14. Areas with Drainage Problems within the Study Area



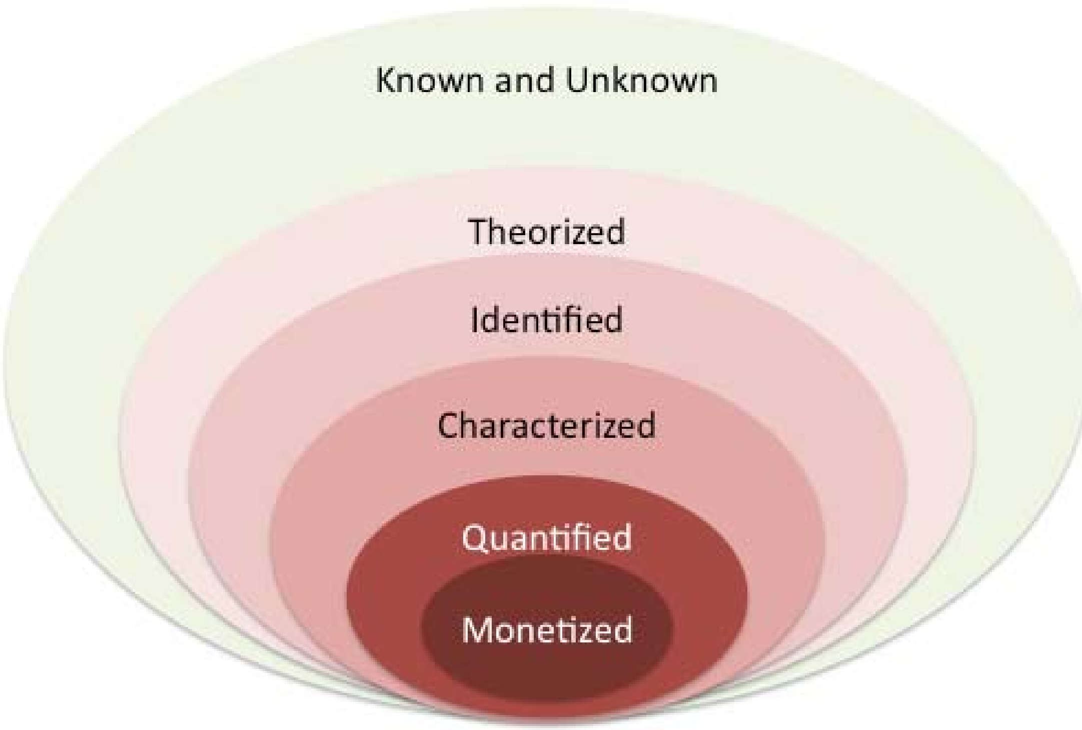
Source: City of Portland, Bureau of Environmental Services

Figure 15. Photos of SE Barbara Welch Blvd During a Heavy Rainstorm, Dec. 2007



Source: City of Portland, Bureau of Environmental Services

Figure 16. Hierarchy of Benefits Associated with Ecosystem Goods and Services Provided by the Natural Resources of the East Buttes Area



Source: ECONorthwest

III. CONCLUSION

The economic arguments presented in this report illustrate some of the benefits the City of Portland, private land owners, and society as a whole would enjoy by protecting the natural resources of the East Buttes area. The natural resources of the East Buttes area provide exceptional fish and wildlife habitat, recreational opportunities, and a host of other ecosystem goods and service, such as cleaner air and cleaner water. Maintaining and restoring the resources' ability to manage stormwater produces additional benefits by reducing the risk to the area's property owners from flooding and landslides. Protection would also help to reduce the City's capital and maintenance costs for controlling stormwater runoff in the area, and protect prior public investments in the area's parks, trails, and restoration projects.

The analysis described in this report is not an economic analysis of the full costs and benefits of protecting vs. not protecting habitat in East Buttes. Instead, we present *illustrative* values of the benefits the City of Portland, private land owners, and society as a whole would enjoy by protecting the natural resources of the East Buttes area. Table 6 summarizes the benefits we were able to quantify in monetary terms for each of the four economic arguments. We caution the reader against adding up the values in the Table 6, for several reasons. The values we present do not represent the full range of potential benefits that might arise from protection. Some benefits, though identifiable, resist quantification in economic terms, and other benefits undoubtedly exist, but remain beyond our current ability to describe. In addition, some of the values associated with different arguments double-count the same benefit. For example, we discuss the benefit of flood protection in two economic arguments: the value of avoiding increased flood risks to property and economic commerce, and the value the ecosystem provides by naturally attenuating floodwaters. We urge readers to consider the benefits in Table 6 as examples of the potential benefits provided by the natural resources in the East Buttes area, and acknowledge that the full value of the benefits may be different—likely greater—than what we report.

The four economic arguments demonstrate that protecting the East Buttes' natural resources through acquisition, regulatory measures, conservation easements, restoration, or other programs can produce a variety of benefits. Because many of the benefits arise from preserving the area's natural ability to attenuate stormwater runoff, the City may be able to maximize its investments by targeting protection to areas where controlling stormwater runoff from impervious surfaces would not be otherwise technically or economically feasible. While there are numerous tools available to protect these resources, land-acquisition programs, such as the Johnson Creek Willing Seller Program and land use regulations, such as environmental zones are among the most effective means of protecting the value of important natural resources and property and minimizing stormwater-related risks.

Table 6. Summary of the Values Associated with the Economic Arguments for Protection

Economic Argument	Description of Value	Value[a]
Reducing flood and landslide risks to private property, public infrastructure, and commerce.	Costs incurred from damage in the study area from the 1996 flood.	$728,000
	Costs incurred from damage downstream of the study area from the 1996 flood.	$5.4 million
	Costs of damage in and downstream of the study area from the 1995 flood.	$318,000
	Costs of damage in and downstream of the study area from the 1994 flood.	$395,000
Reducing public expenditures on planning, construction, maintenance, and clean up.	Partial costs of soil disposal and city staff time spent cleaning up, repairing, and reconstructing stormwater controls, mid-1997 to 2008.	$364,968[b]
	Partial costs of city staff time spent on stormwater planning for one potential development in the East Buttes study area.	$42,000
Preserving the value of prior public investments in the Johnson Creek watershed.	Partial costs of restoration and recreation trail projects in the study area.	$27.8 million
Preserving and enhancing the value of ecosystem goods and services.	*Water storage and release:* avoided costs of reduced flooding and value of increased stream flows to support salmonid habitat.	$6.1 million Unquantifiable at this time
	Habitat for aquatic and terrestrial species: protection of wetlands, value of habitat for bird watching, and value of protecting cutthroat trout.	$33,000 $3.3 million $1.7 million
	Nutrient and pollutant filtration: annual avoided healthcare costs associated with pollutants assimilated by trees.	$240,000
	Soil retention and erosion control: avoided costs associated with reduced sedimentation.	$37,600
	Local climate regulation: annual avoided costs associated with cooling.	$16,000
	Global climate regulation: annual value of sequestered carbon.	$91,896
	Scenic and aesthetic amenities: increased property values from with parks and tree canopy.	$39.5 million
	Recreational opportunities: value of biking on the Springwater Corridor Trail in the study area.	$2 million

Source: ECONorthwest

[a] All values in 2008 dollars, except where otherwise noted.
[b] Value in unadjusted (nominal) dollars. The total value includes costs incurred between 1997 and 2008.