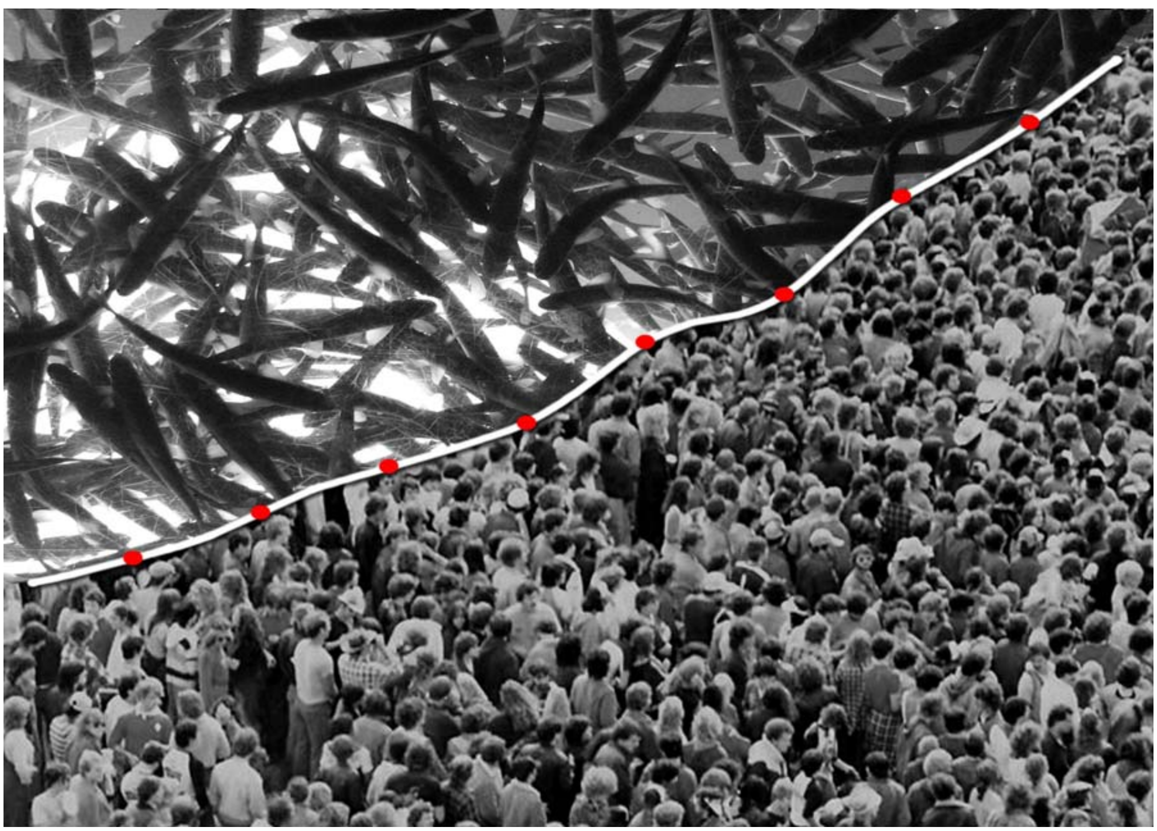
Independent Scientific Advisory Board

Human Population Impacts on Columbia River Basin Fish and Wildlife



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ISAB Human Population Report

ISAB 2007-3

Independent Scientific Advisory Board
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Executive Summary

Human population and its pattern on the landscape significantly impact fish and wildlife. World population doubled from three to six billion in the period 1959-1999. U.S. population tripled in size and doubled in density during the 20th Century. Canada grew at slightly higher rates than in the United States. During the 20th Century the United States changed from being primarily rural to urban, suburban, and exurban. The population shifted south and west, the west growing faster than any other region.

Columbia River Basin Population Trends

Population is growing in the Columbia River Basin, increasing in all four Basin states and the Province of British Columbia from 1930 to present. Regional population growth is projected to continue at least through 2030, although the rate of population growth is expected to stabilize or decline. Some rural areas are experiencing rapid population growth, especially those with recreational and scenic amenities. Central Oregon illustrates these changes. Deschutes County is the fastest growing county in Oregon, and Bend was recently identified as the sixth fastest growing metropolitan area in the nation.

Population density has changed significantly in each of the four major Columbia River Basin states in the past several decades. The highest densities of people in the Columbia River Basin live west of the Cascade Mountains along the I-5 corridor, a pattern that persisted from 1970-2000. In this same period population density increased in and around the major urban areas in the basin (Portland–Vancouver, Spokane and Boise). Even more significant to fish and wildlife have been the increases in population densities in central Oregon (Bend–Redmond area) and central Washington (Yakima–Kennewick-Pasco-Richland area) just east of the Cascade Mountains.

Population Effects in the Columbia River Basin

Population growth increases demand for land, water, and hydroelectricity which in turn generates greater pressure on fish and wildlife.

Human development requires water for residential, irrigation, waste water assimilation, recreational, commercial, and industrial uses. Continued population growth will increase demand for these uses and heighten competition for limited water supplies. The effect of increasing water demand will be exacerbated by the effect of climate change on the quantity and temperature of summer stream flows in many subbasins. Limited controls over groundwater leave it vulnerable to intensified use.

Freshwater withdrawals for domestic and public uses are projected to increase by 71-85% by 2050. In the Canadian portion of the Okanagan Basin per-capita water use is among the highest in Canada. Freshwater withdrawals for irrigation are projected to decline but will be more than offset by increases in withdrawals for public, domestic, industrial, and commercial uses. These increases will have significant implications for instream flow and for maintenance of riparian and aquatic habitats for fish and wildlife.

In Western Washington and Oregon, many acres of forest lands are being converted to residential and commercial development, a trend that is expected to continue. Population growth is a primary reason for the conversion through increases in demand for housing and the subsequent increases in land prices and incentives to sell.

Agricultural land is also being converted to nonagricultural uses. Like forestland, a major factor influencing the conversion of agricultural land is the increase in land prices driven by population growth. The largest conversion of agricultural land is attributed to ranchettes, rural homes, and vacation homes on farm and ranch lands.

Urban development causes marked changes in the physical, chemical, and ecological characteristics of stream ecosystems. In most cases, these changes are detrimental to native aquatic biota, including salmonid fishes.

Exurban development (low density, semi-rural residential) has been the dominant settlement trend in the West since 1970, with a high proportion of homes built in areas of productive soils and proximity to water. The rate of exurban development appears to be increasing. This type of development tends to result in degraded habitat for fish and wildlife through direct habitat conversion and loss, alteration of habitat near roads and buildings, and fragmentation of habitats and landscapes. Exurban development has led to decreased species diversity, decreased abundance and local extirpation of some species, as well as increased conflict between wildlife and people.

Population and Outside-Basin Effects

A variety of population-driven factors external to the Columbia River Basin affect fish and wildlife within the Basin.

International trade through shipping has led to modifications to the lower river and estuary. Channel deepening, currently underway, may result in increasing numbers of ships and cargo tonnage in the river. Shipping has been widely recognized as an important vector for introducing aquatic invasive species to the Columbia River and estuary. Globalization of trade may have contributed to the loss of some industries within the Columbia River Basin, such as aluminum, and will continue to affect resource-based industries.

Increased volumes of materials, especially hazardous goods and fuel powering trains, vessels, and trucks, are moved through the Columbia River Basin in response to demand of a growing human population. With increased movement of goods via all three modes, more accidents and spills are likely.

There is increasing evidence of the intercontinental nature of manmade, airborne chemical pollution that undermines the effectiveness of domestic pollution controls. The continued industrialization of Asian countries is likely to increase the levels of these pollutants and their associated environmental effects on marine, freshwater, and terrestrial habitats of the Columbia River Basin.

Incorporating Human Population into Fish and Wildlife Restoration Planning

The three primary tasks of the Council are:

1. Develop a 20-year electric power plan that will guarantee adequate and reliable energy at the lowest economic and environmental cost to the Northwest
2. Develop a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin
3. Educate and involve the public in the Council's decision-making processes

All three tasks relate to how the region will address human population growth. The production, distribution, and consumption of power are important factors influencing economic development. Fish and wildlife recovery plans that buffer Columbia Basin ecosystems from intensified patterns of land and water use are more likely to include human population considerations. Public education is the mechanism by which Basin residents can engage in coordinated efforts to ensure that the progress in restoring fish and wildlife populations is not undermined by population growth.

Planning Processes

A number of planning processes internal and external to the region provide guidance for integrated environmental planning, protection, and restoration of fish and wildlife populations and public education. Key elements of these processes are stakeholder involvement, spatial modeling of resources and development patterns, investigation of alternative scenarios, and monitoring and evaluation.

Strategies for Fish and Wildlife Habitat Protection

The Columbia River Basin is a dynamic environment of conservation and restoration practices, with a number of examples of creative application of tools to the preservation and restoration of habitat. Many are funded through the Fish and Wildlife Program. Numerous conservation tools exist to promote the Fish and Wildlife Program's objectives to build from strength, create wild salmon refugia, and protect habitat that supports diverse fish and wildlife populations.

Mitigating for a larger human population will involve many of the same approaches that have been used in the basin to date, enhanced by newly emerging tools. The strategies for mitigating the effects of population growth are those that recognize the benefits of permanent protections, the benefits of partnerships with private landowners. and the power of economic incentives for achieving those protections in areas of rising land prices and increasing water scarcity.

Recommendations

The impacts of human population growth can be addressed through planning processes, tools, and coordination with other authorities.

Planning Processes

- Address population growth in planning and prioritization of subbasin projects.
- Require subbasin plan updates to address population and settlement patterns.
- Promote planning processes that include landowner involvement, spatial modeling, alternative development scenarios, and evaluation and monitoring.
- Create dialogue among ranchers, environmentalists, and policy-makers to increase understanding of the economic and ecological value of ranchlands and the economic costs of rural sprawl.
- Encourage Subbasin Management Plans to emphasize flexibility and contain explicit strategies for adapting to population change.
- Focus actions on "protecting the best," especially in areas of rapid population growth.
- Increase surveillance and curb movement of aquatic invasive species via shipping, recreational boating, and other pathways related to increased traffic.
- Assess the range of new market-based protection mechanisms for cost-effectiveness and permanency of protections for fish and wildlife.

Tools

- Establish permanently protected refugia "strongholds" to minimize interactions between salmon and human activities.
- Consider landscape-scale factors in the choice of reserve sites to avoid habitat fragmentation and protect against human infringement.
- Protect areas that will restore headwater sources of cool water in warm streams.
- Pursue permanent protective actions for water and the riparian zone on high priority, stream reaches.
- Promote efforts to reduce the loss of ranchland, farmland, and forests.
- Provide incentives to private landowners to protect fish and wildlife habitat.
- Provide incentives for water conservation.
- Provide incentives to modify the timing and quantity of irrigation withdrawals.
- Invest in permanent protection of in-stream flow.
- Promote and study aquifer storage and groundwater recharge.
- Provide incentives to communities, counties, and subbasins to plan for sustainable groundwater and surface water.
- Protect water quantity and quality in salmonid spawning and rearing habitats.
- Provide incentives to purchase or lease water rights and eliminate withdrawals of shallow groundwater in the vicinity of salmon bearing streams.

- Seek opportunities for cost-recovery through emerging markets for ecosystem services.

Coordination with other Authorities

- Encourage communities, counties and subbasins to develop integrated water and land use plans that promote sustainable surface and groundwater use in the face of population growth and climate change.
- Encourage states and counties to develop groundwater protection ordinances that control land uses that could be detrimental to groundwater quantity or quality.
- Encourage stronger regulations to protect water quality against chemical spills, toxics, bio-accumulative substances, and pharmaceuticals.
- Encourage land-use regulations to prevent development in riparian and high risk upland areas.
- Encourage the development of stricter controls on exurban development.
- Encourage the management of land adjacent to refuge areas for habitat objectives.
- Encourage measures that conserve electricity and discourage overuse.
- Avoid barriers to wildlife movement across good habitats.
- Work with environmental agencies outside the Basin whose mandates affect habitats within the Basin.

Human Population Impacts on Columbia River Basin Fish and Wildlife

I. Introduction

The impact of human settlement in the Columbia River Basin is rarely incorporated into fish and wildlife planning. The Fish and Wildlife Program implicitly assumes a level base case of human development as do most fish and wildlife planning processes, including the Biological Opinion for the Federal Columbia River Power System. Demographic issues are only infrequently addressed in subbasin plans through acknowledgement that population growth is a factor limiting quality habitat.

However, several dimensions of human development are changing in ways that make it an important consideration. Regional population is increasing, settling the landscape in new patterns, and converting land to new economic uses. These trends have unevenly distributed impacts throughout the basin with direct implications for fish and wildlife conservation, mitigation, and recovery.

The completion of the first round of subbasin planning, the increasing emphasis on ecosystem-based management, and the uncertainty introduced by climate change all make human population growth a relevant consideration to fish and wildlife recovery planning in the Columbia River Basin. The incorporation of population issues into fish and wildlife planning will help the region frame recovery actions in a broader and more relevant context. It will also assist in the identification of the types, location, and intensity of potential human impacts on fish and wildlife.

For these reasons, this report addresses the issue of human population and its impact on fish and wildlife restoration in the Columbia River Basin. Section II presents historical population trends and future projections at global, national, and regional levels. Section III addresses the mechanisms of population impact on the natural environment. Section IV describes specific population impacts in the Columbia River Basin on the biophysical environment, water, forests, agriculture, mining, electric power, fisheries and aquatic resources, and wildlife. Section V discusses population-driven outside-basin influences on fish and wildlife habitat. These influences include international trade, shipping, aquatic invasive species, dredging, airborne pollution and transport of hazardous materials. Section VI provides examples of processes and tools for incorporating human population into fish and wildlife planning. Section VII presents key findings on the nature of population growth, the impact of population growth on fish and wildlife, and protections for fish and wildlife. Section VII also contains recommendations for planning processes and tools that account for population effects on fish and wildlife restoration.

