2016 Puget Sound Regional Report

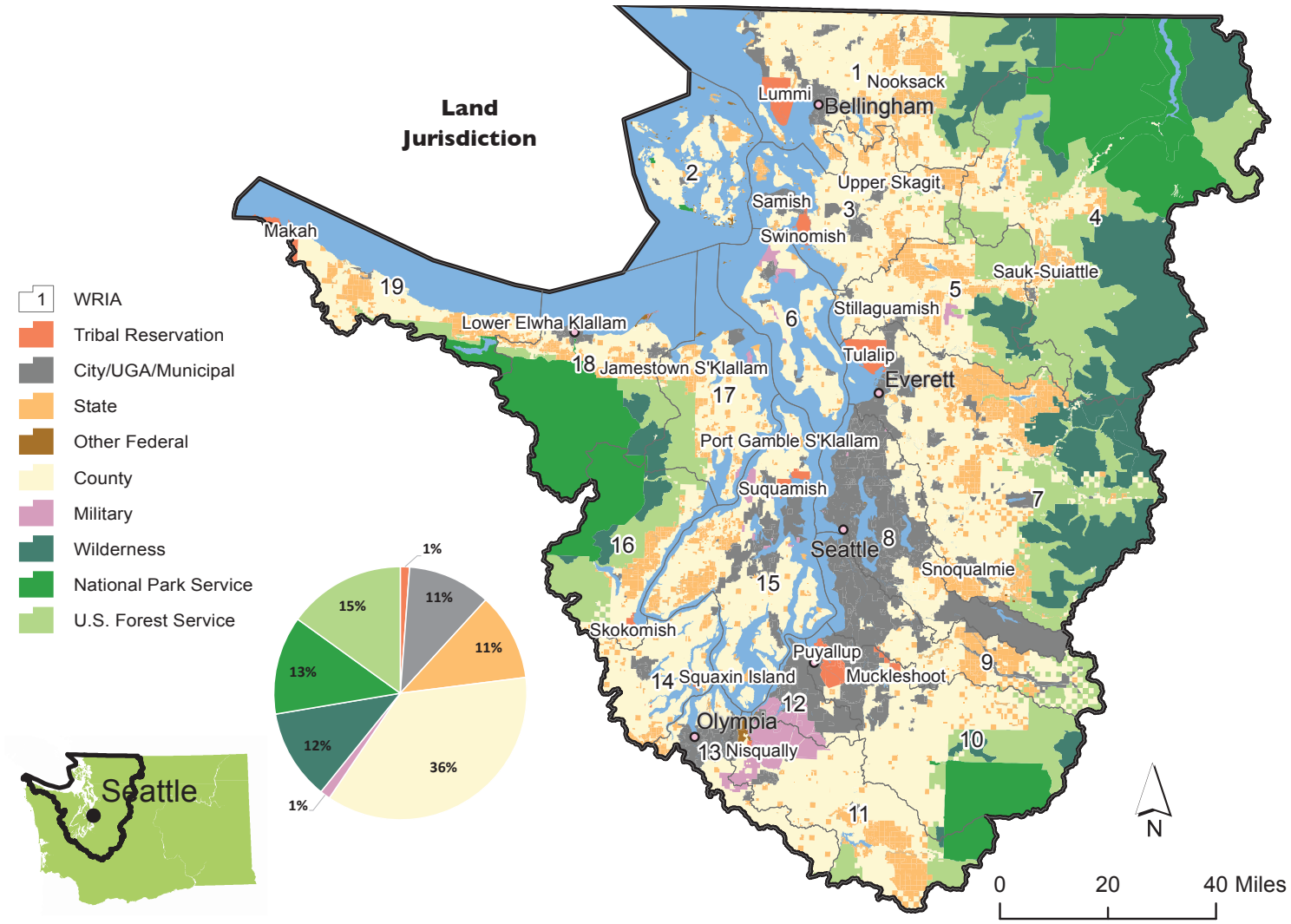
The Puget Sound Region includes the second largest estuary in the United States covering approximately 16,575 square miles, consisting of a complex estuarine system of interconnected marine waterways and basins. The Puget Sound Region has over 20 major river systems, from the Nooksack River along the Canadian border southwest to the Elwha River along the Strait of Juan de Fuca. Some of these watersheds originate in the steep high-elevation headwaters of the Cascade and Olympic mountains with an elevation of over 14,000 feet at the glaciers of Mount Rainier. Rainfall ranges from about 16 inches annually at Sequim, Washington, to over 100 inches at Mount Rainier.[1]

The Puget Sound Region is the traditional home to 19 federally recognized tribes, who have harvested and managed the natural resources of Puget Sound since time immemorial. Euro-Americans began settling the area in the 1850s primarily for the logging resources, along with opportunities in farming and mining. Lowland land clearing for agriculture began in earnest by the 1890's. By the early 1900s, denudation of the forested lowland areas was complete, and nearly all of the lower portions of the basins were converted from forest production. Historically and presently, landuse has been dominated by physical geography.

The foothills and mountains are mainly used for wood products and outdoor recreation. The lowlands are primarily used for agriculture and rural-residential development. Most of the urban and industrial land use is concentrated near the deltas.

The Puget Sound Region is home to two-thirds of the state's population, with a projected population increase to six million by 2026.[2] The following pages look at the impacts of growth, its effects on the landscape and salmonids. Conditions such as increased impervious surface area, groundwater extraction, forest cover loss, diminished riparian forest, culvert barriers and nearshore habitat impairment all negatively affect healthy natural salmonid production. Sustainable natural salmonid production cannot increase unless the quality and quantity of habitat is increased. Natural production lost to habitat degradation and blockage must be mitigated by hatchery production to provide an opportunity for the tribes to exercise their treaty right to harvest salmon. Hatchery production mitigating lost natural production cannot be reduced unless there is a commensurate increase in sustainable natural production, and habitat recovery is required for that.

The Puget Sound Region is home to eight different anadromous salmonid species, pink, chum, Chinook, coho, sockeye, steelhead trout, bull trout and cutthroat trout. Chinook, Hood Canal summer chum, steelhead trout and bull trout are all listed as threatened species under the Endangered Species Act and have Salmonid Recovery Plans targeting their recovery needs.



Data Source: USFWS 2014,[3] WADNR 2014a,[4] WADNR 2014b,[5] WADOT 2010,[6] WADOT 2013a,[7] WAECY 1994,[8] WAECY 2000,[9] WAECY 2011a,[10] WAECY 2013[11]

Puget Sound Salmon Recovery Plan

In January 2007, the National Marine Fisheries Service adopted the Puget Sound Salmon Recovery Plan. This plan calls for all leaders at all levels to join together in the effort to protect and manage the salmon and their habitat. The collective overarching goal shared by the contributors of the Puget Sound Salmon Recovery Plan is:

To recover self-sustaining, harvestable salmon runs in a manner that contributes to the overall health of Puget Sound and its watersheds and allows us to enjoy and use this precious resource in concert with our region's economic vitality and prosperity.[1]

Although each watershed has its own salmon recovery plan, there are common types of actions that all watersheds share. The top ten common actions identified in the 2007 plan are:

Protection and restoration of:
- Estuaries,
- Floodplains,
- Riparian Areas,
- Water Quantity (set instream flows, achieve flows, and conduct needed research to design suites of actions aimed at maintaining instream flows at watershed scales),
- Water Quality,
- Fish Access (e.g., dams, diversions, culverts, tide gates),
- Shoreline and Marine Areas (nearshore),

Proper management of:
- Harvest Management,
- Hatchery Management, and

H-Integration:
- The major factors that affect the abundance, productivity, spatial structure and diversity of salmon populations are often lumped into the "H Factors" of harvest, hatcheries and habitat (including hydropower).[2]

Recovery Efforts Show Signs of Improvement But Still Lagging in Key Indicators

Technical analysis has identified that a factor limiting salmon production is the loss of habitat-forming processes. Most devastating to the long-term viability of salmon has been the modification of the fundamental natural processes that allow habitat to form, and recovery from disturbances such as floods, landslides, and droughts.[3]

At the 10-year mark of the Puget Sound Salmon Recovery Plan, a review of key environmental indicators for the Puget Sound basin shows improvements for water quality and removal of forest road barriers but degradation in water quantity, marine shoreline habitat conditions and impervious surface areas. In general, there is a shortage of staff at all levels (e.g., federal, state, tribal, county) needed to address the issues and implement actions to restore and protect habitat and to monitor and enforce compliance of existing regulations. In addition, funding shortfalls for large-scale projects contribute to the slow pace of progress.

