dered through the fields. The irrigation system in the Dungeness is largely unique to western Washington, but water withdrawals from surface and groundwater sources are used to water crops in several major river basins of Puget Sound.

Water quality problems have been experienced in several watersheds with high proportions of agricultural land use. In the Nooksack basin, water temperatures reaching the threshold of mortality to salmon have been documented in several tributaries, along with high levels of nitrogen, phosphorous and fine sediments. Several Nooksack tributary streams are included on the list of impaired water bodies under Section 303(d) of the Clean Water Act for warm water temperatures, fine sediments, fecal coliform levels, chemical contamination and low instream flows (WCC, 2002). These problems are not the sole result of agricultural practices, as urban runoff, wastewater treatment and other inputs add to the mix.

Farming practices in the second half of the 20th century incorporated lessons learned from the Great Depression and dust bowl years. National initiatives were implemented to form soil and water conservation districts, and similar efforts were organized in Puget Sound to help control erosion and chemical contamination from agriculture. "Best management practices" for farming were developed and are continually being refined, but the extent of implementation of these practices still varies widely around Puget Sound. Many individual farmers are avid fishermen themselves, and have worked toward the improvement of water quality and quantity in their farming practices, but the cost of these improvements often limits what they can do. Farmers presently struggle to retain economic viability in the face of competitive markets, escalating land values and urban/suburban development pressures. The greatest restoration potential for salmon habitat today probably occurs on these agricultural parcels of land, which still have no pavement or other extensive infrastructure which would be costly to modify or remove in order to restore habitat features.

"Farmers in Snohomish County look toward seven generations, but it's hard to see what will happen in the next seven years."

Aaron Reardon, Snohomish County Executive

Urbanization

Early explorers to Puget Sound immediately recognized the region's geographic potential for commerce and trade, and the ideal configuration of protected harbors with year-round access. Proximity to timber resources also promoted major shipbuilding centers, which occurred in Port Townsend, Tacoma, Everett, Bellingham, Olympia and Seattle. However it was the Alaska Gold Rush of 1897 to 1903 which made Seattle into the largest city and seaport in the Pacific Northwest. The miners used the port to purchase supplies and ship them north, and shipped the gold back to determine its value. Returning miners spent their millions in the Puget Sound economy and often settled in the Seattle area. Between 1900 and 1910 the population of Seattle grew from 81,000 to 237,000 (Lambert, 2001).

Although the urbanization of Puget Sound slowed somewhat during the Great Depression, the advent of World War II and the growth of the aviation industry once again caused the population to soar.