II. Population Patterns and Projections for Growth

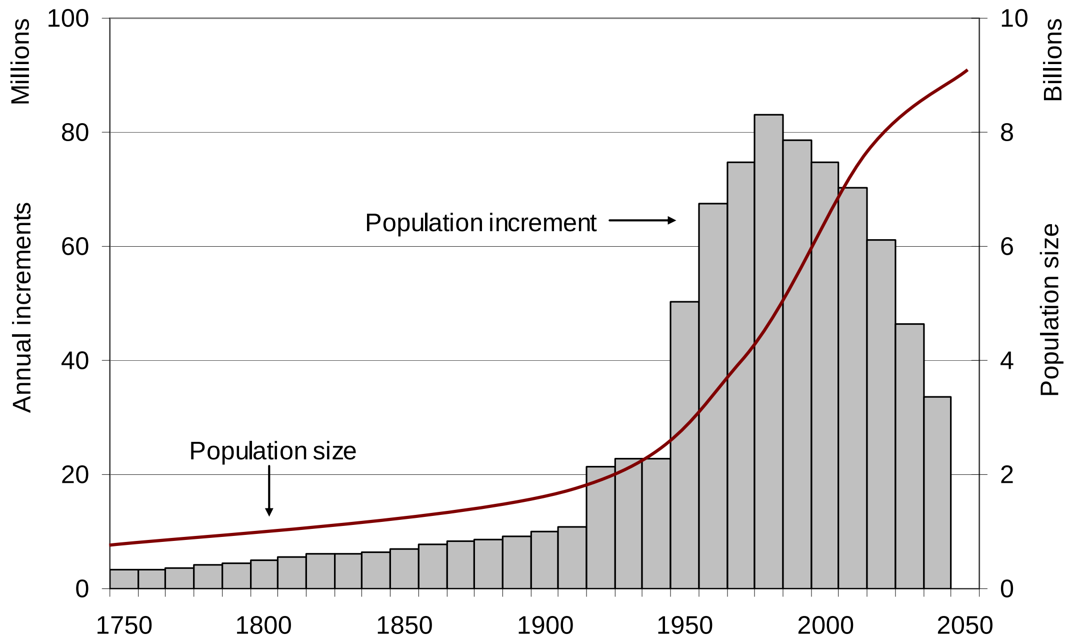
Human population and its pattern on the landscape significantly impact fish and wildlife and provide a context for the current Fish and Wildlife Program. Historical trends can help planners understand the past path of human development in the Columbia River Basin and its effect on natural resources. Population projections can help fish and wildlife planners anticipate future changes in landscape use patterns, understand the implications of those changes for achieving Program goals, and anticipate the types of program actions that are most likely to protect fish and wildlife populations in the future.

Columbia River Basin population change takes place against the larger background of changes in population worldwide, nationally, and in the West.

World Population Trends

In the forty year period 1959-1999, world population doubled, increasing from three to six billion (Figure 1). The 20th Century saw the highest rates of population growth and the largest annual increments to world population. Projections indicate that population growth will continue into the 21st century, although at a slower rate, reaching nine billion by 2042. (United Nations 1999; U.S. Census 2006)

Figure 1. Long-term World Population Growth, 1750-2050



Source: United Nations 1999

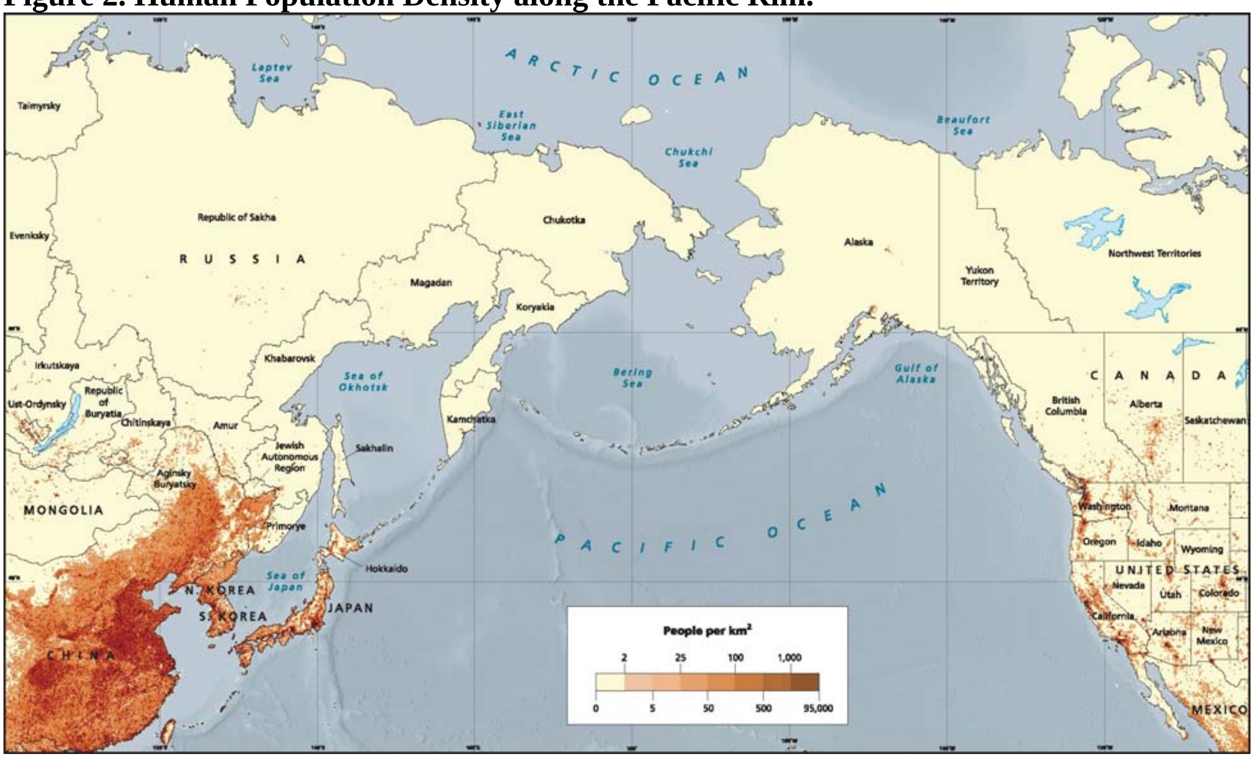
The rate of world population growth increased from about 1.5 % per year during 1950-51 to a peak of over 2% per year in the early 1960s. The increase was attributable to decreasing mortality. Since the 1960s growth rates have declined to the present level of 1.3% per year, reflecting rising marriage age and decreasing fertility. For the world as a whole, the twenty-first century is expected to be one of slower population growth than the 20th century, characterized by declining fertility and the ageing of populations (United Nations 1999).

Worldwide, the average number of children per couple has fallen from 4.9 to 2.7, and life expectancy at birth has risen from 56 years to 65 years. A result of these lower birth rates and increased longevity is a changing population age structure; by 2050 the percentage of the population over 60 years of age is projected to have increased to 22%, from 10% in 2000. The ageing of the population has wide ranging implications for economic growth, savings, investment, labor supply, employment, pensions, and health care (United Nations 1999).

Despite declines in the rate of growth, population numbers will continue to increase throughout the 21st Century. United Nations projections based on assumptions of medium fertility indicate that world population will stabilize after 2200 (United Nations 1999; U.S. Census 2006).

Pacific salmon share the Pacific Rim with the world's most populous countries: China, Japan, Russia, and the United States. Taken together the Pacific Rim countries comprise a large total population: China (1.3 B); Japan (128 M); Russia (146 M with 7 M in the Far East); United States (300 M, with 50 M. on the west coast); Koreas and Hong Kong (70 M); West Coast of British Columbia (4 M). Population density is the highest in the coastal zones, increases toward southerly latitudes and is more continuous in the western Pacific. The impacts of several hundred million people on the North pacific watersheds and seas are significant for salmon. (Augerot et al. 2005.) Figure 2 illustrates population density along the Pacific Rim.

Figure 2. Human Population Density along the Pacific Rim.

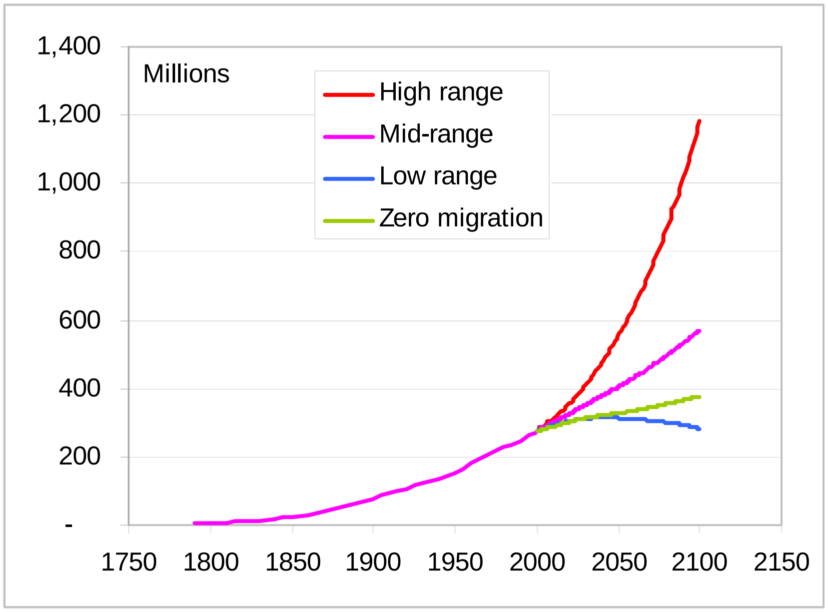


Source: State of the Salmon, a joint program of Wild Salmon Center and Ecotrust.

U.S. Population Trends

U.S. population more than tripled during the 20th Century, with most of the growth occurring in the past 15 years (U.S. Census Bureau 2005; Hobbs and Stoops 2002; Markham and Steinzor 2006). By 2050, the U.S. population is expected to be greater than 420 million people, according to the medium-range projection of the U.S. Census Bureau (Figure 3). The United States is currently the only industrialized country with rapid population growth, and some demographers predict that by 2050 the United States will be the only industrialized country among the world's 20 most populous nations (Population Resource Center 2004).

Figure 3. U.S. population growth from 1950 to 2000, with low, medium, and high projections to 2100.



Source: Markham and Steinzor 2006; U.S. Census Bureau 1999; U.S. Census Bureau 2005a.

Population growth is the sum of natural growth (births minus deaths), plus migration (immigration and emigration). Natural growth accounts for 60% of the U.S. population increase, with the remaining 40% due to net immigration, both legal and illegal (U.S. Census Bureau 2005). The legal immigration rate is about .4%, or slightly over 1 million people annually (U.S. Census Bureau. 2003). The illegal immigrant population is growing by about 525,000 annually (Population Resource Center 2004; Passel and Suro 2005).

Not all immigrants stay in the United States. In the past, many Mexican migrant workers engaged in a "circular" movement, crossing the border into the United States to work, then returning home to Mexico. However, in recent years return migration rates have fallen and more illegal immigrants have remained in the United States. The changing pattern is a result of more immigrants being employed in non-agricultural jobs that are stable across seasons and more living further away from the border states of the Southwest, making the journey back home longer and more expensive. In addition, stricter enforcement of border controls has created higher risks and costs of returning to the United States. The average probability of return for illegal immigrants fell from 47% in the period 1979-84 to 27% in 1997-2003 (Navarro 2006).

Immigration numbers are highly variable over time. The annual number of legal and illegal migrants to the United States grew rapidly in the mid-1990s, peaked by the late 1990s, then declined substantially after 2001. By 2004, the annual inflow of foreign-born persons had declined 24% from its all-time high in 2000. Immigration levels in 2004 are comparable with those of the mid-1990s and still significantly below the peak levels of 1999–2000 (Passal and Suro 2004; U.S. Citizenship and Immigration Services n.d.).

Key United States population trends over the past century are identified in Markham and Steinzor (2006):

- Population growth: U.S. growth is higher than other industrialized nations at a current annual rate of slightly less than 1% (Population Reference Bureau 2005).
- Population density: U.S. population density doubled to 80 people per mi.^{2}, although it remained low relative to the world average of 120 per mi.^{2} (Hobbs and Stoops 2002).
- Population distribution: The United States changed from being primarily rural to urban and suburban. By 2000, half of all Americans lived in suburban areas (Hobbs and Stoops 2002; US Census Bureau 2001).
- Regional distribution: The U.S. population shifted South and West, and those regions dominated the century's growth (Hobbs and Stoops 2002).
- The West: Population grew faster in the West than in any other U.S. region (Hobbs and Stoops 2002).

The Census Bureau updates population figures from the decennial census of population by issuing estimates in intervening years and also estimates population projections. Statistical methods used to calculate these estimates are described in detail in various documents (Maulder 2002). The high, medium, and low projections are based on different assumptions about fertility, longevity, and immigration. Independent of assumptions about fertility and immigration, current trends indicate that the U.S. population is getting older and more diverse by race and ethnicity (Day 2001).

Figure 3 illustrates four possible trends in the U.S. population. Taking the medium projection as an example, we see that the population is projected to reach about 420 million by 2050. The medium projection also indicates a slight decline in the rate of population growth over the next several decades, reaching about 0.7% by the middle of the century (U.S. Census Bureau 2005b).

While population projections depend on the mathematical extrapolation of historical events, i.e., births, deaths, and movement of migrants, in reality these events always deviate from past patterns and result in forecasting errors. Census Bureau statisticians conduct ongoing analyses to judge the validity of these projections by identifying sources and magnitudes of forecasting error. Maulder (2002) presents a detailed analysis of the accuracy of Census Bureau population forecasts and the factors contributing to forecast error. Knowledge of population trends and their implications for the size and distribution of the population become increasingly important when major changes in fertility and net immigration occur. Of the components of population change, fertility assumptions are subject to the highest levels of uncertainty.

Table 1 illustrates forecasting error in total U.S. population caused by uncertainty about future trends in major population variables such as fertility or immigration. It shows the difference in projected and actual total U.S. population in 2006, based on projections made in 2000. Actual 2006 population exceeded the highest range projection by about 3 million people.

Table 1. Projected Versus Actual 2006 U.S. Total Population

Projections for 2006 population from 2000 Census:	
Lowest:	285,581,000
Middle:	290,153,000
Highest:	295,911,000
Actual 2006 population from July 11, 2006 estimate:	299,193,407

Source: U.S. Census Bureau 2000b, 2006

In addition to federal projections, state agencies and other entities produce state-level projections that update and modify decennial census data using county-level economic or labor force models (Campbell 1996).

Canada Population Trends

Fifteen percent of the Columbia River Basin is in British Columbia, with Canadian subbasins producing between 30-35% of the water in the Basin. The Canadian part of the Okanagan subbasin is experiencing high rates of population growth. According to the 2001 census data, the annual population growth in the western Okanagan subbasins ranged from 1 to 8%, higher than the eastern Kootenay subbasins at 0 to -3% (Business Council of British Columbia 2002).

Canada's rate of population growth is slightly higher than in the United States. In 2004/2005, the last year for which statistics were available, Canada’s population increased at a rate of 0.96%, compared to .93% in the United States. Canada's rate of natural increase estimated at 0.33 % in 2005-06, is similar to the previous year. Natural increase, in decline since the beginning of the 1990s, has stabilized since 2000. International migration has accounted for more than 60% of Canada's population growth since 2001 (Statistics Canada 2006).