Review of the trend for these key environmental indicators since the 2012 State of Our Watersheds Report shows a decline for the indicators and a concern for whether the state of Washington will be able to repair the fish barriers per the court order:

Tribal Indicator	Status	Trend Since SOW 2012 Report
Shoreline Modifications / Forage Fish	Since 2008, over twice as much new armoring has been added as being removed. 40% of Puget Sound shorelines have some type of shoreline modification stressor, with 27% of the shoreline armored. Since the habitat is crucial for salmon; protection and restoration of nearshore marine waters is a component of the Puget Sound Salmon Recovery Plan.	**Declining**
Impervious Surface	Excluding federal lands, impervious surface area increased to about 7% in 2011, an increase of 2.6% since 2006. By 2026, the forecast population for Puget Sound will increase by over 750,000 and an increase in impervious surface to over 1,574 square miles at greater than 12% impervious surface area. The Puget Sound Salmon Recovery Plan lists "minimize impervious surfaces" as a key strategy for protecting habitat.	**Declining**
Forestland Cover	Between 2006 and 2011, an additional 153 square miles of forest cover was lost. The projected trend is to see continuing high rates of forest cover loss if protective actions are not taken. Minimizing forest cover removal to reduce long-term impacts is a "key strategy for protecting habitat" component of the Puget Sound Salmon Recovery Plan.	**Declining**
Water Wells	Despite the recent downturn in the economy, well drilling has continued, with a 3% growth since 2009. Most development has occurred in the lower portions of the watersheds and although the growth rate of rural wells has diminished, this has been during a time of economic downturn. As the economy recovers, the rate of new wells will probably increase.	**Declining**
Culverts	During the first two years of implementing the *U.S. v. Washington* Culvert Case Injunction, the state of Washington has corrected 76 fish-blocking culverts. At the current schedule, if additional support is not gained, the corrections of the remaining 800 culverts would be completed in 44 years or the year 2060.	**Concerns**
Riparian Buffers	Diminishing riparian forests in the lowlands of western Washington continue to impair habitats critical to the recovery of the region's anadromous salmon. The number of 6th level HUCs rated for "Properly Functioning" riparian forest cover shrank by 10.5% between 2006 and 2011. For most of Puget Sound in 2011, NMFS identified degraded riparian areas as a limiting factor to the recovery of Chinook salmon.	**Declining**

The Tribes continue to work toward the protection and restoration of healthy and functional nearshore, estuarine and river habitat, restoring those areas that are degraded, and conducting research to understand the organisms and the habitats they occupy.

Looking Forward

The increasing population of western Washington negatively impacts the landscape both physically and biologically. With population growth comes increased negative effects upon the landscape: developed impervious surfaces; forestland conversions for housing and infrastructure; pollution; water consumption; increased opportunity for invasive species; landscape modification (e.g., docks, piers, levees, culverts, bank hardening, channel modification); reduction in species diversity/density; loss of contiguous habitat (e.g., riparian, migration corridors); and related effects (e.g., sedimentation, mass wasting, climate change, diminished water quality, aquifer/groundwater depletion, native species endangerment/extirpation). While population growth is expected to continue, that growth needs to be managed to minimize its potential negative effects, and current impacts must be mitigated to restore and maintain a healthy landscape for all.

Among these impacts, impervious surfaces restrict groundwater recharge and contribute to increased pollution, both chemical and physical. Surface water withdrawals reduce streamflows and wetland volume downstream. Groundwater withdrawals, if not balanced by recharge, reduce streamflow, wetland volume, and freshets into seawater. Larger and additional roads and railways increase the number of stream crossings with the potential to impact salmonid access to habitat, and are also an impervious surface. Canopy cover is an important component of our hydrologic cycle; it supports life important to the salmonid life cycle. In the riparian zone, forests moderate temperature impacts, contribute woody debris, capture some pollutants otherwise released to the landscape, and reduce the potential for mass wasting events. The increase in global average temperatures in the air and oceans, contributes to the suite of climate change effects.

Climate change occurs within the context of land and water use that already has diminished the ecological integrity of our watersheds. These changes leave aquatic and terrestrial species increasingly vulnerable to changes in climate conditions in the Pacific Northwest region. The deep relationship between traditional tribal lifeways and the ecosystems of Puget Sound leave member tribes especially vulnerable to the effects of climate change. Critical tribal resources, including salmon, shellfish, terrestrial plants and wildlife, are already experiencing climate change impacts. The tribes currently employ many strategies to protect natural resources but climate change could threaten the effectiveness of these strategies and the resilience of ecosystems in responding to our changing environment.

Blocking Culverts Impact Salmonid Survival

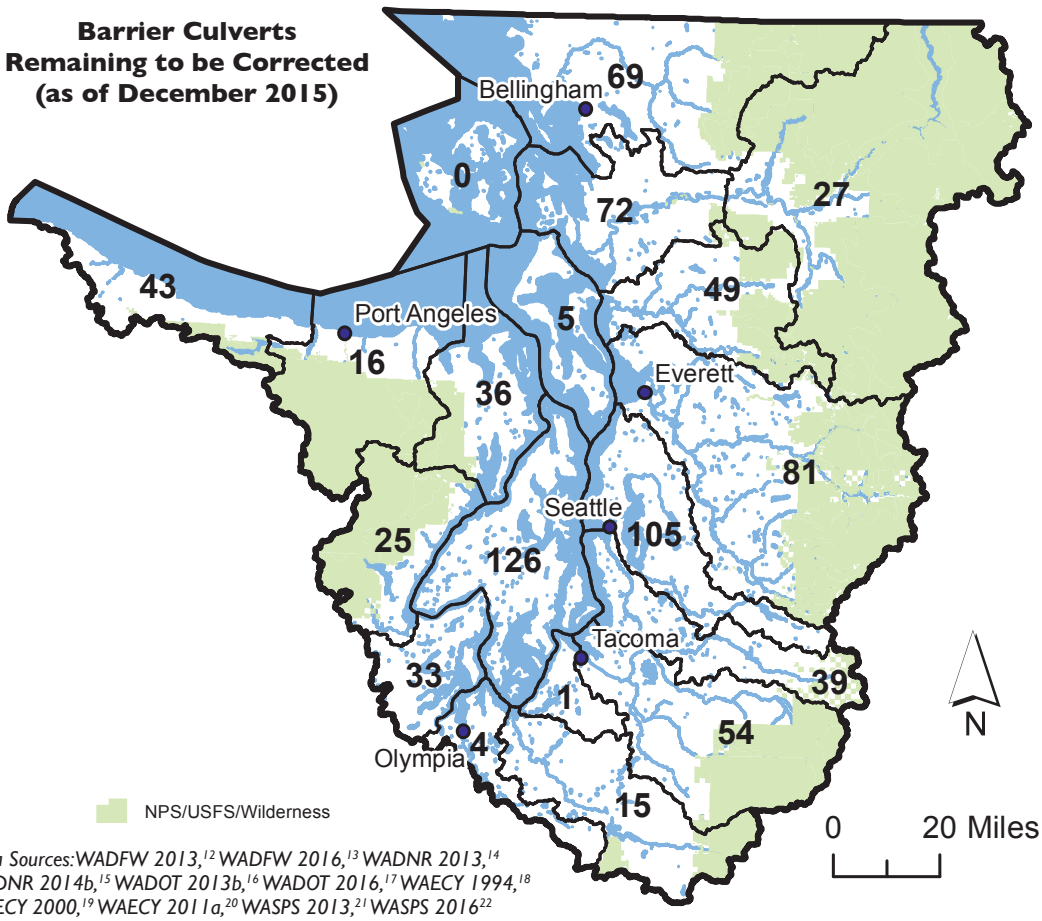
During the first two years of implementing the U.S. v. Washington *Culvert Case Injunction, the state of Washington has corrected 76 fish-blocking culverts. At the current schedule, if additional support is not gained, the corrections of the remaining 800 culverts would be completed in 44 years or the year 2060.*