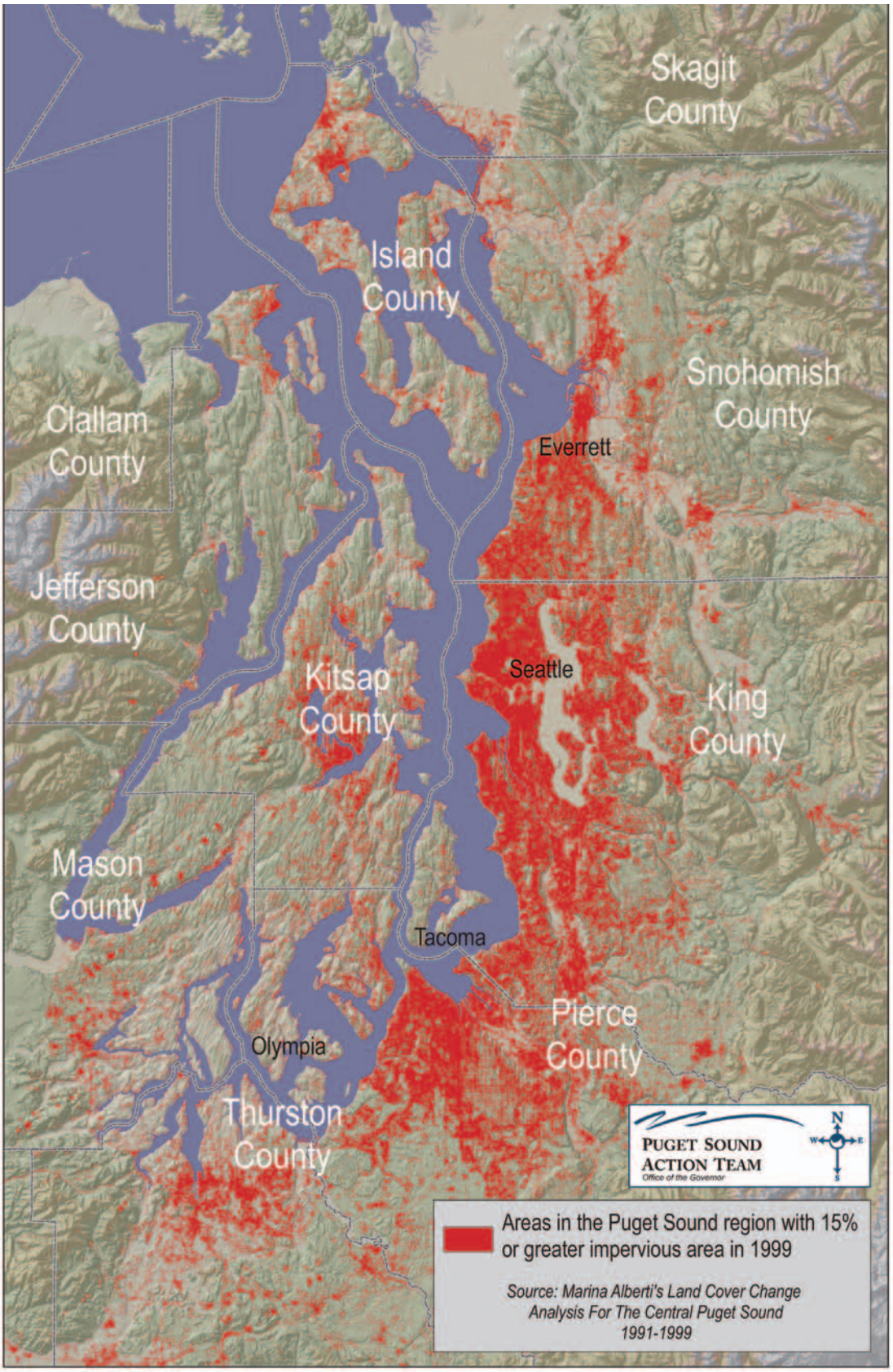

Figure 3.1 indicates the amount and location of impervious surface in the Puget Sound region. Map courtesy the Puget Sound Action Team

Today the cities of Seattle, Everett and Tacoma form a metropolitan area of over three million people along the Interstate 5 corridor. Suburbs and small cities have rapidly filled in the spaces in between, and a complex human-constructed network of roads, bridges, and utilities provide residents with transportation corridors, power, water supply and waste disposal. This system of urban infrastructure has largely displaced the natural network which once sustained salmon habitat throughout the freshwater and nearshore areas of Puget Sound.

Streams in heavily urbanized areas have lost much of their complexity and riparian vegetation. For example, Thornton Creek in the Seattle area lost all of its wetlands and 60% of its open channel network during 100 years of development. The remaining stream system is heavily armored with rock and concrete along its banks, has extensive culverts and pipes, and little native vegetation remains. Despite heavy outplants of salmon into the creek for many years, only a handful of returning adults have been observed in recent years.

When watersheds are urbanized, problems may result simply because structures are placed in the path of natural runoff processes. In almost every point that urbanization activity touches the watershed, sources of pollution occur. Water infiltration is reduced due to an increase in impervious surfaces. As a result, runoff from the watershed is flashier, with increased flood hazard. Flood control and land drainage schemes may concentrate runoff, resulting in increased bank erosion, eventually causing widening and downcutting of the stream channel. Sediments washed from the urban areas contain trace metals such as copper, cadmium, zinc, and lead. These together with pesticides, herbicides, fertilizers, gasoline and other petroleum products, contaminate drainage waters and harm aquatic life necessary for salmon survival (FR 62, 5/6/97).

Wastewater treatment plants contribute additional metals and contaminants such as ammonia, chloride, aluminum, boron, iron, manganese, oil/grease, PCBs and other toxic substances.

"As cities around the Sound grew and prospered, human activities left chemical contaminants buried in the sediments. Pulp mills, chemical factories, smelters, shipyards, oil refineries, and other industries dumped byproducts into the Sound for years before federal and state governments placed controls on such discharges. Most of the contaminated sediments of Puget Sound are found in the nearshore areas of urban bays near Seattle, Tacoma, Bremerton, Everett and other major cities." (Puget Sound Action Team, 2004).

A 1997 study by NOAA and the Washington Department of Ecology indicated that 400,000 acres of the areas tested for sediment in Puget Sound are clean. However, 5,700 acres are highly degraded, and sediments of intermediate quality cover 179,000 acres. This represents an improvement from the 1970's when contaminant levels peaked. The Puget Sound Action Team has indicated that much of the contamination still present in the mud came from historic activities that are now outlawed or controlled by state and federal laws.

Much of the urbanized area in Puget Sound is concentrated near the mouths of rivers and along estuarine shorelines, coinciding with important and sensitive habitat required by salmon. Urban leaders face challenges accommodating the anticipated growth of the region without exacerbating existing habitat deficiencies.

"Our watershed is keenly aware that we have the biggest population center, and the largest recovery challenge."

Jim Compton, Seattle City Councilman

Photo by Dan Kowalski

Nearshore, Estuary and Marine Habitat Modification

An 1885 survey estimated that there were 267 square kilometers of tidal marsh and swamps bordering Puget Sound. Tidelands extended 20 km inland from the shoreline in the Skagit and Stillaguamish watersheds. Approximately 100 years later, only 54.6 km2 of intertidal marine or vegetated habitat is estimated to occur in the Puget Sound basin. This represents a decline of 80 percent across the region due to agricultural and urban modification of the lowland landscape (NMFS/Chum BRT, 1997). In heavily industrialized watersheds, such as the Duwamish, intertidal habitat has been eliminated by 98 percent, (Figure 3.2).

In addition to the high-intensity industrial and urban development at major river mouths in Puget Sound, intertidal and nearshore habitats throughout the Sound have been modified by shoreline armoring (e.g. construction of rock, concrete, and timber bulkheads or retaining walls). These modifications have a cumulative environmental impact that

Estuary	Area (ha)		Change (%)
	Pre-development	Amount in 1970's	
Nooksack	445	460	+3
Lummi	580	30	-95
Samish	190	40	-79
Skagit*	1600	1200	-25
Stillaguamish	300	360	+20
Snohomish	3900	1000	-74
Duwamish	260	4	-98
Puyallup	1000	50	-95
Nisqually	570	410	-28
Skokomish	210	140	-33
Dungeness	50	50	0

*More recent and more encompassing studies of the large scale habitat changes in the Skagit Delta indicate a loss of riverine tidal and estuarine habitat of 72% (Beamer et al., 2003).

Figure 3.2 Changes in Areas of Selected Puget Sound Estuaries from 1800s to 1970s. (from Simestad, et al. 1992 as cited in Upstream)