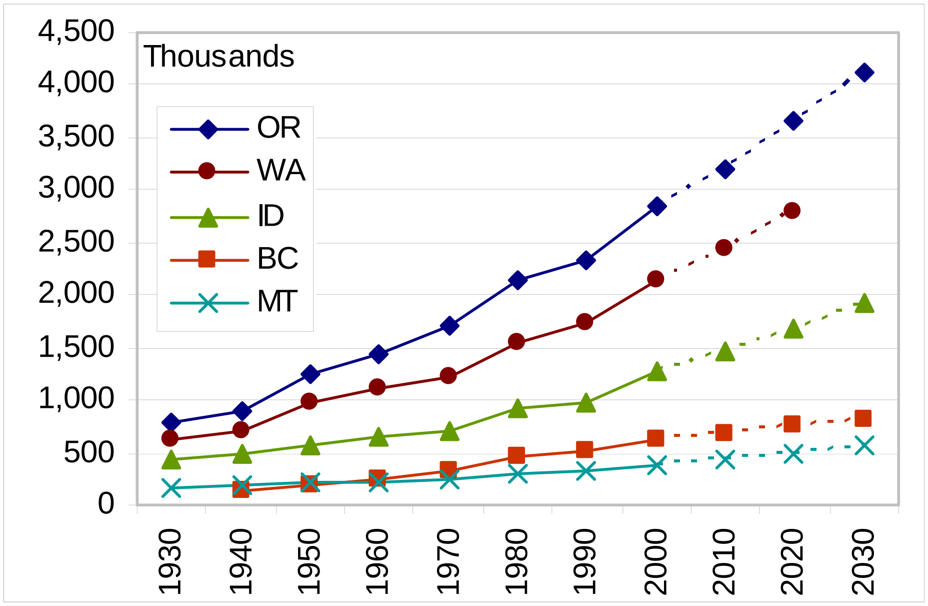
Columbia River Basin Population Trends

Population is growing in the Columbia River Basin, with all four Basin states and the Province of British Columbia increasing in total numbers from 1930 to present.

Population increases in the Basin are projected to continue (Figure 4), although there is a wide range of estimates of the specific number (40-100 million by the end of the 21st century). Projections to 2040 of population growth rates for the interior Columbia River Basin range from 0.3 percent per year to 1.6 percent per year (McCool and Haynes 1996). Lackey et al. (2006) conclude from current estimates that if the largely migration-driven population growth continues unabated, it will result in a three to sevenfold increase in the population in the Columbia Basin region.

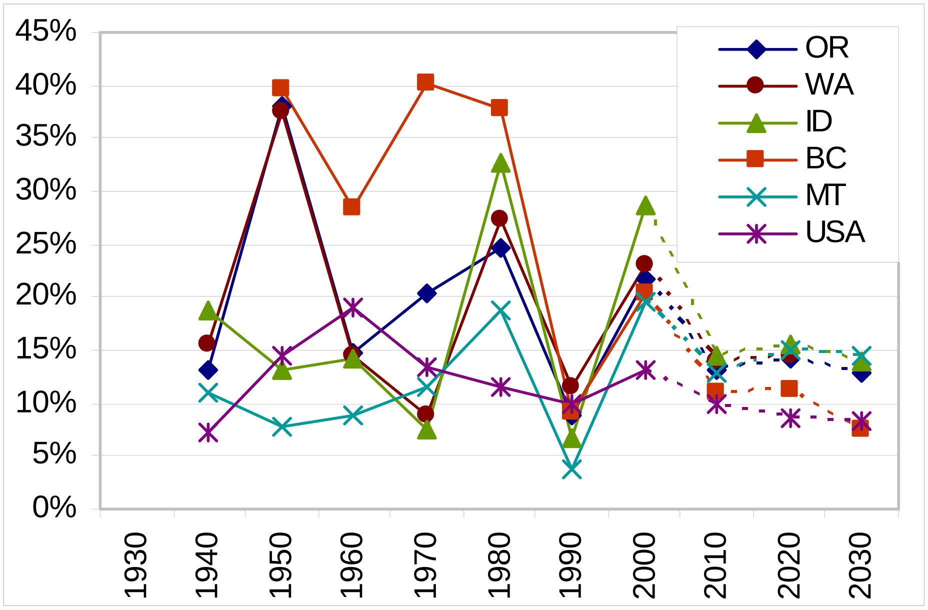
Figures 4 and 5 show that while rates of population growth are expected to stabilize or decline in the Columbia River Basin, total population numbers for each of the four basin states and British Columbia are expected to continue to increase at least through 2030.

Figure 4. Decadal Trends and Projections in Columbia River Basin Population Size, 1930-2030.



Source: All data from federal US and Canada censuses, plus state and regional district projections for 2010 and 2020.

Figure 5. Decadal Trends and Projections in Columbia River Basin Population Growth Rate 1930-2030



Source: All data from federal US and Canada censuses, plus state and regional district projections for 2010 and 2020.

Population density has changed significantly in each of the four major Columbia River Basin states in the past several decades (Figure 6). The highest densities of people in the Columbia River Basin live west of the Cascade Mountains along the I-5 corridor. This pattern has persisted from 1970 to 2000 and persists in projections through 2010 and 2020.

Although much of the Columbia River Basin is rural and sparsely populated, with large amounts of federal lands, some areas are experiencing rapid population growth, especially those with recreational and scenic values. This population growth into undeveloped areas adjacent to U.S. Forest Service and Bureau of Land Management lands can result in stress on the political and physical infrastructure of rural communities; decrease the quantity and quality of fish and wildlife habitat; and increase cost of fire protections (ICBEMP 2000). Development increases demand for fresh water from surface and groundwater, affecting flows in many salmon-bearing streams. Decreases in the snow pack at higher elevations will exacerbate this situation especially during low-flow summer and fall seasons (ISAB 2007-2).

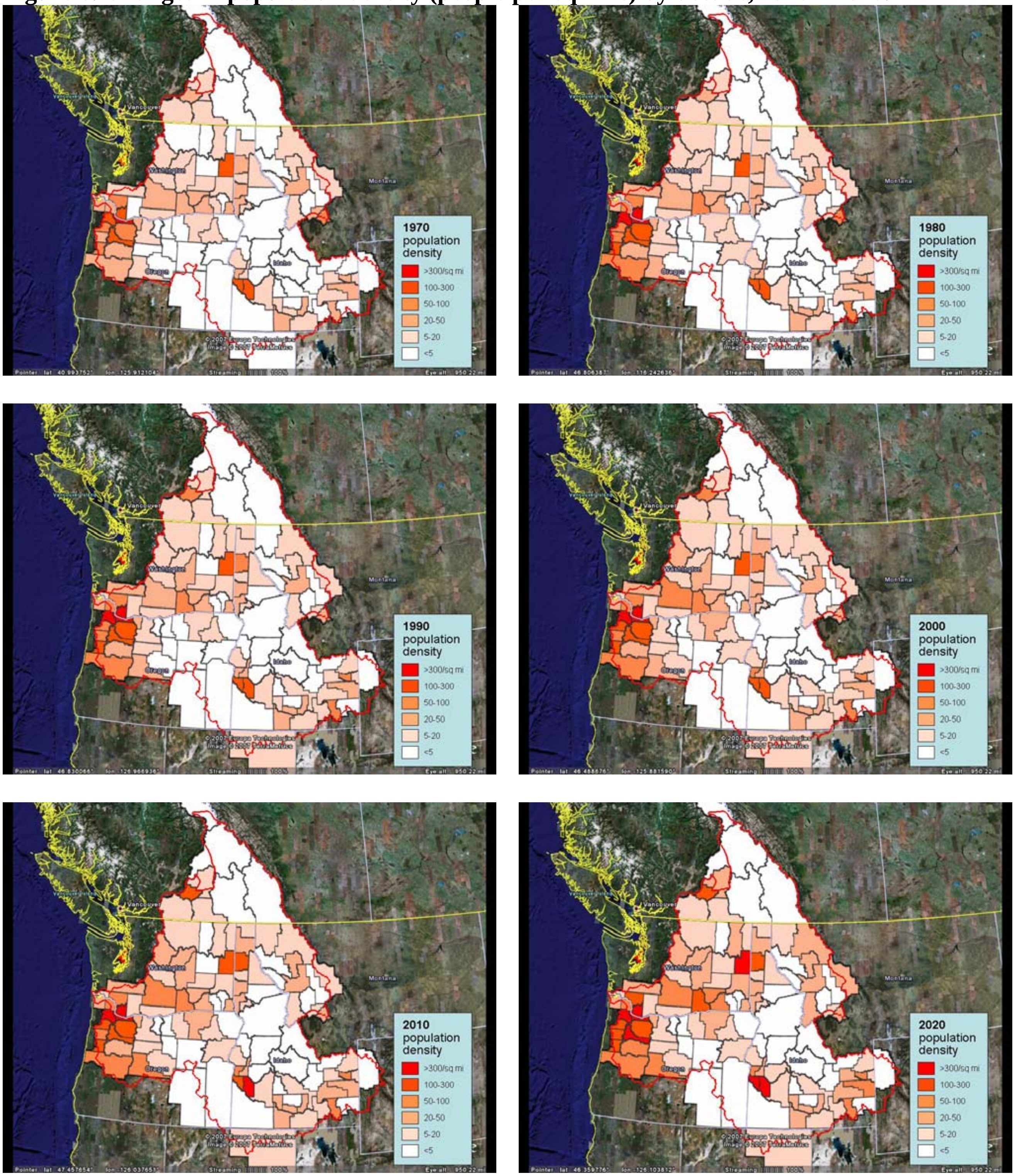
Central Oregon illustrates these changes, where population has been growing rapidly (a 20% increase in population in the last five years) in both incorporated and unincorporated areas (Population Research Center 2006). Deschutes County is the fastest growing county in Oregon; Bend was recently identified as the sixth fastest growing metropolitan area in the nation. Growth rates over the last five years for the major urban centers in Central Oregon, Bend, and Redmond, have oscillated between 4 and 11% with Redmond at an average of 8% per year and Bend at 6% per year. Madras and Prineville have seen lower rates, with Prineville averaging 4 to 5% and

Madras from 1 to 3%. Sisters has seen huge swings in population growth rates, including a 32% increase in 2003 (Population Research Center 2006).

Population density has increased in and around the major urban areas in the basin (Portland-Vancouver, Spokane and Boise) during this same period. Even more important for impacts on fish and wildlife have been the notable increases in population densities in central Oregon (Bend–Redmond area) and central Washington (Yakima–Kennewick-Pasco-Richland area) just east of the Cascade Mountains (Figure 6). Rural land use is changing to include more “hobby” farms, a change that will affect water use and management and, ultimately, fish and wildlife habitat. Net in-migration and population growth in rural areas, along with the associated demographic changes rural population, are generally regarded as the causes of fragmentation and loss of irrigable land and reduced demand for irrigation water (Aylward 2006).

The rate at which Columbia River Basin population has grown has changed significantly in the four decades since 1960 (Figure 7). Throughout that time period growth has occurred at a rate of 20 to 40% in most urban areas. The most notable change has been the rapid increases in growth in the interior and rural areas of the basin, particularly in the 1970s and 1990s. As seen in Figure 6, the densities of people per square mile in the interior basin and rural areas have increased but not nearly as dramatically as the rate of growth shown in Figure 7. This is because even small numbers of people moving into a low population density area will make a relatively large rate of change. Projections for the next several decades (2000 to 2010 and 2010 to 2020) predict increasing growth throughout the basin with even greater shifts into the interior of the basin and rural areas.

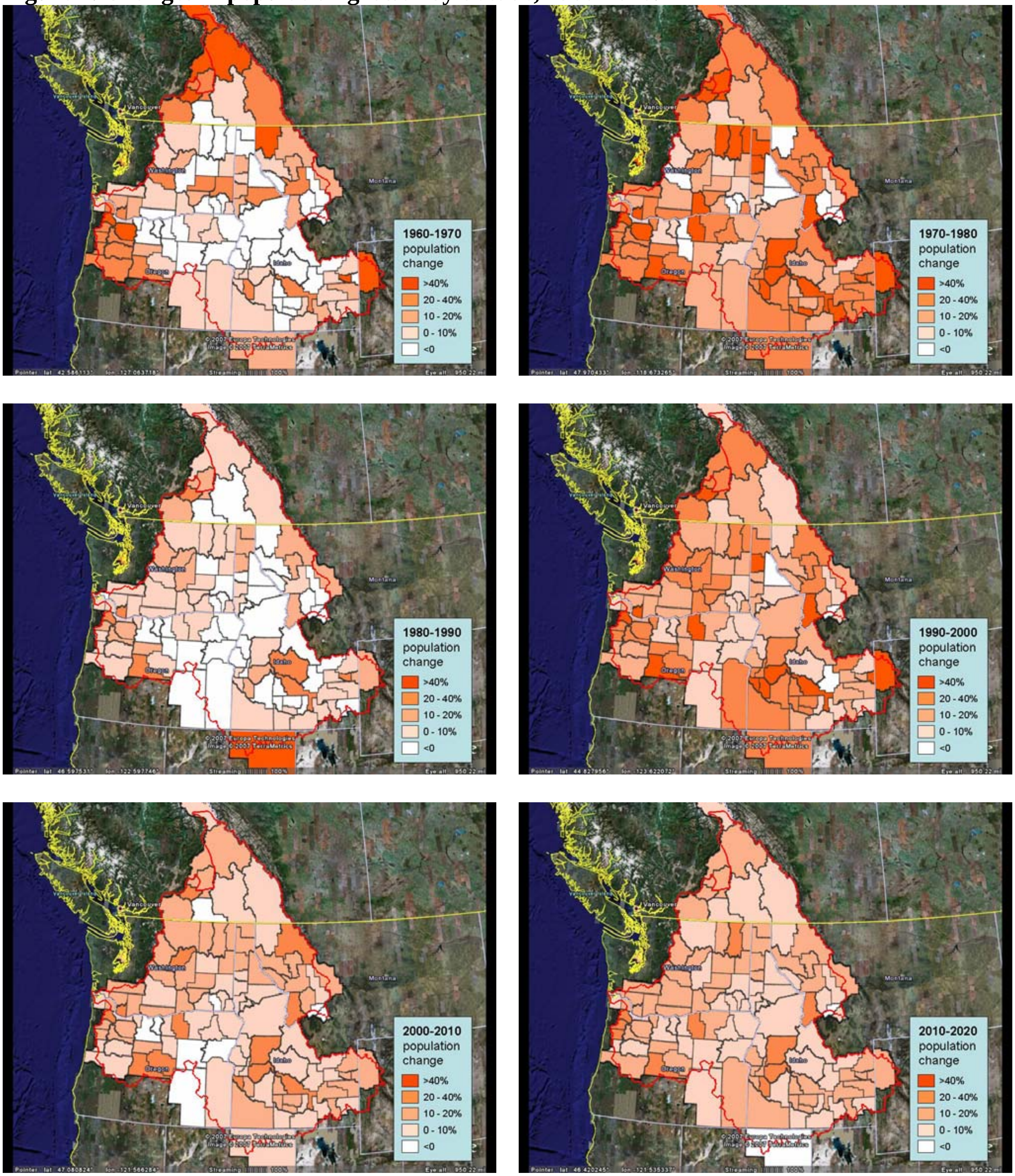
Figure 6. Changes in population density (people per sq mile) by decade, 1970 – 2020.