Usable habitat for Puget Sound salmon is a fraction of what it once was, and our ability to recover the salmon populations directly depends on the recovery of habitat.[1]

"Impaired fish access is one of the more significant factors limiting salmonid productivity in many watersheds."[2] In 2013, the U.S. District Court ruled that "the Tribes and their individual members have been harmed economically, socially, educationally, and culturally by the greatly reduced salmon harvests that have resulted from State created or State-maintained fish passage barriers."[3]

The Puget Sound Salmon Recovery Plan states that "the loss of rearing habitat quantity and quality is the primary factor affecting population performance," and that the status quo is unacceptable.[4] Not only do physical barriers limit fish passage and available habitat, they can also damage water quality and disrupt sediment deposition.[5]

Because of this damage, "In 2001, the United States and western Washington Tribes brought an action against the State of Washington for their failure to construct and maintain fish passage on state-owned culverts."[6] In 2007, the court ruled that the right of taking fish, as secured by the treaties, means that the state must "refrain from building or operating culverts…that hinder fish passage."[7]



Data Sources: WADFW 2013,[12] WADFW 2016,[13] WADNR 2013,[14] WADNR 2014b,[15] WADOT 2013b,[16] WADOT 2016,[17] WAECY 1994,[18] WAECY 2000,[19] WAECY 2011a,[20] WASPS 2013,[21] WASPS 2016[22]

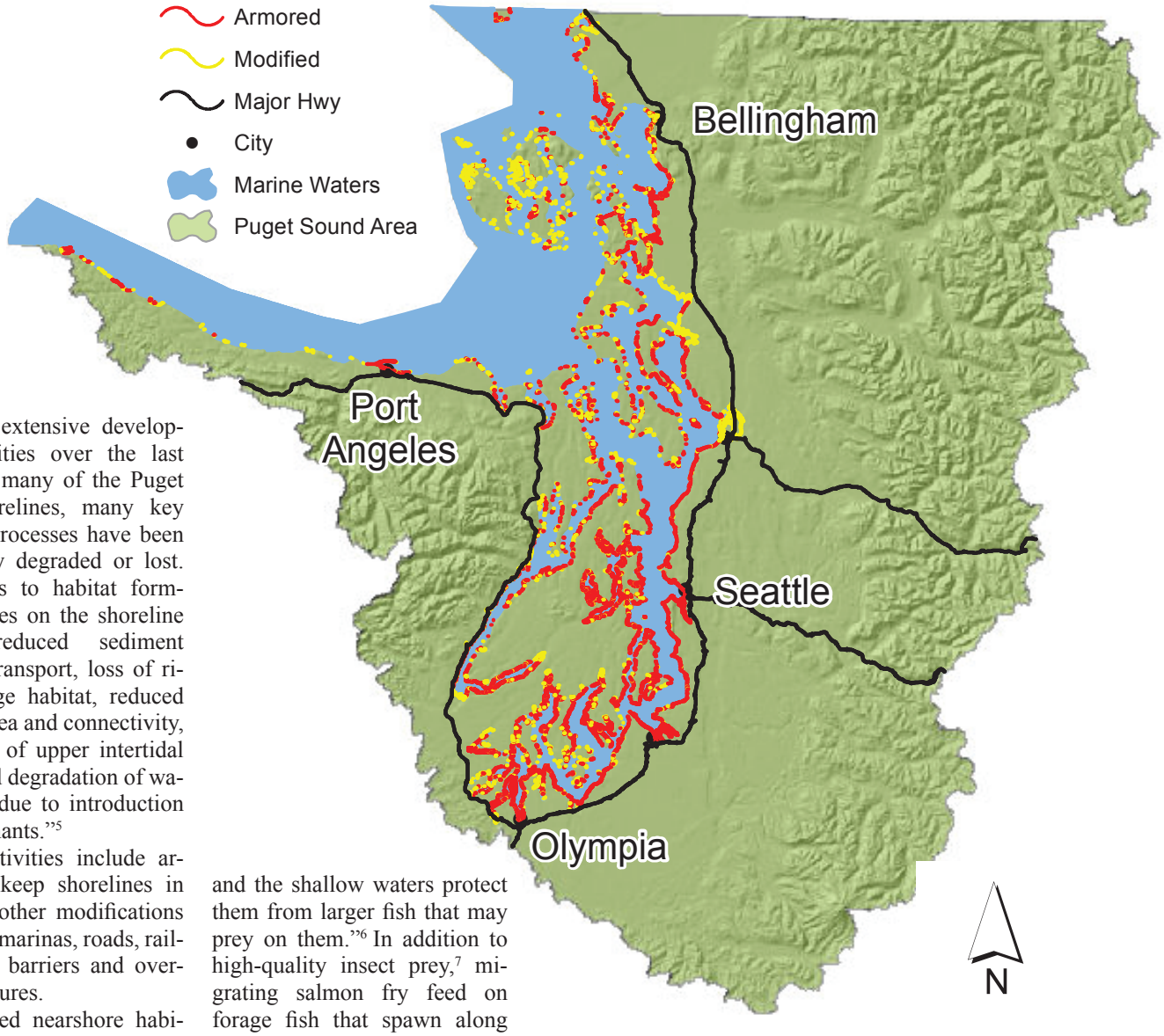
In March 2013, the U.S. District Court granted the permanent injunction requested by the federal government and tribes, holding that the tribes "have suffered irreparable injury in that their Treaty-based right of taking fish has been impermissibly infringed. The construction and operation of culverts that hinder free passage of fish has reduced the quantity and quality of salmon habitat, prevented access to spawning grounds, reduced salmon production in streams in the Case Area, and diminished the number of salmon available for harvest."[8] Multiple state agencies were affected by this ruling. Washington State Parks and the Department of Fish and Wildlife are required by State law to fix their injunction culverts by October 31, 2016.[9] Based on their plans for 2016, which are in line with previous years, they should meet the deadline. Some of Department of Natural Resources' culverts have a longer timeline for correction.[10]

Owner	Original Count	Fixed 2013-15	Add to List	Removed from List	2015 Count	Planned for 2016	Remaining if 2016 planned is fixed
DNR	51	42	5	2	11	11	0
DOT <200	*141*	*2*	*7*	*7*	*139*		*139*
DOT >200	*660*	*19*	*28*	*28*	*641*	*18*	*623*
DOT Unknown	*1*				*1*		*1*
DOT Total	802	21	35	35	781	18	763
Parks	13	9			4	4	*0*
DFW	10	4	3	5	4	4	0

Washington Department of Transportation (DOT) is required to fix culverts that block 200 meters or more of habitat by 2030. Although spending and completing culvert correction has improved, DOT culvert repair funding is less than 12% of where it needs to be to complete repairs by the court appointed deadline.[11] DOT still needs to fix over 600 barrier culverts (>200m of habitat) in the Puget Sound Region region; 18 are planned for 2016.