(projected population) (projected population)

Source: All data from federal US and Canada censuses, plus state and regional district projections for 2010 and 2020.

Figure 7. Changes in population growth by decade, 1960-2020.



(projected population) (projected population)

Source: All data from federal US and Canada censuses, plus state and regional district projections for 2010 and 2020.

III. Linking Population to the Natural Environment

Population trends are closely associated with major changes in the natural environment at both national and regional levels. Population is linked to the environment in several ways: the number of people, how and where those people live, how they use natural resources, and how they handle the waste they produce. Markham and Steinzor (2006) provide a summary of five key population attributes that influence environmental resources that together comprise the "ecological footprint" of people (Rees 1992).

Population size and growth are linked to the environment because they demonstrate how rapidly each person on average is a "multiplier" of environmental impacts. The South and West are the most populous and fastest growing regions in the nation.

Population distribution can increase pressures on resources through increasing density. It can also relieve pressures on environmental resources if people are distributed over the landscape appropriately; for example in "clustered" rather than "sprawl" development. The movement of people to coastal regions has been particularly strong, with more than half of the U.S. population now living within 50 miles of the coast (Beach 2002).

Population composition – age, income, educational level, ethnicity and other characteristics – can determine where and how people live, move, vacation, and develop land. Age provides a good example of the environmental implications of demographic factors. Today's older population is the largest in U.S. history (US Census Bureau 2000a). The aging "baby boomer" segment of the population comprises 26% of the total U.S. population (US Census Bureau 2006), is wealthy, and has high rates of resource consumption (Gillion 2006). Over the next quarter century, the proportion of elderly Americans is projected to double in at least 14 states in the South and West, the result of the immigration of retirees and out-migration of younger adults in those areas (Population Reference Bureau 2000).

Households use resources, occupy a certain amount of space, and emit waste and pollutants. The extent of their environmental effect depends on the number of households, number of persons per household, the size of homes, and the amount of land surrounding homes. In recent years, the number of U.S. households has increased while average U.S. household size has decreased. The average size of new homes has increased, requiring more resources for construction and more energy for heating and cooling. An analysis of sprawl for the 100 largest urbanized areas in the United States found that about half the sprawl between 1970 and 1990 appeared to be related to land use and consumption choices that led to an increase in average amount of urban land per resident. The other half was due to the 20-year increase in number of residents within those urbanized areas (Kolankiewicz and Beck, 2001). A recent newspaper article chronicled the growing conversion of timberland to rural residential development in Washington, contributing to suburban sprawl along the I-5 corridor (Gordon 2007).

Consumption of natural resources depends on the amount and type of food, water fuel, land, and manufactured goods that are used and how they are produced. In general, a higher-income population consumes more resources, and generates more waste and pollution, than does a lower-income population. However, affluence can also be associated with lower impact on environmental resources as it enables people to consume goods that are more energy efficient or are otherwise more environmentally sound and to invest in environmental protection.

One way to represent linkages between human population and the environment is through the "I = PAT" equation: "Environmental Impact = Population x Affluence/Consumption x Technology."

- Environmental Impact: how species, natural resources and whole ecosystems are affected or impacted by humans.
- Population: the total number of people. Population always acts in combination with the other IPAT factors below.
- Affluence/Consumption: often correlated with income, this is how much each person consumes in terms of resources such as water, energy, passenger miles, space/resources used for housing. Waste generated through resource consumption is part of this equation.
- Technology: this represents how a resource is used and how much waste and pollution is created by the production and consumption of the resource. Sometimes it improves environmental impact, e.g., with the use of energy efficient products, or it can worsen it, e.g., with the use of inefficient coal-burning power plants (Markham and Steinzor 2006).

IV. Population Effects in the Columbia River Basin

The Columbia River Basin has a long history of human impacts on the environment. Past uses of natural resources in the basin are major determinants of present ecosystem conditions. For example, changes to the Willamette River Basin landscape began by the early 19th Century. Intensive trapping eradicated beaver and caused long-term effects on hydrology, vegetation, and wildlife (Hulse et al. 2002). New and more intensive patterns of using fish and wildlife replaced relatively stable historical patterns, further altering the natural ecosystems of the basin. Pre-contact Native American populations had altered landscapes and affected the aquatic environment to some degree, but it was the introduction of industrial activities to the Columbia River Basin, and the consequent settlement and human population growth, that resulted in widespread changes in land uses and basin hydrology (NRC 2004). In the early industrial period, short-term resource extraction was emphasized at the expense of healthy balanced ecosystems (NRC 1996a).

Waves of immigration to the Columbia River Basin began in the 1840s bringing new settlement patterns to the landscape. Population growth led to expansion of agricultural lands, clearing of forests, timber production, mining, trapping and fisheries. Dams were constructed for power, irrigation, and flood control. Towns and roads expanded. As a result, wetlands were eradicated, river flows reduced, streams rerouted, and water quality degraded. Fish and wildlife habitat was blocked, fragmented, degraded, and lost. Large-scale economic and physical changes resulted from the construction of the Federal Columbia River Power System (NRC 2004). Significant areas once accessible to native anadromous fish populations were blocked by dams and these populations were extinguished. With the development of trade and transportation, invasive species increased. The overall effect was an expansion and intensification of the human footprint on the landscape (Gilden and Smith 1998; Hulse et al. 2002, Loy et al. 2001).

Through the Fish and Wildlife Program and an array of federal and state statutes, many actions have been taken to mitigate and remedy the effect of humans on Columbia River Basin fish and wildlife populations. However, continuing population growth is likely to increase demand for land, water, and hydroelectricity. This demand will in turn generate greater pressures on fish and wildlife. A National Research Council review of Pacific Northwest salmon management concluded that, “As long as human populations and economic activities continue to increase, so will the challenge of successfully solving the salmon problem” (NRC 1996a).

The Biophysical Environment

The combination of climate, topography, soils, and vegetation defines ecological provinces in the Columbia River Basin that determine the potential for human use. Changes in both the size and distribution of population will be influenced by climate, vegetation, and the availability of water. Human population will in turn affect ecological processes.

The climate of the Columbia River Basin differs markedly depending upon topography, elevation, and atmospheric circulation patterns. Elevation and topography within the basin vary from just above sea level to over 13,000 feet, from flat plains to steep, eroded canyons. Climate strongly influences the biological productivity, soils, streamflows, wildfires, and human uses of land and resources (ICBEMP 2000).

Temperature also varies widely over the basin. High elevations experience cold winters and short cool summer and growing seasons. Interior regions experience the greatest interannual climate variability with the most frequent and severe droughts (Anderson et al. 1998; ICBEMP 2000). With warmer temperatures, forests will be more susceptible to wildfires, insects and disease.

Vegetation varies with soils, precipitation patterns, and climate, supporting a high diversity of vegetation within the basin, from moist sites with western hemlock and red cedar to dry shrub land and grass land sites dominated by sagebrush and bunch wheatgrass (Anderson et al. 1998; ICBEMP 2000). With climate change, changes will occur in the distribution and types of vegetation.

Most precipitation in the region falls in winter, as snow or rain, when storms from the Pacific Ocean move inshore. In the summer, the North Pacific High generally blocks the flow of moisture into the Pacific Northwest. This results in a pattern of wet winters and stable, dry summers, except for occasional summer thunderstorms in the interior basin. Annual precipitation varies widely, from over 100 inches per year in the Cascade Mountains to less than eight inches in the low-elevation interior. Much of the basin receives less than 12 inches a year. This pattern of precipitation limits irrigation, land uses and development, as well as recovery from human or natural disturbances (ICBEMP 2000).

Precipitation is the ultimate source of water, but not all precipitation runs off directly into streams as surface flows. Some seeps into the soil and rocks as groundwater, linking surface and groundwater supplies. Groundwater seeps into streams, often through springs. It maintains base flows during dry periods and cools the water, providing critical services to cool-water fishes such as salmonids.

Climate has a profound influence on the quantity, quality, and timing of water resources that in turn effect water availability for vegetation, fish and wildlife, and human uses. Climate change will result in smaller future snowpacks confined to higher elevations that will generate lower streamflows and higher temperatures during the summer and fall, and higher flows in the winter and spring. This will affect the use of water for agriculture, municipalities, industries and households. It will also affect the frequency of floods and wildfires and the ecology of streams, riparian areas and wetlands. Lower stream flows will result in decreased water quantity and quality in many streams, shrinking favorable habitats for cool-water species. Changes in estuarine and ocean environments also are likely to occur and will also be detrimental to the production of salmon. “These changes could have profound impact on the success of restoration efforts and the status of Columbia River fish and wildlife” (ISAB 2007-2).

Changes in precipitation, snow pack and temperature related to climate change have been recorded in the Basin (ISAB 2007-2). The 32-year drought that began in the 1840s caused extreme low flows in the Columbia River. Low flows occurred again in the 1930s during a 20-year drought that affected vegetation and promoted insect infestations (ICBEMP 2000). In contrast, the more recent period from 1950 to 1987 is anomalous in having no notable multiyear droughts (Gedalof et al. 2004).

Water

Human development requires water for residential, irrigation, waste water assimilation, recreational, commercial, and industrial uses. Instream flows also support aquatic and riparian ecosystems, including salmonids and other cool-water species in the Columbia River Basin. As development of land intensifies, so will the demands for water. Continuous population growth in the basin will place increased demands and heighten competition for limited water supplies.

The effects of increasing water demand will be exacerbated by climate change effects on the quantity and temperature of summer stream flows in many subbasins (ISAB 2007-2). Hurd et al. (1999) conclude that consumptive uses of water in the western United States are relatively vulnerable to climate change. They note that intensive water use is associated with intensive development. In the Columbia River Basin curtailment of water uses from instream uses is more likely, especially if the watershed is susceptible to drought and extreme events.

Increased rural development will have impacts on both water quantity and water quality available for aquatic ecosystems. Homes will require water, usually from subsurface groundwater sources. According to the Oregon Department of Environmental Quality, 70% of Oregonians, including 90% of rural residents rely on groundwater as their water source (Bastasch 2006). However, groundwater and surface flows are connected, and groundwater is the source of base flows during the low-flow season for many streams. Groundwater depletion occurs when the rates of groundwater withdrawals exceed the long-term recharge rates. Where this occurs, increased groundwater use may not be a viable adaptation to either reduced surface water supplies or increased demands (Hurd et al. 1999).

Withdrawals for wells can induce movement of water from streams into an aquifer, depleting stream flows. Groundwater pumping is of greatest concern during periods of low flow, especially if surface water is already depleted by drought or changes in climate (Winter et al. 1998). Pumping may result in lowered surface flows, reductions in spring flows, higher stream temperature, lower oxygen levels, and even dewatering of streams. In Arizona, groundwater pumping for rapid development has resulted in drastically lower flows into the San Juan River (Glennon 2002).

According to the Oregon Progress Board (2007), the percent of key streams meeting the minimum stream flows for all months of the year has decreased from the late 1990s (but has improved somewhat in more recent years) and despite a long-term improvement in most streams, a small percent of streams have worsening water quality. In the upper Deschutes basin, a region of rapid rural, urban and commercial development, consumptive groundwater use has diminished stream flows fairly rapidly, thus further impacting stream reaches already stressed by low water availability for fish and wildlife (Lite and Gannett 1999).

Wells that serve individual homes in Oregon are exempt from the need to obtain a water-use permit from the Oregon Department of Water Resources. These exempt wells may extract up to 15,000 gallons of water per day. There are over 200,000 uses of ground water exempt from permits in Oregon (DeVoe and Russell 2005) and about 4,000 new domestic wells are drilled each year in Oregon. Jarvis (2005) reports that by 2025 as many as 10,000 exempt wells may be installed in the Willamette Valley under Measure 37 claims and over 12,000 new wells may be drilled in the Deschutes Basin. Ballot Measure 37, passed in 2004 and codified as Oregon Revised Statutes (ORS) 197.352, allows property owners to claim compensation for reductions in property values caused by land use or other environmental regulations. Oregon is able to limit the number of wells installed in Groundwater Limited Areas and Critical Groundwater Areas.

Groundwater extraction and reduced streamflow can also affect flows in the hyporheic zone in the shallow subsurface of the streambed. Hyporheic zones are active sites for aquatic life. For example, spawning success of salmonids is greater where water flowing through the streambed brings cool, oxygenated water into contact with the eggs deposited in gravel. The effect of groundwater pumping on hyporheic zones and the resulting effect on aquatic life are not well known (Winter et al. 1998). Oregon manages groundwater and surface water conjunctively where they are connected, presumably when a well is located within ¼ mile of surface water, and not elsewhere. Other states are acknowledging the connection between groundwater and surface water and may limit groundwater extraction in the future.

Wetlands are also sensitive to the effects of groundwater pumping through the lowering of the water table and the increase in seasonal changes in the water table. Wetlands have many benefits to wildlife, for floodwater retention, assimilation of waste water and protection of land from erosion. They are also important for retaining water, which contributes to recharging groundwater and moderating the rate of the release of water to streams after the major periods of rainfall or snow melt.

Water quality is affected by rural development. Septic tank discharges contain nitrates, bacteria, household chemicals that may ultimately enter streams. Introduction of nutrients and organic matter into streams, from septic drainage or untreated grazing animal waste, introduces bacterial contamination and increases the biochemical oxygen demand, resulting in less oxygen available for fish and other aquatic life.

In California, Idaho, Oregon, and Washington, freshwater withdrawals for domestic and public uses are projected to increase by 71-85% by 2050 (Houston et al. 2003). Freshwater withdrawals for irrigation are projected to decline to about 6-12% below 2000 levels by 2050 because of the conversion of agricultural land to urban, rural residential, and related uses. In spite of these relative changes in water use, irrigation is expected to continue to be the primary user of freshwater in the basin in 2050. However, reductions in irrigation withdrawals are projected to be more than offset by increases in withdrawals of public, domestic, industrial, and commercial uses. These increases will have significant implications for the availability of water for instream uses and maintenance of riparian and aquatic habitats for fishes and wildlife (Houston et al. 2003).

In the Canadian portion of the Okanagan Basin per-capita water use is among the highest in Canada. The combination of high per capita use with increasing numbers of people has the potential to harm fish and wildlife (Northcote 1996). According to Hartman, Northcote, and Cederholm (2006), “The Okanagan basin exemplifies the manner in which agriculture, urbanization, demographic growth, and political behavior interconnect to degrade the salmonid habitat and populations at both the valley and local stream level.” Climate change is expected to exacerbate water use problems in the future (Neale, 2005). A recent government report on climate change and water management in the Okanagan Basin concludes that the basin’s water supply systems’ capacity may not be adequate to meet future demands (Cohen et al. 2006).

A number of planning processes are underway in the Canadian Okanagan Basin to address water and growth issues. These processes incorporate the potential impact of population growth and water use on fish and wildlife habitat and on water quality. In addition, BC Hydro is conducting a separate planning process for each of its hydroelectric facilities. The process will produce water plans describing a set of operating rules for each facility that address habitat, hydropower, domestic and industrial water use, and First Nations needs (BC Hydro 2006).

The International Joint Commission implements the Boundary Waters Treaty of 1909 between the United States and Canada. The treaty requires the development of orders regarding the levels of transboundary rivers at the international border. These orders prevent water releases or storage in one country from causing floods in the other. However, the limited authority of the International Joint Commission does not extend to water use or to the impacts of population growth in either country (International Joint Commission 2007).

Forests

Throughout the United States, 10.3 million acres of non-federal forest land was converted to non-forest uses between 1982 and 1997 (Alig et al. 2003). Between the present and 2030, about 44 million acres of private forest land could be subject to large increases in development pressure (Stein et al. 2005, cited in Erickson and Rinehart 2005). Private forest land is held by a diverse group of interests, including industrial forest companies, investment companies, families, environmental organizations, and tribes, each subject to different pressures leading them to convert forest land. The conversion of private forest land affects not only the forest land directly subjected to development but also the quality of the surrounding habitat as the forest becomes fragmented (Erickson and Rinehart 2005; Kline et al. 2000).

In Western Washington, many acres of forest lands are being converted to residential and commercial development. The trend in forest land conversion accelerated during the 1990s, especially along the I-5 corridor. Forecasts of converted acreage range from 200k-300k acres by 2010 or 2012. The amount of land that is likely to be converted is difficult to estimate because land-use inventories are inexact and provide little information on urban areas (Alig et al 2003; Erickson and Rinehart 2005; Gordon 2007). In addition, there is little data providing empirical understanding of the causes, location and rates of conversion.

In recognition of the need for more information on this trend, the Washington State Legislature has recently funded a study of forestland conversion (Erickson and Rinehart 2005). Comparable development pressures on forest land are occurring in Oregon, especially in the Willamette Valley (Hulse et al. 2002). Even in areas with low population density, some forest land conversion is occurring in the form of vacation home or recreational property development. For example, in areas of eastern Washington¸ such as the Okanagan Valley, former forest or range lands are increasingly being divided into parcels of 20 acre or more and sold to “amenity migrants” for residential use (Gordon 2007).

Population growth is a primary reason for the conversion. Population growth increases demand for housing, which increases land prices and the incentive to sell. Erickson and Rinehart (2005) cite a landowner quoted by Beuter and Alig (2004) “With what you have to pay for timberland these days, you can’t afford to use it to grow timber.” Other important reasons for forestland conversion are the lower cost of timber production in other areas, especially overseas, and land-use controls that allow the conversion (Gordon 2007).

Change in land ownership can also accelerate forest conversion. Relatively small parcels of forest land (less than 5,000 acres) often are divided during intergenerational transfers and often the new owners, motivated by rapid financial gain, sell these lands for development (Erickson and Rinehart 2005). Traditionally, large areas of forest lands were held primarily by forest products companies. However, over the last decade investors have purchased much of the forest that was previously held by companies. As the investors have no manufacturing facilities to supply and are driven to obtain the greatest possible financial gain, lands suitable for conversion are often sold for development (Erickson and Rinehart 2005). This trend is continuing and, coupled with increased demand for land conversion to meet the needs for an expanding population, will likely maintain conversion of forest land to more intensive land uses at high rates into the foreseeable future.

Agriculture

For the United States as a whole, the number of farms has been in steady decline since the 1950 level of 5 million to under 2 million today. In contrast, acreage planted in major crops has remained relatively constant at about 250 million acres. Farms are bigger; the current average cropland acreage per farm is 2.5 times the level it was in 1950 (Ray et al. 2003). The agricultural picture of the Columbia River Basin differs somewhat from the national average. Conditions in Oregon agriculture illustrate many key trends in the region as a whole:

- The size structure of farms is changing. Numbers of mid-size farms are declining, but numbers of small and large farms are increasing.
- Farming practices are changing. About 15% of Oregon agricultural land is now in a certification program such as the Oregon Department of Agriculture's Good Agricultural Practices/Good Handling Practices, Food Alliance, Oregon Tilth, and Salmon Safe.
- The mix of crops is changing. For example, there has been a steady increase in wine grape acreage in both Oregon and Washington. A 2006 survey of Washington grape acreage documented 31,000 acres planted in wine grapes, an increase of 3,000 acres since 2002 (Columbia Valley Wine Association 2007). In contrast, Oregon strawberry production declined 30% from 2004-2006 as markets were lost to competing production areas. Overall, 2006 was a good year for Columbia River Basin agricultural revenues, assisted by droughts in competing areas and a weak dollar.
- The agricultural industry is aging. Oregon farmers are now the oldest on record, with an average age of almost 55 years. The implication of this age structure is that fewer young people are choosing farming as a profession and up to half of Oregon farmland will change hands in next 10-15 years.
- Agricultural land is being converted to nonagricultural uses. Seventy percent of Oregon's highest quality soils are in the Willamette Valley, where more than 70% of the population lives and where population growth is greatest. Farmland acreage conversion is estimated to be 300,000 acres in Oregon by 2010. A major factor influencing the conversion of agricultural land is increasing land prices driven by population growth (ODA 2007).

According to 1000 Friends of Oregon (2004), Oregon loses about 870 acres of agricultural land per year to urban expansion, and about 700 acres per year to rural development of rezoned agricultural land outside of urban growth boundaries. The largest conversion of agricultural land, 15,000 acres per year, is attributed to ranchette, rural homes, and vacation homes on farm and ranch lands, creating a "rural sprawl" that often takes land out of production and fragments the agricultural land base. The number of authorized uses in "exclusive farming use" areas has expanded over time to more than 50, including motocross racetracks, golf courses, destination resorts, solid waste disposal sites, and RV campgrounds (1000 Friends of Oregon 2004).

The 20 top issues facing Oregon agriculture identified by the Oregon Department of Agriculture (2007) include several that are directly or indirectly related to population growth and its impact on land prices and land development:

- Availability, storage, and distribution of water
- Impending pressure from climate change
- Preserving farmland against development pressures
- Invasive species and impacts on agriculture and ecosystems
- Aging of farmers and pending land turnover
- Tax incentives to encourage farm continuation
- Wildlife damage and mitigation assistance

A 1972 report to the Oregon Governor on the future of the Willamette Valley formed the basis for Oregon's subsequent land use laws containing goals designed to protect Oregon's quality of life (Halprin and Associates 1972). The laws have helped prevent sprawl and preserve open space and farmland by slowing the conversion of farmland through establishing urban growth boundaries. However, urban growth boundaries expand into surrounding agricultural lands as population increases, and the laws contain no explicit language for protection of fish and wildlife habitat (Sinclair 2005; Oregon Department of Agriculture 2007). Oregon's Ballot Measure 37 opened the potential for residential development of agricultural land. More than 2/3 of the over 2,000 filed claims for compensation under this measure are for development on farmland (Oregon Department of Agriculture 2007). Revisions to the rules regarding compensation are now under consideration by the Oregon Legislature.

Federal farm programs have been used throughout the Columbia River Basin to help alleviate some of the economic pressures facing agriculture and achieve conservation objectives that benefit fish and wildlife populations. The 1985 Farm Bill established the Conservation Reserve Program (CRP) to provide incentives to simultaneously prevent conversion of working farm, ranch and forestlands and put environmentally valuable land into long-term conservation use. It has since expanded in scope and scale to a suite of financial incentive programs designed to protect both working landscapes and specific types of habitat. The USDA programs have been successful in providing compensation to landowners for land kept out of production to achieve biodiversity, wildlife habitat, and water quality goals.

Consideration of conservation programs under the 2007 Farm Bill reflects a continuing interest in preventing conversion of agricultural land while providing environmental benefits through existing programs, new "green payments" for conservation actions and the encouragement of private sector markets for environmental services. The Farm Bill also reflects expanding federal efforts to develop biofuels through the promotion of more agricultural involvement in biofuel production (Washington Association of Wheat Growers 2007b). Biofuels development presents two areas of potential threat to the CRP and its utility in protecting fish and wildlife habitat; the removal of acreage from the program and the use of CRP acreage for biomass production and wind energy (USDA 2006).

The "ethanol effect" of rising corn prices has led to increased pressure by the agricultural industry to release acreage from the CRP or to use lands in the CRP to harvest biomass. Countervailing concerns are expressed by wildlife and conservation interests in the loss, fragmentation, or degradation of wildlife habitat if harvest on CRP lands is allowed, even if planted in native grasses (Bies 2006).

Domestic ethanol production capacity is growing rapidly: within 2006, national production capacity increased from 4.4 billion gallons per year to 6.3 billion gallons. Almost all ethanol is produced from corn, but it can also be made from cellulosic biomass such as prairie grasses, wheat straw, agricultural residues, and woody biomass crops. The use of crop residues would remove their availability to wildlife for food and cover (Bies 2006).

Research in biofuels is ongoing within the Columbia River Basin. In 2002 the Pacific Northwest National Laboratory announced the formation of the Northwest Bioproducts Research Institute comprising four research organizations. The Institute is formed around the goal of developing methods for converting agricultural and food processing wastes and residue into bio-based energy products (PNNL 2002). In March 2007 the federal government announced a public-private investment partnership in a cellulosic ethanol refinery to be built in Shelley, Idaho, with an annual production target of 18 million gallons (Washington Association of Wheat Growers 2007a).

Mining

Mining for precious metals influenced early settlement patterns in the Columbia River Basin and involved practices that caused destruction of salmon habitat. In placer mining, large amounts of the stream bed were removed, washed, screened, and eventually discarded on stream banks. Piles of discarded rock (tailings) were left near streams and continue to exist. Although now a minor component of mining in the region, the mining of precious metals left a legacy of permanent changes in stream structure (Rost 1998).

The majority of mining in the Columbia River Basin is now for sand and gravel. Population growth increases demand for concrete and asphalt, which use gravel as a basic component. Most gravel extraction takes place along or in rivers. In Oregon, deep water dredging in the main channels of rivers such as the Columbia and Willamette, sand bar “scalping” operations in rivers, and gravel pits in floodplains are all methods used to procure gravel (Rost 1998). Gravel mining in floodplains carries potential for significant adverse impacts on fish by promoting rapid channel migration and avulsion (Grindeland and Hadley 2003). Without regional management of sand and gravel mining, continuity of sediment transport will be disrupted, causing channel and bed erosion, channel incision, and low availability of spawning gravels for salmonid fishes (Kondolf 1997).

A current example of the conflict that can arise between mining and fish and wildlife objectives is the proposed large-scale expansion of the Glacier Northwest gravel mine on Maury Island in Puget Sound. The expansion would make it the largest gravel mine in the United States in terms of annual extraction. The expanded mine would increase barge traffic on the Sound, require disposal of soil removed to access the gravel, some of which is contaminated with arsenic and lead, and generate other impacts affecting salmon and bird habitat (Turner 2006).

Columbia River Basin Electricity Demand and Supply

Regional electricity demand is forecast to grow from 20,080 average megawatts in 2000 to 25,423 average megawatts by 2025 in the medium forecast. The average annual rate of growth in demand is just less than 1 percent per year (NPCC 2005).

The medium case electricity demand forecast means that the region's electricity needs would grow by 5,343 average megawatts by 2025, an average annual increase of 214 average megawatts. The annual growth rate from 2003 to 2025 is 1.5 percent per year, with annual megawatt increases averaging 330. The most likely range of demand growth (between the medium-low and medium-high forecasts) is between 0.4 and 1.50 percent per year. The Council's biennial assessment, conducted in 2007, shows that actual loads in the region are growing in the medium-low range of forecast.

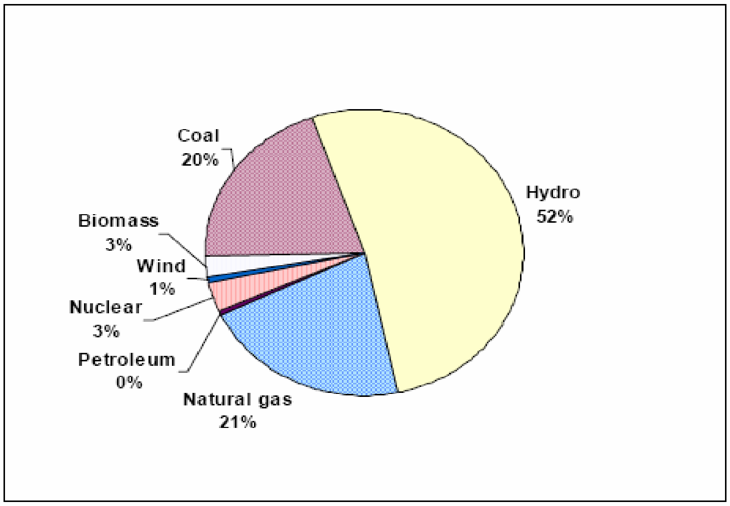
Table 2. Summary of forecast range in electricity demand.

	(Actual)			**Growth rates**	
	2000	**2015**	**2025**	**2000-2015**	**2000-2025**
Low	20,080	17,489	17,822	-0.92	-0.48
Medium Low	20,080	19,942	21,934	-0.05	0.35
Medium	20,080	22,105	25,423	0.64	0.95
Medium-High	20,080	24,200	29,138	1.25	1.50
High	20,080	27,687	35,897	2.16	2.35

Source: NPCC 2005.

The region's electricity supply is still dominated by hydroelectric power. Hydroelectricity accounts for roughly half of the region's electrical energy supply (Figure 8), but its amount in any given year depends on water conditions. In an average water year, the hydroelectric system can provide about 16,000 average megawatts of electricity. For planning, the region has formally relied on only the 12,000 average megawatts, which is the amount of generation capability under the worst historical water conditions (critical water). In a good water year, the hydroelectric system might be able to generate 20,000 average megawatts of electricity. Generation by coal and natural gas is responsible for most of the power not provided by the hydroelectric system, with small contributions from nuclear, wind, and other sources.