Shoreline Modifications Continue

Since 2008, over twice as much new armoring is being added as is being removed.[1] 40% of Puget Sound shorelines have some type of shoreline modification stressor,[2] with 27% of the shoreline armored.[3] Since the habitat is crucial for salmon, protection and restoration of nearshore marine waters is a component of the Puget Sound Salmon Recovery Plan.[4]



"Due to extensive development activities over the last century on many of the Puget Sound shorelines, many key nearshore processes have been significantly degraded or lost. Impairments to habitat forming processes on the shoreline include: reduced sediment input and transport, loss of riparian fringe habitat, reduced estuarine area and connectivity, filling over of upper intertidal beaches and degradation of water quality due to introduction of contaminants."[5]

These activities include armoring to keep shorelines in place, and other modifications such as fill, marinas, roads, railroads, tidal barriers and overwater structures.

A modified nearshore habitat with diminished protection from predators, reduced prey abundance and contaminated water is detrimental to achieving salmon recovery goals. Natural shorelines form a migratory pathway for juvenile salmon, which use pocket estuaries "located at the mouths of streams and drainages, where freshwater input helps them to adjust to the change in salinity, insect production is high, and the shallow waters protect them from larger fish that may prey on them."[6] In addition to high-quality insect prey,[7] migrating salmon fry feed on forage fish that spawn along shorelines.[8] These effects have caused a decline in growth and lower survival rates.[9]

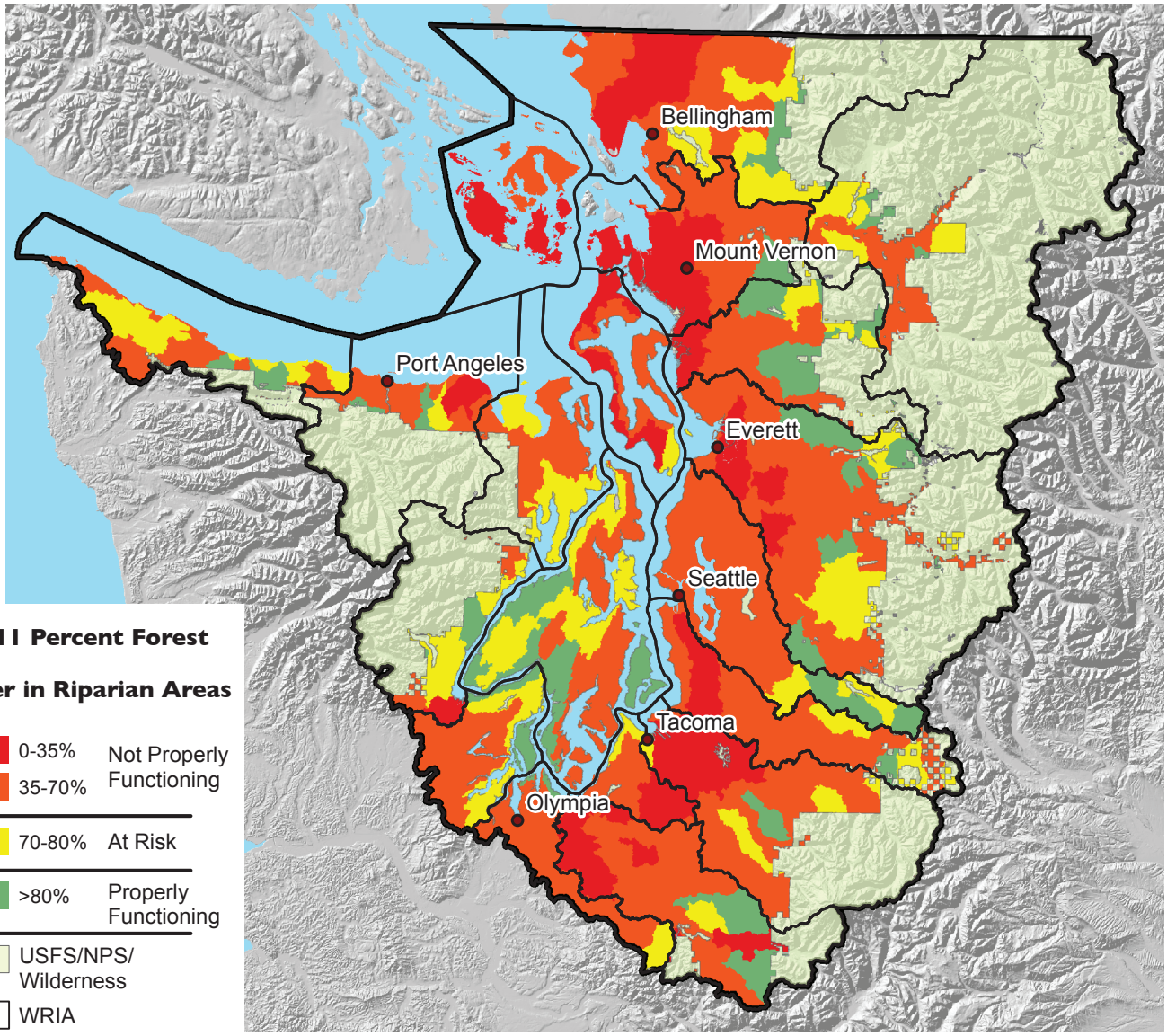
Increased restoration of shoreline is needed to mitigate for the additional armoring that has continually been added. Although removal of shoreline armoring has increased since WDFW started tracking it in 2005, until 2014, new armoring was greater than that removed.[10]

NOAA, from Encyclopedia of Puget Sound

Data Sources: ACOE 2008,[11] Carman et al. 2015,[12] PSNERP 2008,[13] WADOT 2010,[14] WADOT 2011,[15] WAECY 1994,[16] WAECY 2000[17]

Diminished Riparian Forests

Diminishing riparian forests in the lowlands of western Washington continue to impair habitats critical to the recovery of the region's anadromous salmon. The number of 6th level HUCs rated for "Properly Functioning" riparian forest cover shrank by 10.5% between 2006 and 2011. For most of Puget Sound in 2011, NMFS identified degraded riparian areas as a limiting factor to the recovery of Chinook salmon.[1]



"Since statehood in 1889, Washington has lost an estimated 70% of its estuarine wetlands, 50% of its riparian habitat, and 90% of its old-growth forest."[2]

"Although focusing growth inside UGAs (Urban Growth Areas) is required by GMA (Growth Management Act), the protection of forest cover has not been met by existing regulatory tools. Growth pressures clear land in UGAs, even along riparian corridors and other areas important for salmon habitat."[3]

The Puget Sound area consists of 425 6th level Hydrologic Units (HUCs) from the U.S. side of the Salish Sea out to the mouth of the Strait of Juan de Fuca. 303 of these HUCs are partially or completely outside of USFS/NPS/Wilderness Areas. Of these identified HUCs, only 16.8% are rated "Properly Functioning" riparian forest cover in 2011, down from 18.8% in 2006. NMFS identified degraded riparian areas as a limiting factor important for recovery in their 2011 Implementation Status Assessment Final Report.[4]

The diminished riparian function of most watersheds and marine shoreline results in decreased water quality, temperature regulation, cover, bank stability, LWD recruitment, sedimentation, detrital/nutrient input, and impacts to other biotic and abiotic conditions for salmon and their supporting environment. Human population growth will continue throughout Puget Sound. However, its concomitant effects in riparian areas must be managed to ensure recovery of this vital salmonid habitat limiting factor.