Figure 8. Sources of Pacific Northwest Electrical Energy Generation



Source: Northwest Power and Conservation Council 2005.

Effects of Urbanization on Fisheries and Aquatic Resources

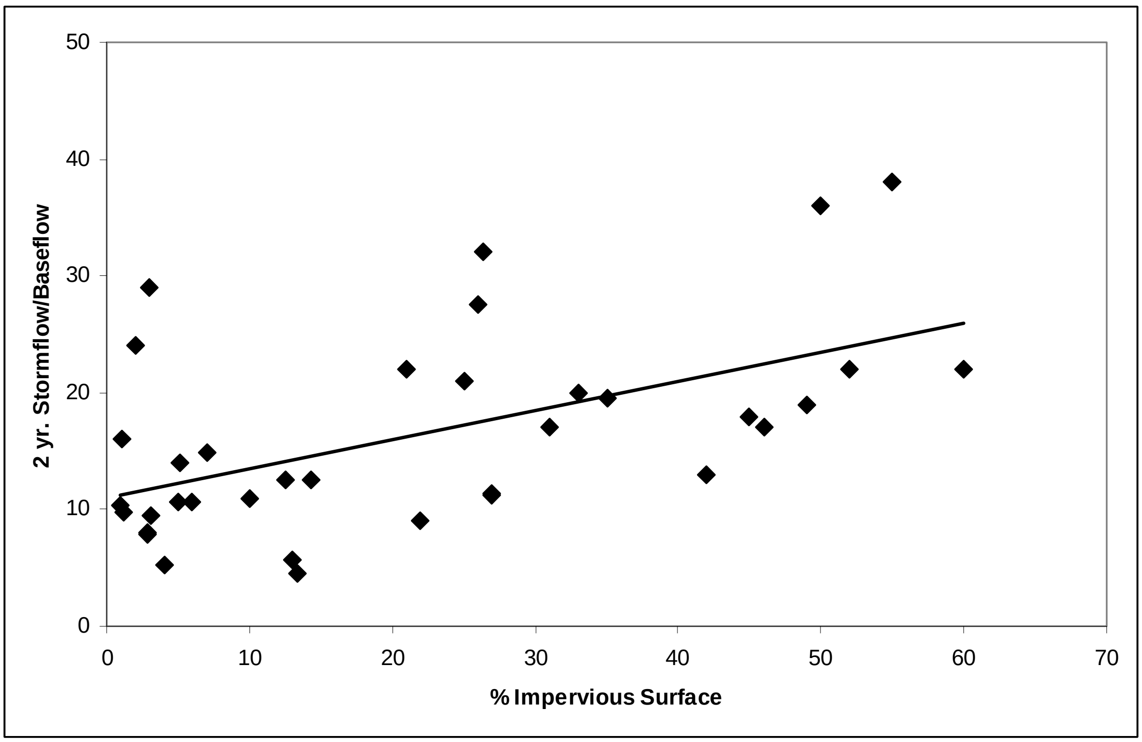
Human use of land in the Columbia basin has been evolving over the last 150 years. Traditional land uses, such as agriculture, grazing and logging, continue to be major activities in the basin. Most lands suitable for these uses were converted by the middle of the 20th century. The impacts of these activities on aquatic habitats has been thoroughly studied (Williams 2005) and are often considered in the development of restoration plans. However, substantial areas of land once used for agriculture and forestry are being converted in response to the increase in population in the region. The following discussion focuses on the response of aquatic habitat and biota to urbanization because conversion of lands from forest or agricultural uses to urban, industrial, residential or recreational uses will become increasingly common in the Columbia Basin in the future. The impacts of development on streams, especially urban development, have received a considerable amount of research attention in the last decade, including a substantial amount of work in the Pacific Northwest. These efforts have demonstrated that urban development causes marked changes in the physical, chemical and ecological characteristics of stream ecosystems. In most cases, the changes caused by development are detrimental to native aquatic biota, including salmonid fishes.

Physical Effects

Urbanization greatly increases the amount of impervious surfaces in a watershed (pavement, roofs etc.). As a result, precipitation cannot penetrate into the soil, causing an increase in surface runoff (Dunne and Leopold 1978). Research in various locations in North America have indicated that at high levels of impervious surface the proportion of stream flow due to surface runoff can be as much as five-fold that seen in forested catchments (Arnold and Gibbons 1996). The increase in surface runoff due to urbanization is often even greater in the Pacific Northwest due the naturally high infiltration capacity of the soils and the low intensity of the rainfall, which makes surface runoff a rare phenomenon in undeveloped watersheds (Booth and Jackson 1997).

Increased surface runoff causes the lag time between precipitation and stream flow response to decrease (Hirsch et al. 1990). The effect of decreased lag time is higher peak flows but of shorter duration than those in forested catchments receiving comparable rainfall (Leopold 1968). The reduction in infiltration of water into the soil caused by impervious surfaces reduces groundwater recharge and causes a reduction in the base flow discharge of streams in urban areas (Barringer et al. 1994). As a result of the combined impacts of urbanization on water runoff and infiltration, the difference between base flow and storm flow in urban watersheds increases (Figure 9; May et al. 1997).

Figure 9. Change in the ratio of a storm flow with a two-year return interval to baseflow with increasing impervious surface level. An increase in the two-year storm flow and a decrease in base flow in urban settings causes this ratio to increase with increasing impervious surface. Figure redrawn from data presented in May et al. (1997).



Urbanization fundamentally alters channel networks. Drainage density in urban areas can decrease dramatically due to filling and paving over natural channels and routing flow into pipes (Hirsch et al. 1990). Stream flows in urban watersheds also are impacted by the implementation of measures to speed water from watershed surfaces to channels and modifications in channels to move water downstream as rapidly as possible. Gutters and storm drains were traditionally configured to move water rapidly to stream channels. These modifications of the architecture of the drainage network contribute to an increase in peak flow and increase the frequency of discharge events of sufficient magnitude to cause sediment transport and habitat disruption (Booth and Jackson 1997; Meyer and Wallace 2001).

Channel width and depth also are impacted by development as both sediment supply and discharge regimes are altered. Channels dimensions respond to accommodate these changes (Dunne and Leopold 1978). Increased overland flow, reduction in vegetative ground cover, and removal of riparian vegetation can combine to increase the delivery of sediment to channels in urban environments several orders of magnitude over rates observed in undeveloped systems (Wolman and Schick 1967) and generally cause a shift towards finer-sized sediment (Jobson and Carey 1989). Channels often respond to these changes in flow and sediment delivery by becoming wider, deeper (Leopold 1973) and less complex (Booth and Jackson 1997) with the distance between pools increasing (Paul and Meyer 2001). In-channel large wood, an important determinant of channel form and habitat quality in Pacific Northwest streams, tends to be lacking in urban environments (May et al. 1997).

The removal of riparian vegetation and the reduction in groundwater input to urban streams can alter water temperature (Galli 1991). Typically urban streams exhibit higher summer temperatures, lower winter temperatures and greater diurnal fluctuation than streams in forested areas (Pluhowski 1970). Summer precipitation has been seen to result in short-term increases in water temperature of as much as 15^{o} C due to surface runoff absorbing heat from paved surfaces (Pluhowski 1970).

Chemical Effects

Chemicals introduced into streams from an urban environment are more diverse than those generated by other land uses. Effluent from industrial facilities, discharge from wastewater treatment plants, runoff from paved surfaces, and pesticides and fertilizers from lawns all find their way into urban streams (Paul and Meyer 2001). Although some urban areas have installed systems to reduce chemical contamination in storm water runoff, many municipalities do not have this expensive technology (Heaney and Huber 1984; Paul and Meyer 2001). Failing septic systems are also a major source of chemical contamination for streams in some urban watersheds (Faulkner et al. 2000).

Urban streams are commonly enriched with nutrients. Both nitrogen and phosphorus, the elements that contribute most significantly to eutrophication (excessive plant production) in aquatic systems, can exhibit elevated concentrations in urban streams (Meybeck 1998; Winter and Duthie 2000). Typically, the concentrations of these nutrients do not attain levels seen in agricultural areas, where large quantities of fertilizer are applied, although even in mixed agricultural/urban areas, the urban landscape does make a significant contribution (Osborne and Wiley 1988). Elevated concentrations of calcium, sodium, potassium, and magnesium also have been reported in urban streams (Ometo et al. 2000). The primary sources of nutrients in urban streams are waste water treatment plants, septic systems, and fertilizer in surface runoff (LaValle 1975). The algae and plant growth supported by nutrients in urban streams produces large quantities of organic matter as the vegetation decomposes which, combined with high water temperatures, often results in low levels of dissolved oxygen (Paul and Meyer 2001).

Various toxic metals are found in urban streams including chromium, copper, manganese, zinc, cadmium, and nickel (Wilber and Hunter 1979; Neal and Robinson 2000). Lead concentrations in urban streams have declined since lead was eliminated from automotive fuels (Paul and Meyer

2001). High levels of mercury, especially as particle-bound methyl mercury, are found in streams infrequently but may reach high levels in some systems (Mason and Sullivan 1998). Automobiles and trucks are a common source of all these metals. Tires and brake linings contain various metals that are shed on road surfaces and subsequently washed to streams (Mielke et al. 2000). Some industrial discharges also contain metals (Paul and Meyer 2001).

Pesticides are usually detected in urban streams, often at concentrations high enough to impact aquatic biota (Hoffman et al. 2000). Sediment and organisms in urban streams have been found to contain levels of some types of pesticides that exceed those seen in areas of intensive agriculture (USGS 1999). Although pesticide application rates in urban environments is not well documented (Coupe et al. 2000) some studies suggest that pesticide use in urban areas actually accounts for about a third of all pesticides applied in the United States annually (LeVeen and Wiley 1983). These chemicals are most commonly applied to control insects, weeds, or fungi in buildings, lawns, and gardens and enter steams primarily through runoff. However, some pesticides do volatilize (become airborne) and elevated levels of these chemicals have been noted in precipitation in some studies (Coupe et al. 2000), providing a mechanism for the direct delivery of these chemicals to streams.

Various other organic chemicals also can be delivered to streams in urban environments. Petroleum-based organic compounds are frequently detected in urban streams (Moring and Rose 1997). Even chemicals that are no longer in use can continually bleed into urban systems. Poly chlorinated biphenyls (PCBs), for example, are still frequently found although the manufacture of this material has been banned; there is a high correlation between urban land use and PCBs in stream sediments in the Willamette River watershed (Black et al. 2000). Flame retardant chemicals called polybrominated diphenyl ethers (PBDEs) are increasing in fish and fish-eating birds in the Pacific Northwest (Rayne et al. 2002; Elliott et al. 2005). Recently, PBDEs were reported in eggs of the fish-eating Osprey from the lower Columbia River and elsewhere in Oregon and Washington (Henny et al. 2006).

Another recent water quality/contaminants concern, especially for waterways in urban areas, has been the frequent detection of pharmaceuticals, hormones, and personal care products, often referred to as PPCPs, in water samples. This class of chemical contaminants is released to the environment after passing through wastewater treatment plants. In a large nationwide study of personal care products and other organic wastewater contaminants by the USGS (Kolpin et al., 2002) covering 139 streams and rivers, 82 of the 95 chemicals that they screened for were detected (more commonly in rivers near urban areas but also even in remote areas). One class of these chemicals is known as endocrine disrupters, which includes birth control hormones. These compounds have been shown to affect the reproductive system of adult male rainbow trout at very low concentrations (Routledge et al. 1998).

Other personal care products which are known to contain chemicals that may be toxic to aquatic life include: antibiotics, steroids, antidepressants, caffeine, insect repellant, and fragrances. These were all found commonly in the rivers sampled in a USGS nationwide survey (Kolpin et al. 2002). Analysis of recent water samples from the Columbia River estuary (Morace 2006) indicated that many of these personal care products were present at detectable levels including: acetaminophen, diphenhydramine (a common antihistamine), antibiotics (erythromycin and trimethoprim), and the known endocrine disruptor, bisphenol A. Beyond their detection, very little is known regarding the long-term effects of these personal care products on humans or aquatic organisms, and research is needed to determine their effects including interactive and synergistic effects.

Many of the contaminants discussed above are transported through stream systems both dissolved in stream water and bound on sediment, clay, or organic matter particles. Thus, organisms living in urban streams can be exposed to contaminants either through absorption from the water or by ingestion of contaminated particles (Benke and Wallace 1997). Metals, in particular, have an affinity for organic matter particles and much of the metal found in streams is in a particulate form. Sediments with high organic content can have metal concentrations several orders of magnitude higher than concentrations in sediments with low organic content (Mason and Sullivan 1998). Transport of some pesticides also is closely associated with particle transport in rivers (Foster et al. 2000). The relative proportion of dissolved and bound forms varies widely among chemicals and governs the primary pathway by which each chemical enters the stream trophic system.

Ecological Effects

The effects of urbanization on hydrology, channel characteristics, sediment dynamics, and chemistry of streams also alter the ecological properties of these systems. A considerable amount of research on the ecological effects of urbanization has focused on stream macroinvertebrates. Less work has been directed towards algae and microbial communities in these systems, although some information has been published on these topics. There has been a considerable amount of work in the last decade on the impact of urbanization on fish communities, especially the response of salmonid fishes.

Some urban streams exhibit very high bacterial densities, primarily of coliform bacteria. Densities of these bacteria are particularly high in systems impacted by waste water treatment facilities or failing septic systems (Gibson et al. 1998). Storm sewers also can be significant sources of coliform bacteria as demonstrated by a study in Vancouver, British Columbia (Nix et al. 1994). As a result, bacterial densities in urban streams often increase after rainfall (Duda et al. 1982). Increases in nitrifying bacteria have also been noted below some sewage treatment plant outfalls (Jancarkova et al. 1997) and iron oxidizing bacteria are common in urban streams where anoxic water enters the channel from groundwater or storm sewers, producing a bright orange stain on the stream bed (Dickman and Rygiel 1998).

Relatively little study of the impacts of urbanization on algae has been done. However, there is evidence that algal species diversity declines in urban settings (Chessman et al. 1999) and algal productivity increases in some urban streams due to high light and nutrient levels (Richards and Host 1994). However, algal production may be inhibited in some systems due to increased frequency of bed disturbance, sediment deposition, and high turbidity levels (Dodds and Welch 2000). Some algae are sensitive to metals, which may limit productivity of these species in some streams (Olguin et al. 2000). Herbicides in urban streams also may limit algal production, although this issue has not received much research attention (Davies et al. 1994).

Urbanization has been associated with a decline in invertebrate community diversity in nearly all studies where this issue has been addressed (Paul and Meyer 2001) and invertebrate abundance also typically decreases (Lenat and Crawford 1994). Decreases in community diversity occur as less tolerant taxa are excluded from the fauna (Resh and Grodhaus 1983). Certain taxa are sensitive to the types of habitat and water quality changes associated with urbanization, including mayflies, stoneflies and caddisflies (Hachmoller et al. 1991). Increased abundance of more tolerant taxa also may occur, including chironomids or midges, oligochaete worms, and some snails. Highly impacted streams, such as those with very high levels of toxins or water temperature, can depress even the tolerant taxa, leading to low abundances of invertebrates in streams suffering these extreme conditions. A considerable amount of study has occurred over the years on the response of invertebrates to sewage treatment plant discharge. The high levels of organic pollution historically associated with these facilities greatly reduced invertebrate community diversity below the discharge but improved treatment technology has reduced impacts downstream from these sites (Wright et al. 1995).

The impacts of land use changes on invertebrate community characteristics have frequently been assessed using multi-metric indices such as the Benthic Index of Biological Integrity (Karr 1991). Application of this index to streams in the Puget Sound region has revealed a sharp decrease in many community metrics with increasing levels of impervious surface (Horner et al. 1997).

The changes in invertebrate communities in urban landscapes are likely due to a variety of factors. Increased sediment, increased toxin levels, decreased food availability, increased temperature, and altered hydrological regimes all can impact invertebrate communities (Pederson and Perkins 1986; Doeg and Milledge 1991). Invertebrates also represent a pathway for transfer of toxic materials, including metals and pesticides, to fishes. Benthic organic particles are a primary food resource for many invertebrates and various pollutants often bond to these particles. These toxic materials are incorporated into the tissues of invertebrates upon ingestion of the benthic particles. Subsequent fish ingestion of contaminated invertebrates transfers, and often concentrates, these toxins in the fish, which are again concentrated at higher trophic levels, e.g., humans and ospreys.

Fish Community Response

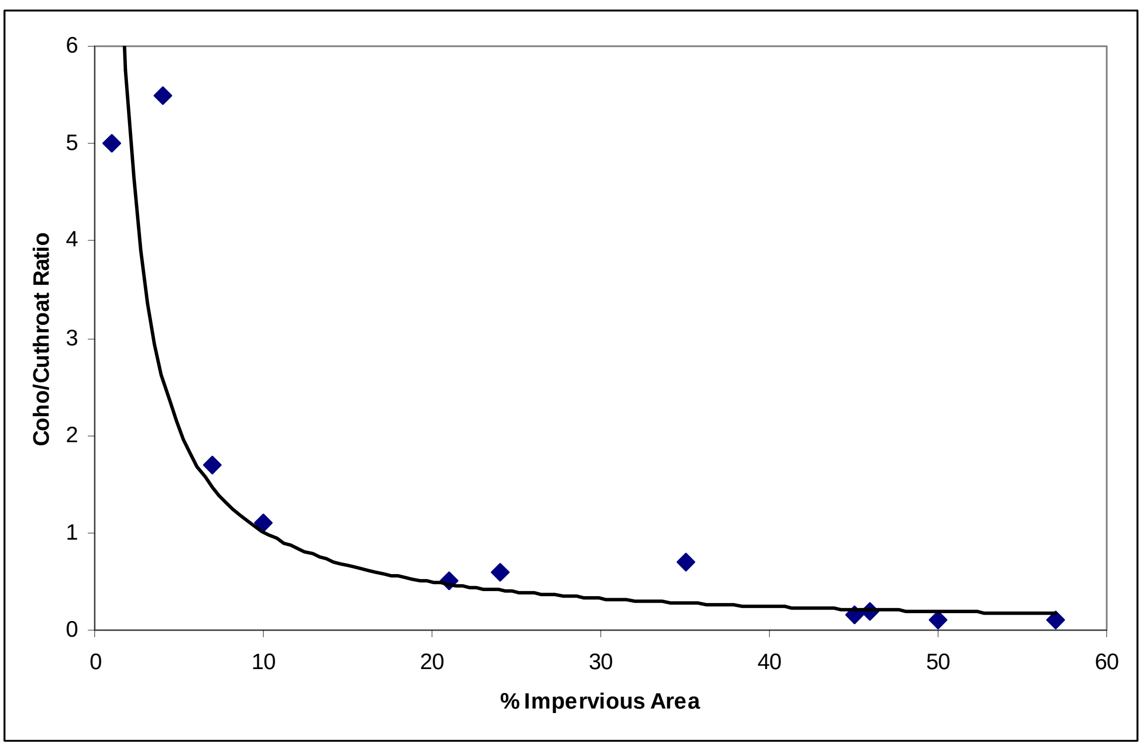
Urbanization is generally associated with a decline in fish community diversity and abundance. Often only very tolerant taxa are present in streams in heavily urbanized areas (Yoder et al. 1999) and invasive species often enjoy a competitive advantage over native species under urban conditions (Boet et al. 1999). In some cases, extirpation of native fishes in urban streams has been reported (Weaver and Garman 1994).

Salmonid populations appear to be especially sensitive to urbanization. In a rapidly-developing area in the mid west, conversion of agricultural lands to urban uses has consistently led to declines in salmonids and other cold-water fish species (Wang et al. 2003). A comparison of fish communities in streams in southeastern Wisconsin between the 1970s and the 1990s revealed a 15% drop in the number of fish species and a 41% decline in fish density (Wang et al. 2000). Urban lands increased in the watersheds of these study streams by 7% between the survey dates.

Restructuring of fish communities by urbanization also has been reported for streams in the Pacific Northwest. The fish community in Kelsey Creek, a small stream in Bellevue, Washington, was found to be dominated by cutthroat trout while a nearby stream in a rural area was dominated by coho salmon (Scott et al. 1986). The trout population in Kelsey Creek consisted primarily of young fish whereas the cutthroat trout found in the rural stream included a much higher proportion of older fish. Surprisingly, the salmonid community in Kelsey Creek was highly productive, about 1.6 to 3.3 times the production measured in the rural stream. The authors attributed this increase in production to higher water temperatures during winter and an abundant food source.

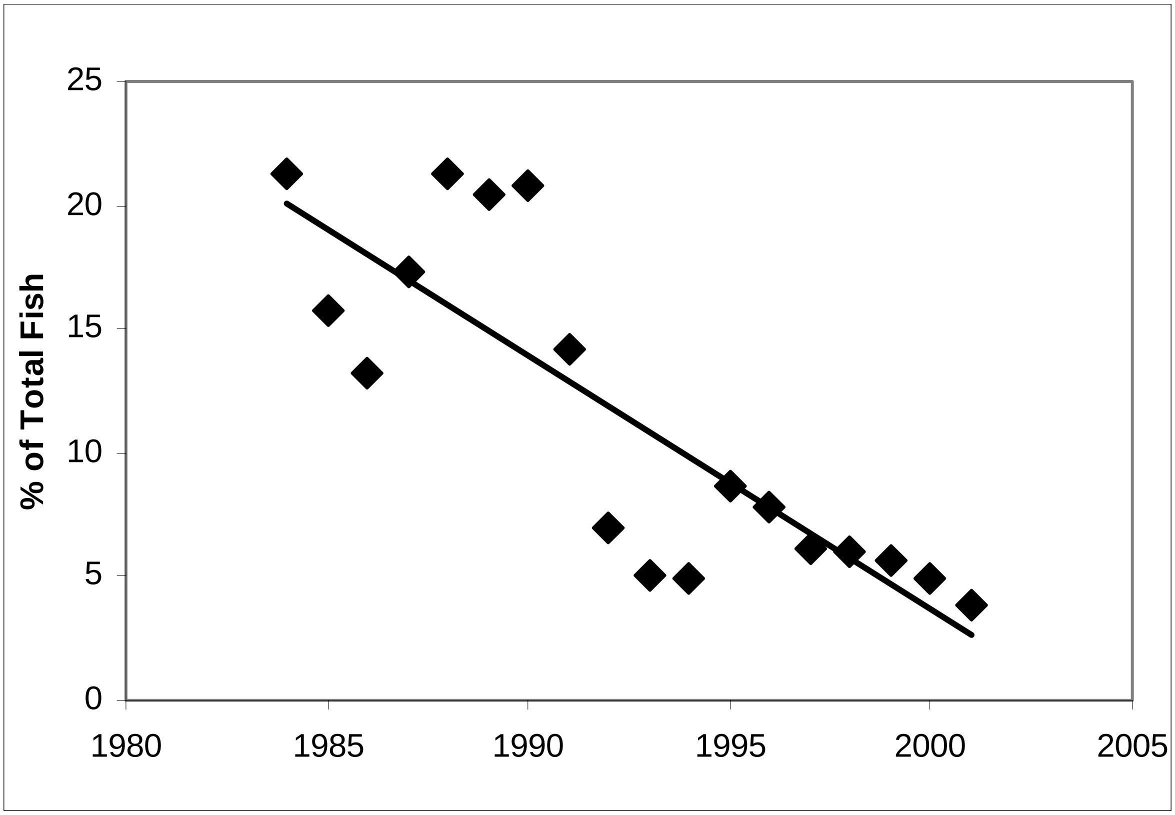
A more extensive survey of streams in the Seattle area has verified that urbanization is associated with a switch in the dominant salmonid species from coho salmon to cutthroat trout (Figure 10; May et al. 1997). Coho salmon were dominant only in streams with very low levels of urban development; watersheds with impervious areas of less than 5%. At high levels of impervious surface cutthroat were the dominant fish species and coho were essentially absent from streams draining areas with more than 35% impervious surfaces.

Figure 10. Change in the ratio of coho salmon to cutthroat trout in fish communities occupying streams at varying levels of urbanization in the Seattle, Washington area. Figure redrawn from data presented in May et al. (1997).



The effect of urbanization on coho salmon in the Seattle area also is apparent in a shift in the distribution of spawning fish away from urbanizing areas. Spawning count evaluations of coho salmon from 1985 through 2001 for 84 streams in this region indicated that the proportion of the spawning aggregation using those streams that underwent urban development over this period declined dramatically (Figure 11; R. Bilby, unpublished data). The sites that underwent urban development between 1984 and 2001 supported about 20% of the total spawners at all 84 sites in the mid 1980s but only about 4% by 2000.

Figure 11. Change in the proportion of spawning coho salmon supported by 12 streams that underwent urban development between 1984 and 2001. Over this time period, spawning activity shifted from these sites to stream draining areas of less intensive land use (R. Bilby, Weyerhaeuser Co., unpublished data).



A variety of factors may be contributing to the shift from coho-dominated to cutthroat-dominated fish communities with increase urbanization in the Pacific Northwest. Reduction in the availability of floodplain habitats, preferred by young coho salmon, in urban environments is likely a contributing factor (Scott et al. 1986). Spawning behavior also may make coho salmon more susceptible to urbanization than cutthroat trout. Coho salmon are a fall spawning species while cutthroat trout spawn in the spring. Therefore, coho eggs are incubating in the stream bed at a time when high flows are most likely to occur. As indicated earlier, one of the effects of urbanization is an increase in the frequency and severity of high flow events (Booth and Jackson 1997). Therefore, coho eggs could be more susceptible to being scoured from the gravel or suffocated by deposited sediment in urban streams. Cutthroat would avoid much of the impact from altered hydrology by spawning after most of the risk of elevated flows had passed.

Recently, studies in the Seattle area have identified another factor that is likely contributing to the decline of coho salmon in urban systems (N. Scholz, NOAA-Fisheries, Seattle, unpublished data). Adult coho salmon entering urban streams frequently die before completing spawning. This pre-spawn mortality reaches very high levels in some streams. Rates ranging from 25% to nearly 90% have been measured in streams in the Seattle area compared with a rate of about 1% in a forest stream in the Puget Sound region. The cause of the high mortality rates of adult coho salmon in urban systems is not known but appears to be correlated with high densities of roads. Cutthroat trout do not suffer high mortality rates in these urban streams at the time when the coho salmon are being impacted. Thus, high pre-spawn mortality coupled with higher susceptibly of incubating eggs to the effects of high discharge and decreased rearing habitat quality likely all contribute to the observed change in fish community composition.

Wildlife Response

Urbanization extensively changes habitat and can greatly alter and reduce the community of wildlife that is present. Studies of wildlife along gradients of urban development have typically found decreased diversity of native species and increased abundance of non-native species, a preponderance of smaller animals and medium-sized vertebrate predators (e.g., fox, raccoon, though one study found ants to be the dominant predator in an urban environment), high densities of domestic pets, and primarily more generalized species with loss of many more specialized species (Pickett et al. 2001; Nilon and Pais 1997). For example, exotic generalists such as pigeons, starlings, and sparrows can constitute the great majority (>80%) of the bird community of cities (Pickett et al. 2001). Additionally, the biota of urban areas is significantly biased toward species that are characteristically associated with people and buildings, so is relatively similar among cities. Urban areas also can be sources of introduction and spread of non-native species of plants and animals.

Although urban areas were once considered unsuitable habitat for most wildlife species, the pattern of urban/suburban sprawl has led to more wildlife associated with urbanized areas, including species that once were thought to be restricted to rural or pristine habitats (e.g., deer and coyotes). Additionally, it is well recognized that different land uses within urban areas harbor different communities of wildlife (cf. Nilon and Pais 1997; Pickett et al. 2001). It is now recognized that urban areas and even sprawling urban corridors can be managed to maintain some wildlife diversity (Goode 1989, Bender et al. 2004, Adams 2005). Urban areas can be suitable habitat for some small mammals, birds, reptiles, and amphibians, and could be managed to restore or conserve such wildlife species (Ditchkoff et al. 2006).

Some states have urban wildlife programs, including Washington, the identified functions of which are urban habitat and species management and provision of information and education (Adams 2005). Urban wildlife conservation is a challenge that requires input from planners, landscape designers, social scientists, ecologists, and the people of urban areas. Without thoughtful planning, urbanization will continue to alter, fragment, and isolate wildlife habitat (Adams 2005).

Effects of Exurban Development on Fish and Wildlife

Low-density rural home development (i.e., exurban development, which can be defined as roughly 6-25 homes/km2) has become the fastest-growing form of land use in the United States since 1950 (Hansen et al. 2005) and has been the dominant trend in human settlement in the Western United States since 1970 (Brown et al. 2005).

Exurban areas are defined as moderately low density, semi-rural residential lands that are intermediate between urban and rural in population or housing density and are distinct from suburban in being away from the urban fringe (Theobald 2004). Thus, an exurban area is a semi-rural region beyond the suburbs of a city characterized by low density, large lot development (about five acres per house, or more). There are not consistent or exact definitions of the densities of people or housing units that correspond to these categories, except for urban, which is defined by the U.S. Census Bureau as a city having a population of at least 50,000 residents or an area with a population density of at least 3.86 people/ha. As guidance, urban areas can be considered as having roughly >1 housing unit (HU)/ac, exurban as having 1HU/1-40ac, and rural as having <1 HU/ac (Brown et al. 2005).