Data Sources: SSHIAP 2004,[5] SWIFD 2014,[6] WADNR 2014b,[7] WADOT 2010,[8] WAECY 2000,[9] WAECY 2006,[10] WAECY 2011b[11]

Forest Cover Loss Continues in Puget Sound Lowlands

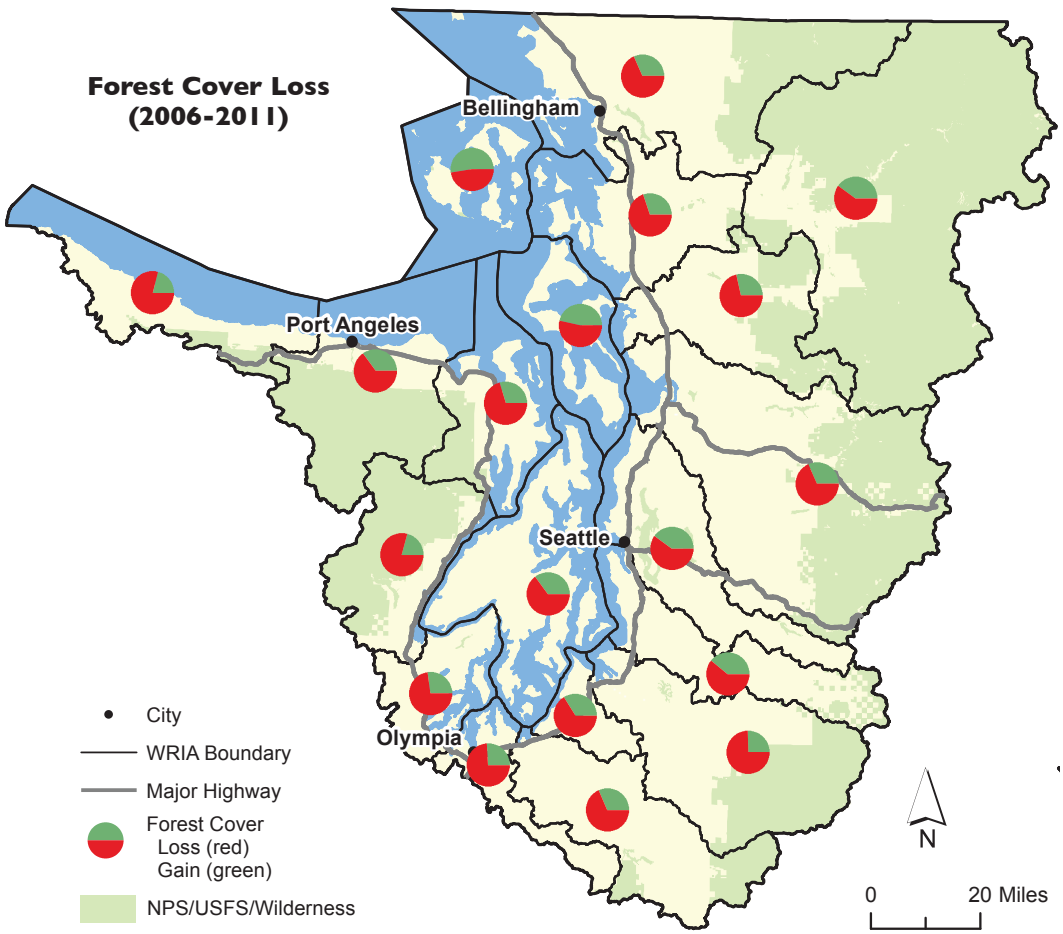
Between 2006 and 2011, an additional 153 square miles of forest cover was lost. The projected trend is to see continuing high rate of forest cover loss if protective actions are not taken. Minimizing forest cover removal to reduce long-term impacts is a "key strategy for protecting habitat" component of the Puget Sound Salmon Recovery Plan.[1]

Within the Puget Sound Area (WRIAs 1-19) and outside of the National Park and Recreation areas, lies an area of approximately 11,950 square miles (excluding the marine waters). There was a decline in forested area between 2006 and 2011, of 153 square miles (net), due to timber harvesting and land conversions. While 378 square miles of forested land cover were lost, 225 square miles were gained through forest growth.

Between 1996 and 2006, 131 square miles of the lost forest cover were zoned for non-forestry uses. Analyzing 2011 forest cover, 163 square miles of the lost forest cover are on land zoned for non-forestry uses. The rate of loss for this five-year cycle (2006-2011) is 249% of the rate for the previous 10-year period (1996-2006). Forestlands converted to non-forestry uses continue to degrade the landscape.

"From 1988-2004, Western Washington forest lands have declined by 25%….These losses (meaning conversion to other uses), were the result of changes in market conditions for wood products, changes in land ownership, impacts from competing land uses and the health of timber stock. Recent research from the University of Washington indicates that nearly one million more acres of private forestland are threatened with conversion. Across all of Washington, the potential risk of conversion is highest in the Puget Sound region….This habitat loss is added to the existing background of land disturbance and development across Puget Sound. The numbers show a disturbing trend of continuing loss despite the State's adoption of some of the most aggressive land management tools in the Nation, including the Shoreline Management Act (SMA), Growth Management Act (GMA), Critical Areas Regulations (CAR) and the Forests and Fish Agreement, which led to changes in the Forest Practices Act to protect Salmon."[2]

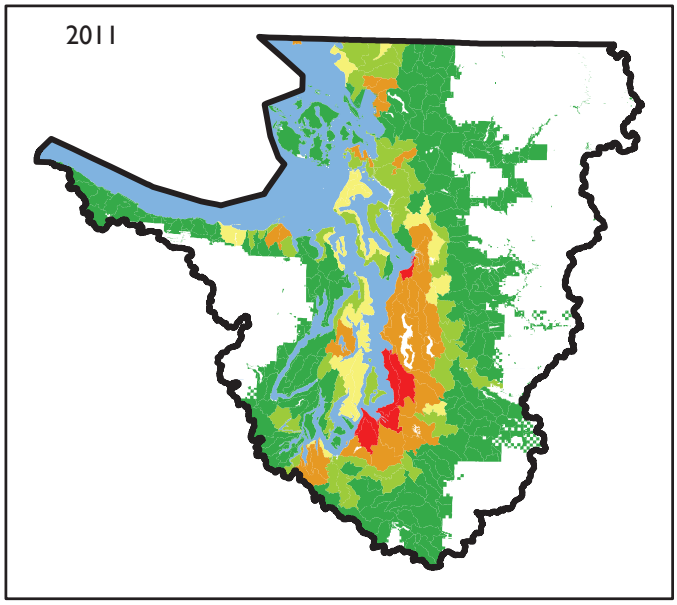
340 acres of forest were removed within the 100-year floodplain of the Skykomish River between 2009 and 2011.

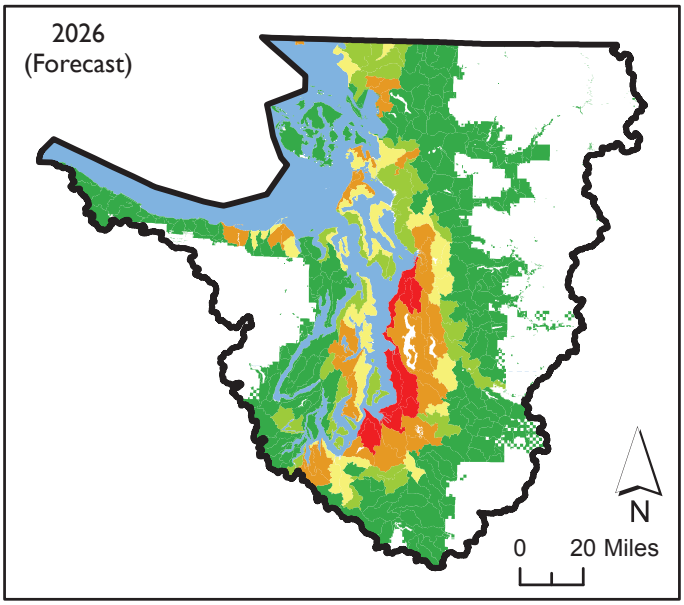


Data Sources: NAIP 2009,[3] NAIP 2011,[4] UW 2012,[5] WADNR 2014b,[6] WADOT 2011,[7] WAECY 2000,[8] WAECY 2006,[9] WAECY 2011a,[10] WAECY 2011b[11]

Impervious Surface Continues to Increase

Excluding federal lands, impervious surface area increased to about 7% in 2011, an increase of 2.6% since 2006. By 2026, the forecast population for Puget Sound will increase by over 750,000 and an increase in impervious surface to over 1,574 square miles. The Puget Sound Salmon Recovery Plan lists "Minimize impervious surfaces" as a key strategy for protecting habitat.[1]





As impervious surface increases in a watershed, stream temperatures and sediment transport are likely to increase and instream biodiversity decrease by reducing the number of insect and fish species; and contributes to pollutants in stormwater runoff, which can contaminate local aquatic systems.[2] Contaminated runoff poses significant threats to freshwater, estuarine, and marine species, including the Pacific Northwest's salmon and steelhead runs.[3] The addition of impervious surface reduces water infiltration and increases runoff, causing higher peak flows during wet times and lower dry weather flows due to lack of groundwater recharge.[4]

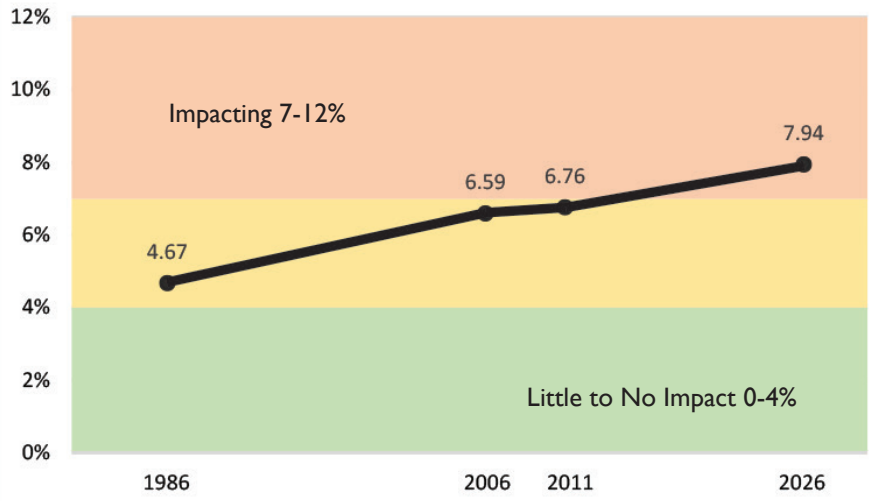
Between 2006 and 2011, the rate of annual impervious surface increase has decreased from the rate between 1986 and 2006. However, this occurred at a time of economic depression, where most of the slowed population increase was in urban areas. The 2026 impervious surface forecast is based upon a continuation of the 2006-2011 behavior. If the population increases much more than forecast, or if an improving economy causes people to regress to 1986-2006 behavior, there is potential for an even greater increased impervious surface level.

The Chinook Recovery Plan leans heavily on local planning, land-use policies, and provisions contained in the local watershed plans to protect federally designated habitat.[5] However, even with critical areas ordinances, planned development areas outside of the designated Urban Growth Areas will continue to contribute to increases in impervious surface area.

Impervious Surface Categories

- Little to no Impact (0-4%)
- Beginning to Impact (4-7%)
- Impacting (7-12%)
- Degrading (12-40%)
- Potentially Unrestorable (>40%)
- Waterbodies
- Puget Sound Area Boundary

Puget Sound Impervious Surface (1986-2026 forecast), excluding NPS and USFS



Data Sources: NLCD 2006,[6] NLCD 2011,[7] USGS 2014,[8] WAECY 1994,[9] WAOFM 2007,[10] WAOFM 2011,[11] WAOFM 2012,[12] WAOFM 2015[13]

Groundwater Withdrawals Impact Surface Flows

Despite the recent downturn in the economy, well drilling has continued, with a 3% growth since 2009. Most development has occurred in the lower portions of the watersheds and although the growth rate of rural wells has diminished, this has been during a time of economic downturn. As the economy recovers, the rate of new wells will probably increase.

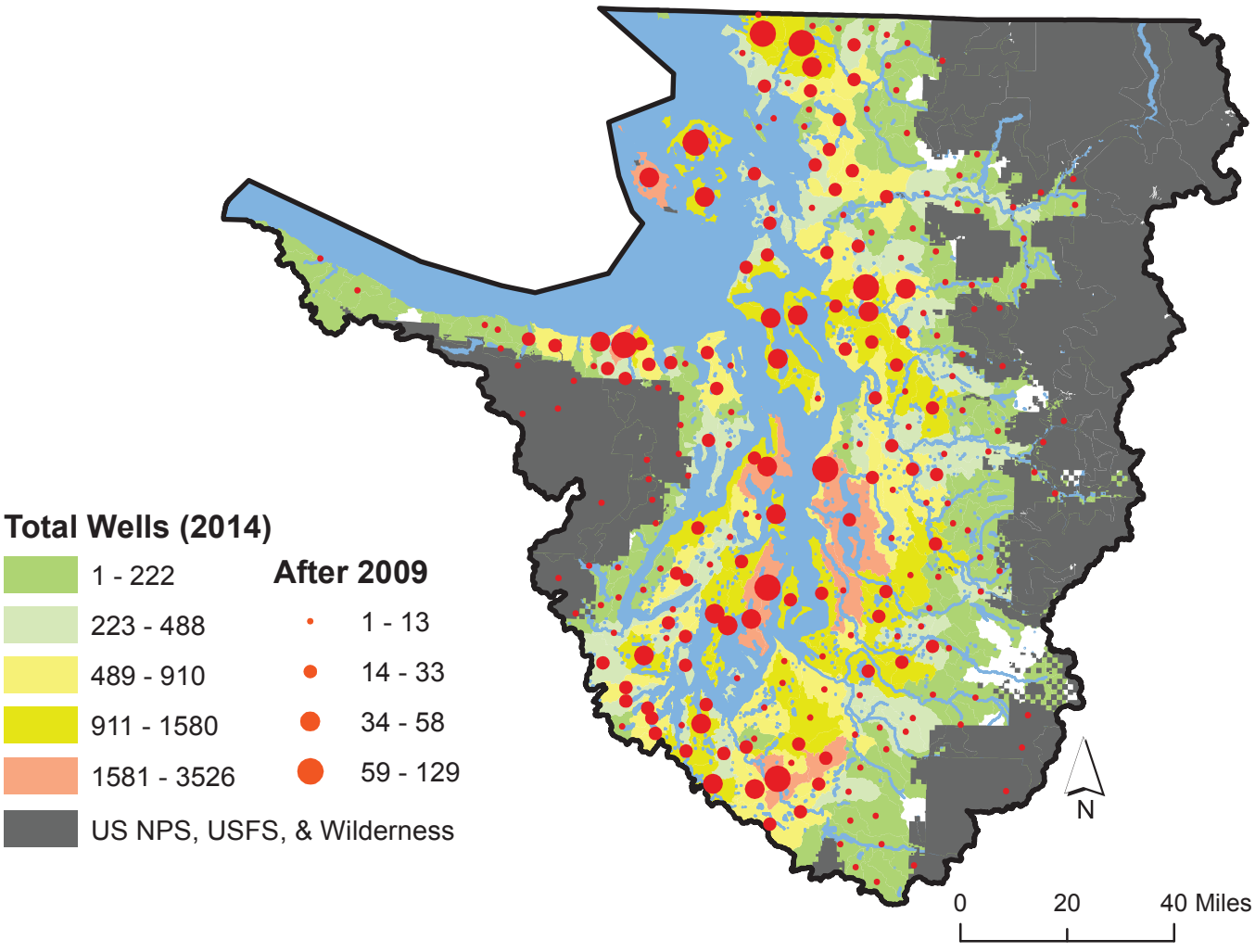
Population growth within the Puget Sound watershed, both in the past and in the near future, will have increased demands on groundwater resources. Washington state instream flow rules allocate river flow for ecological requirements, but state law allows new wells to withdraw 5,000 gallons of groundwater per day without obtaining a permit that would require scientific evidence that water is legally available.[1] Groundwater withdrawals can cumulatively affect streamflows, especially in late summer when flows are naturally low.

An aquifer's natural outflow discharges into lakes, wetlands, streams and seawater through springs and seeps on the land surface and through groundwater. Adequate natural outflow is essential for sustaining base streamflows, maintaining lake levels, providing freshwater inputs to the nearshore, and preventing seawater intrusion.

As development occurs and more groundwater is extracted than is being recharged, the natural outflow from groundwater subsequently decreases. This reduces the amount of freshwater available to lakes, wetlands, streams and the Puget Sound nearshore. Reduced freshwater inputs to the Puget Sound nearshore can have a negative impact on shellfish and out-migrating juvenile salmonids.

The reduced availability of surface water can have a negative impact on all stages of the salmonid life cycle. Water quality (e.g., temperature, flows) is affected by decreased inputs from groundwater. Less groundwater input concentrates pollutants, increases temperature, and diminishes dissolved oxygen. This is detrimental to salmonid migration, spawning and rearing.

Population growth within the Puget Sound watershed will continue to increase demand on water resources. Wells are drilled without regard to aquifer sensitivity and stream recharge needs, which makes it more important that something changes as Puget Sound's freshwater demand increases. Unchecked growth and its associated increase demand for groundwater must be addressed, if implementation of the Puget Sound salmon recovery strategy is to successfully move forward.



Data Sources: USGS 2014,[2] WADNR 2014b,[3] WAECY 2013,[4] WAECY 2015[5]

Citations

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1 PRISM Climate Group. Downloaded September 2015. 30-year normal raster dataset. Corvallis, OR: Oregon State University.

2 WAOFM. 2014. April 1, 2014 Population of Cities, Towns and Counties. Olympia, WA: Washington Office of Financial Management.

3 USFWS. 2014. Polygons of FWS Approved Boundaries. Falls Church, VA: U.S Fish and Wildlife Service.

4 WADNR. 2014a. Washington State DNR Managed Land Parcels. Olympia, WA: Washington Department of Natural Resources.

5 WADNR. 2014b. Washington State Non-DNR Major Public Lands (NDMPL) Polygons. Olympia, WA: Washington Department of Natural Resources.

6 WADOT. 2010. City Points. Olympia, WA: Washington Department of Transportation.

7 WADOT. 2013a. Polygons depicting the boundaries of Tribal Lands in Washington State. Olympia, WA: Washington Department of Transportation.

8 WAECY. 1994. Polygons of Washington State Shorelines and Boundary. Olympia, WA: Washington Department of Ecology.

9 WAECY. 2000. Water Resource Inventory Area (WRIA) Polygons. Olympia, WA: Washington Department of Ecology.

10 WAECY. 2011a. NHD Major Areas, Streams, and Waterbodies. 1:24000. From U.S. Geological Survey, in cooperation with others. National Hydrography Dataset. Olympia, WA: Washington Department of Ecology.

11 WAECY. 2013. City Boundaries and Urban Growth Areas Polygons. Olympia, WA: Washington Department of Ecology.

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1 Shared Strategy for Puget Sound. 2007. Puget Sound Salmon Recovery Plan Volume 1. National Marine Fisheries Service.

2 Ibid.

3 Ibid.

Blocking Culverts Impacts Salmonid Survival

1 Shared Strategy for Puget Sound. 2007. Puget Sound Salmon Recovery Plan Volume 1. National Marine Fisheries Service.

2 Joint Natural Resources Cabinet. 1999. Statewide Strategy to Recover Salmon: Extinction is Not an Option.

3 Subproceeding 01-01 Memorandum and Decision. United States of America, et al. v. State of Washington, et al. Case No. CV 70-9213. United States District Court, Western District of Washington at Seattle.

4 Shared Strategy for Puget Sound. Puget Sound Salmon Recovery Plan.

5 Joint Natural Resources Cabinet. Statewide Strategy.

6 Hollowed, J. October 2011. Personal communication. Olympia, WA: Northwest Indian Fisheries Commission.

7 Subproceeding 01-01 Memorandum and Decision.

8 Ibid.

9 Sledd, J & J. Shorin III. Injunction Overview: U.S. v. Washington. 2014. Presentation at Culverts Inaugural Annual Meeting. Kanji & Katzen PLLC and Attorney General's Office.

10 Nagygyor, A. 2015. PowerPoint presentation from Culverts Second Annual Meeting. Washington Department of Natural Resources.

11 WADOT. 2014. 14-11-2750 Accelerating Fish Barrier Correction: New Requirements for WSDOT Culverts. December 2014. Olympia, WA: Washington Department of Transportation.

12 WADFW. 2013. Washington State Department of Fish and Wildlife Case Culverts Points. Obtained from J. Henning 2013 October 4. Olympia, WA: Washington Department of Fish and Wildlife.

13 WADFW. 2016. Spreadsheet WDFW_InjunctionCulvertDispositionMarch2016.xlsx received 2016-3-22, in email from D. Price. Olympia, WA: Washington Department of Fish and Wildlife.

14 WADNR. 2013. DNR Case Culverts Inventory Points. Obtained from A. Nagygyor 2013 October 9 and J. Holden 2013 November 22. Olympia, WA: Washington Department of Natural Resources.

15 WADNR. 2014b. Washington State Non-DNR Major Public Lands (NDMPL) Polygons. Olympia, WA: Washington Department of Natural Resources.

16 WADOT. 2013b. Washington State Department of Transportation Case Culverts Points. Obtained from M. Barber 2013 October 4. Olympia, WA: Washington Department of Transportation.

17 WADOT. 2016. Spreadsheets WSDOT_WRIAs1_23.xlsx, WSDOT_WRIAs20_23.xlsx, WSDOT_Edited.xlsx received from K. Prosser in March 2016.

18 WAECY. 1994. Polygons of Washington State shorelines and boundary. Olympia, WA: Washington Department of Ecology.

19 WAECY. 2000. Water Resource Inventory Area (WRIA) Polygons. Olympia, WA: Washington Department of Ecology.

20 WAECY. 2011a. NHD Major Areas, Streams, and Waterbodies. 1:24000. From U.S. Geological Survey (in cooperation with others) National Hydrography Dataset. Olympia, WA: Washington Department of Ecology.

21 WASPS. 2013. Washington State Park Case Culverts Points. Obtained from D. Petersen 2013 October 2. Olympia, WA: Washington Department of Natural Resources.

22 WASPS. 2016. Spreadsheet WSPRC_InjunctionCulvertDispositionJanuary2016.xlsx received 2016-3-16, in email from D. Petersen. Olympia, WA: Washington Department of Natural Resources.

Shoreline Modifications Continue

1 Carman, R., B. Benson, T. Quinn & D. Price. 2015. Trends in shoreline armoring in Puget Sound 2005-2014 from Washington State Hydraulic Permit Application database. Spreadsheet PSSA_2005-2014_rc_7-22-15.xlsx received 2015-08-24, in email from R. Carman. Olympia, WA: Washington Department of Fish and Wildlife.

2 ACOE. 2008. Processed form of Puget Sound Nearshore and Restoration Project Shoreform Change Polylines (Version 2). Received in 2011 from Scott Campbell.

3 PSNERP. 2008. Puget Sound Nearshore and Restoration Project Shoreline Armoring Polylines. Puget Sound Nearshore Ecosystem Restoration Partnership.

4 Shared Strategy for Puget Sound. 2007. Puget Sound Salmon Recovery Plan Volume 1. Plan Adopted by the National Marine Fisheries Service (NMFS). Seattle, WA: Shared Strategy for Puget Sound.

5 Nisqually Salmon Recovery Team. 2010. Nisqually 2010 Three-Year Work Program.

6 Shared Strategy for Puget Sound. Puget Sound Salmon Recovery Plan.

7 Duffy, E., D. Beauchamp, R. Sweeting, R. Beamish & J. Brennan. 2010. Ontogenetic diet shifts of juvenile chinook salmon in nearshore and offshore habitats of Puget Sound. Transactions of the American Fisheries Society 139: 803-823.

8 Shared Strategy for Puget Sound. Puget Sound Salmon Recovery Plan.

9 Fresh, K. 2006. Juvenile Pacific salmon in Puget Sound. Technical report 2006-06. NOAA Fisheries Service, Northwest Fisheries Science Center. Prepared for: Puget Sound Nearshore Partnership.

10 Carman et al. 2015. Trends in shoreline armoring.

11 ACOE. 2008. Processed form of Puget Sound Nearshore.

12 Carman et al. 2015. Trends in shoreline armoring.

13 PSNERP. 2008. Puget Sound Nearshore and Restoration Project Shoreline Armoring Polylines.

14 WADOT. 2010. City Points. Olympia, WA: Washington Department of Transportation.

15 WADOT. 2011. National Highway System polylines. Tumwater, WA: Washington Department of Transportation.

16 WAECY. 1994. Polygons of Washington State Shorelines and Boundary. Olympia, WA: Washington Department of Ecology.

17 WAECY. 2000. Water Resource Inventory Area (WRIA) Polygons. Olympia, WA: Washington Department of Ecology.

Diminished Riparian Forests

1 Judge, M. 2011. 2011 Implementation Status Assessment. Final Report. A qualitative assessment of implementation of the Puget Sound Chinook Recovery Plan. Prepared for the National Marine Fisheries Services. Task Order 2002.

2 Ibid.

3 Ibid.

4 Ibid.

5 SSHIAP. 2004. Hillshade derived from University of Washington Digital Elevation Model (DEM). Olympia, WA: Northwest Indian Fisheries Commission.

6 SWIFD. Statewide Washington Integrated Fish Distribution. 2014. Washington State Department of Fish and Wildlife & Northwest Indian Fisheries Commission.

7 WADNR. 2014b. Washington State Non-DNR Major Public Lands (NDMPL) Polygons. Olympia, WA: Washington Department of Natural Resources.

8 WADOT. 2010. City Points. Olympia, WA: Washington Department of Transportation.

9 WAECY. 2000. Water Resource Inventory Area (WRIA) Polygons. Olympia, WA: Washington Department of Ecology.

10 WAECY. 2006. C-CAP Land Cover. Modified from National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center (CSC)/Coastal Change Analysis Program (C-CAP). Olympia, WA: Washington Department of Ecology.

11 WAECY. 2011b. C-CAP Land Cover. Modified from National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center (CSC)/Coastal Change Analysis Program (C-CAP). Olympia, WA: Washington Department of Ecology.

Forest Cover Loss Continues in Puget Sound Lowlands

1 National Marine Fisheries Service. 2007. Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan.

2 Judge, M. 2011. 2011 Implementation Status Assessment. Final Report. A qualitative assessment of implementation of the Puget Sound Chinook Recovery Plan. Prepared for the National Marine Fisheries Services. Task Order 2002.

3 NAIP. 2009. USDA National Agricultural Imagery Program. Washington, DC: U.S. Department of Agriculture.

4 NAIP. 2011. USDA National Agricultural Imagery Program. Washington, DC: U.S. Department of Agriculture.

5 UW. 2012. Washington State Parcel Database: version 2012 edition 9.2 release 1.2. Seattle, WA: University of Washington, College of Forest Resources.

6 WADNR. 2014b. Washington State Non-DNR Major Public Lands (NDMPL) Polygons. Olympia, WA: Washington Department of Natural Resources.

7 WADOT. 2011. National Highway System polylines. Tumwater, WA: Washington Department of Transportation.

8 WAECY. 2000. Water Resource Inventory Area (WRIA) Polygons. Olympia, WA: Washington Department of Ecology.

9 WAECY. 2006. C-CAP Land Cover. Modified from National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center (CSC)/Coastal Change Analysis Program (C-CAP). Olympia, WA: Washington Department of Ecology.

10 WAECY. 2011a. NHD Major Areas, Streams, and Waterbodies. 1:24000. From U.S. Geological Survey (in cooperation with others) National Hydrography Dataset. Olympia, WA: Washington Department of Ecology.

11 WAECY. 2011b. C-CAP Land Cover. Modified from National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center (CSC)/Coastal Change Analysis Program (C-CAP). Olympia, WA: Washington Department of Ecology.

Impervious Surface Continues to Increase

1 Shared Strategy for Puget Sound. 2007. Puget Sound Salmon Recovery Plan Volume 1. National Marine Fisheries Service.

2 Schueler, T. 2003. Impacts of impervious cover on aquatic systems. Watershed protection research monograph no. 1. Ellicott City, MD: Center for Watershed Protection.

3 Fisheries Service. 2012Water Quality: How toxic runoff affects Pacific salmon & steelhead. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

4 Schueler. 2003. Impacts of impervious cover on aquatic.

5 Shared Strategy for Puget Sound. Puget Sound Salmon Recovery Plan.

6 NLCD. 2006. National Land Cover Dataset Percent Developed Impervious. 2011 edition. Multi-Resolution Land Characteristics.

7 NLCD. 2011. National Land Cover Dataset Percent Developed Impervious. 2011 edition. Multi-Resolution Land Characteristics.

8 USGS. 2014. Watershed Boundary Dataset 12-Digit (Sixth Level) Hydrologic Unit Codes (HUCs) Polygons. Downloaded from Washington Department of Ecology. U.S. Geological Survey, in cooperation with others.

9 WAECY. 1994. Polygons of Washington State Shorelines and Boundary. Olympia, WA: Washington Department of Ecology.

10 WAOFM. 2007. Projections of the Total Resident Population for the Growth Management Act (2000 to 2030, Low to High). Olympia, WA: Washington Office of Financial Management.

11 WAOFM. 2011. Estimates of Total Population for Water Resource Inventory Areas. Olympia, WA: Washington Office of Financial Management, Small Area Estimate Program.

12 WAOFM. 2012. Projections of the Total Resident Population for the Growth Management Act (2010 to 2040, Low to High). Olympia, WA: Washington Office of Financial Management.

13 WAOFM. 2015. Estimates of April 1 Population Density and Land Area by County. Olympia, WA: Washington Office of

Financial Management, Forecasting and Research Division.

Groundwater Withdrawals Impact Surface Flows

1 Revised Code of Washington 90.44.050

2 USGS. 2014. Watershed Boundary Dataset 12-Digit (Sixth Level) Hydrologic Unit Codes (HUCs) Polygons. Downloaded from Washington Department of Ecology. U.S. Geological Survey, in cooperation with others.

3 WADNR. 2014b. Washington State Non-DNR Major Public Lands (NDMPL) Polygons. Olympia, WA: Washington Department of Natural Resources.

4 WAECY. 2013. City Boundaries and Urban Growth Areas Polygons. Olympia, WA: Washington Department of Ecology.

5 WAECY. 2015. Water Well Logs Points. Olympia, WA: Washington Department of Ecology.