In 1950, less than 1% of the land area of the United States was at urban density and ~5% at exurban; in 2000, these values had increased to 2% and 25%, a dramatic change in the impact of people at lower density on the land (Brown et al. 2005). Additionally, exurban growth was disproportionately outside of existing metropolitan counties and was especially high in several Western ecoregions, including portions of the Columbia River Basin.

The rate of exurban growth also appears to be increasing, being higher from 1970-2000 than from 1950-1970 in the Northwest forested mountains. Population gains in rural counties exceeded those in metropolitan areas in the 1970s, for the first time in more than 150 years, with the pattern of development one of decreasing household size and decreasing settlement density, referred to as rural sprawl (Brown et al. 2005).

High levels of natural amenities and recreational opportunities were identified as of increasing importance to decisions for settlement (Brown et al. 2005, Hansen, Theobald et al. 1997, 2000), and consequently, exurban development has been disproportionately high near federal forest and other wildlands (Hansen et al. 2002; 2005). Increase in exurban land area is predicted to be dramatic in the Northwest Forested Ecoregion, which includes parts of the Columbia River Basin, even with modest population gains (Brown et al. 2005).

During the latter half of the 20th century, the area of low-density, exurban settlement in the United States grew to occupy more than 15 times the area of higher density urban settlement, becoming the largest overall spatial impact of people on the landscape (Brown et al. 2005). Although croplands decreased by roughly 22% east of the Mississippi, cropland area was roughly stable in the West (Brown et al. 2005). Analysis of population and settlement patterns using county-level housing unit data from the United States Census Bureau showed that the developed footprint in the United States grew from 10.1 to 13.3% of the privately owned land area between 1980 and 2000 (Theobald 2005). This study forecasts urban and suburban housing densities to expand by 2.2% by 2020, but exurban development to expand by 14.3%.

Consideration of exurban development points out limitations to assessing impacts of human population by population data alone, as these data are tabulated by primary residence so do not account for second and vacation homes (Brown et al. 2005, Theobald 2004). Areas with high numbers of second or vacation homes, a dominant pattern of development in the Rocky Mountain and Pacific Northwest regions (Hansen et al. 2002, 2005), have higher population than is reflected in the primary census data, and they have added settlement impacts in the form of housing units and supporting infrastructure, such as roads and power lines. An analysis of U.S. Census Bureau data on housing units (Brown et al. 2005) showed that from 1970-2000 there was increased movement to non-metropolitan areas, decreased household size, and decreased settlement density.

Important ecological resources such as wetlands, riparian zones, and valley bottoms are often disproportionately located on private lands, and these areas tend also to be disproportionately the sites of exurban development (Theobald 2004, Gude et al. 2005, Knight et al. 1994). Human settlement tends to result in degraded habitat for other species through direct habitat conversion and loss, alteration of habitat near roads and buildings, and fragmentation of habitats and landscapes (Theobald et al. 1997). Riparian areas have been particularly strongly affected by development and conversion of wildland and rural areas, and the vegetation, fish and wildlife, as well as the ecosystem function, of riparian corridors are threatened with continuing patterns of disproportionate development (Hansen et al. 2002).

The proportion of homes built in areas of productive soils and proximity to water has remained consistently high (Gude et al. 2006), and this trend is likely to continue if not constrained by public policy. Since these areas also are critical to fish and wildlife, impacts of exurban development on biodiversity can be severe. Data suggest that exurban development typically has led to decreased species diversity, decreased abundance, and local extirpation of some species, especially larger and more specialized species, and increases in species that are associated with people, including non-native species, weeds, and domestic pets such as cats and dogs that can be significant predators (Hansen et al. 2002, Smith and Wachob 2006, Laliberte and Ripple 2004, Knight et al. 1994). These effects can extend to public lands kilometers distant from the development (Hansen et al. 2005).

Exurban development also can cause economic difficulties for municipalities as they incur costs of infrastructure support to outlying developed areas (e.g., Weiler and Theobald 2003, Nelson and Sanchez 2005). Exurban development typically converts active farms and forests into low density land uses that generate fewer local government revenues than costs (Nelson and Sanchez 2005). For example, exurban areas exacerbate the need for protection from wildfire, a threat that has increased dramatically in the region in recent decades, in part as a consequence of climate change (ISAB 2007-2).

The continued march of settlement into formerly rural or wildland areas is a major cause of decline of wildlife (Laliberte and Ripple 2004) and also has increased the number of conflicts between wildlife and people, ranging from deer consuming gardens to serious conflicts over such large carnivores as wolves, mountain lions, and grizzly bears. These economic and social costs and conflicts were prominently noted in some subbasin plans (e.g., the Flathead), although planning to reduce or avoid such costs and conflicts generally was not developed.

Despite the apparent substantial disadvantages of exurban development to preservation of fish and wildlife, Theobald (2004) asserts that conservation efforts may frequently be more cost-effective in exurban areas than in urban areas since conservation of urban areas often requires acquisition, extensive restoration, and prolonged maintenance. In contrast, he notes that local and regional land trusts now hold millions of acres of protected land across the United States, often in exurban areas.

Many studies have shown that clustered development has fewer negative effects on fish and wildlife (e.g., Theobald et al. 1997), yet the dominant ongoing pattern of settlement in the Columbia River Basin is exurban sprawl. A recent study showed that urban containment can be very effective in limiting exurban sprawl (Nelson and Sanchez 2005). For Portland, Oregon, a city categorized as having strong containment policies regulating development, the rate of exurban increase between 1990 and 2000 was -3%, among the lowest of the urban areas studied. In contrast, urban areas with no containment policies typically had rates of change of exurbanized land area from 12 to over 50% increase. It is notable that only 1/3 of the metropolitan areas in this study had some form of land-use policy containing expansion around them.

Much recent exurban development in the Rocky Mountain West and Columbia River Basin has been concentrated near large acreages of public lands such as forests, parks, wilderness areas, and nature reserves, so the impacts of population change may be disproportionately large for these so-called protected lands (Hansen et al. 2002; Theobald 2004). Thus, municipal, county, and state regulations on development may need to give special attention to these wildland margin areas.

V. Population and Outside-Basin Effects

A variety of population-driven factors external to the Columbia River Basin affect fish and wildlife within the Basin. These include international trade, shipping, dredging, hazardous material transport, and airborne pollution.

International Trade

International trade has direct and indirect effects on Columbia River Basin ecosystems. Direct effects have resulted from modifications to the lower river and estuary as shipping developed to export and import materials and commodities from overseas and eastern states. Globalization of trade may have contributed to the loss of some industries within the Columbia River Basin, such as aluminum smelting. Globalization and international trade will affect specific resource extraction industries of the Columbia River Basin in different ways, decreasing the price and production of some resources and increasing others. For example recent droughts in Australia’s wine producing regions have increased prices of Columbia River Basin wine grapes and led to expanded acreage in these crops. In contrast, competition from low cost production areas such as Mexico in the strawberry market have led to decreases in commercial production in the Columbia River Basin (Oregon Department of Agriculture 2007).

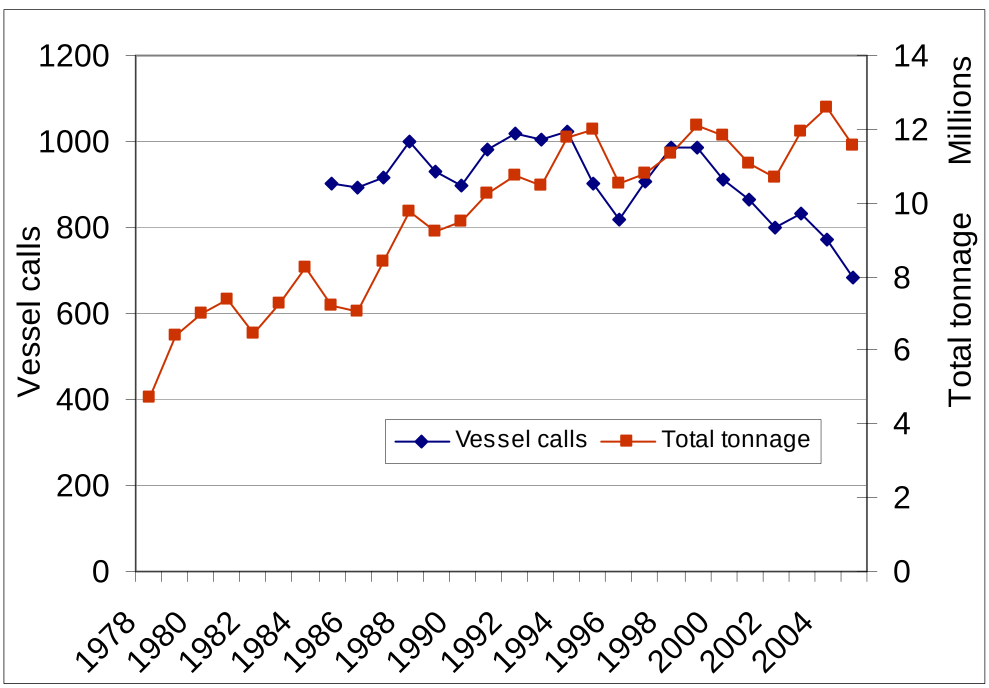
Shipping

The Columbia River and its estuary have been used for centuries as a transportation corridor, first by Native Americans as a trade route between the coast and the interior. The Hudson's Bay Company built Fort Vancouver at the confluence of the Willamette and Columbia rivers in 1825 and exported furs from the fort to England. The first shipment of wheat out of the river was in 1878. Since that time the river has been increasingly channelized, deepened, and used for import and export of goods by deep-sea shipping. Six deep-sea ports are currently operating: Longview/Kelso, Kalama, and Vancouver Washington and Portland, Astoria, and Rainier, Oregon (Anon. 2006).

Trade occurs predominantly along the Pacific Rim. For example the port of Longview imports coal from China and calcined petroleum coke from China and Brazil. Rainier imports gypsum from Mexico (Starratt 2003). There is also significant trade with other American ports, especially San Francisco (Sytsma et al. 2004, and river shipping on the Columbia-Snake River system carries goods from as far inland as Nebraska (Washington State Department of Agriculture 2005).

Patterns of shipping through the Port of Portland are variable over time. Although the number of ships using the port has declined in recent years, total tonnage of cargo has remained stable. Increases in both ships and cargo tonnage may occur as a result of increased use of Columbia River ports by container ship traffic following the completion of channel deepening projects currently underway.

Figure 12 Vessel Calls and Total Tonnage in the Port of Portland, 1978-2006.



Source: Port of Portland Marine Terminal Statistics.
www.flypdx.com/SelfPost/A_200712292341HistoryWeb78-04.pdf

Several important ecological issues are linked with shipping and the dams and locks that shipping requires. These include introduction of aquatic invasive species, stranding of fish by waves, and loss of habitat to port infrastructure.

Aquatic Invasive Species: Shipping has been widely recognized as an important vector for bringing in aquatic invasive species to the Columbia River and estuary via a variety of means including ballast water, hull fouling, ballast sediment, mud on anchors and other sources (NRC 1996b). Sytsma et al. (2004) reported that at least 81 species of organisms (vascular plants, algae, invertebrates, and fish) have been introduced to the Columbia River since the mid 1880s. The shipping vector is thought to be particularly important for invertebrates of Asian origin, such as the Siberian freshwater shrimp (Emmett et al. 2002). Because many aquatic invasive species that have colonized the estuary are tolerant of freshwater, some of them have the potential spread far upriver into the reservoirs and possibly the tributaries, as has occurred with some native estuarine species. For example a native estuarine mysid has been reported in the John Day Reservoir (Haskell and Stanford 2006).

Established aquatic invasive species clearly have modified the biodiversity of aquatic ecosystems in the Columbia River Basin. However the ecological impact of the introductions is very poorly documented. Aquatic invasive species are routinely discovered in the Basin, with a new invertebrate aquatic invasive species being found about every five months in the past ten years (Sytsma et al. 2004). If shipping increases, the introduction rate of aquatic invasive species will likely increase, although regulations such as ballast water control and management may help reduce the rate of introductions.

Shipping and recreational boating have the potential to transfer aquatic invasive species from freshwater habitats to the east of the Columbia River Basin. For example trailered recreational boats have the potential to carry zebra mussels (*Dreissena polymorpha*), and their close relatives, quagga mussels (*Dreissena rostriformis bugensis)*. Quagga mussels were discovered in Lake Mead in January 2007, the first discovery west of the continental divide.

Stranding of fish by waves: Pearson et al. (2006) found that juvenile Chinook salmon and other fish species were stranded when cast onto shore in waves from passing deep-sea ships. Of the 126 ship passages they monitored, 36% percent resulted in fish stranding. Growth in the shipping industry could increase stranding mortality.

Loss of habitat to port infrastructure: Port facilities and docks are adjacent to the river's or estuary's edge. Additional construction for storage facilities to accommodate more ship-borne cargo will result in increased impact to habitat.

Dredging

Dredging of the lower Columbia River and estuary to improve navigation was begun as early as 1878 with the aim of developing a 20 ft (6.1 m) navigation channel. In the past 100 years the channel has been dredged to 40 ft (12.2 m) and widened to 600 ft (182.9 m). The current channel is currently being dredged an additional 3 ft (0.9 m) to its authorized depth (USCAE 2006). Sherwood et al. (1990) estimated that between 1909 and 1982 between a third and a half of the annual fluvial sediment supply was removed from the channel. Since 1976 annual maintenance dredging between river mile 4 and 50 has averaged about 8.8 million cubic yards (6.7 M m^3) (ISAB 2000). The sediments were deposited in the ocean off the mouth of the river, pumped onto the margins of the river to create industrial land, or used to create artificial islands (ISAB 2000). Although the original intents of the artificial islands was to develop fish and wildlife habitat (e.g., Miller Sands/Rice Island), in recent years fish-eating birds nesting on the islands are now considered a major source of juvenile salmon mortality (Collis et al. 2002).

The ISAB (2000) provided a comprehensive description of the effects of dredging in the Lower Columbia River and estuary. The navigation channel has concentrated flow in one deeper main channel, with several interacting physical effects involving flow and volume changes. Although the detailed ecological effects of these changes have not been investigated comprehensively it is clear that the distribution of biota has been affected. For example the transport of marine zooplankton over the sill at the mouth of the Columbia River into the estuary was enhanced by the deepening of the channel (Simenstad and Cordell, 1985). Direct mortality of anadromous fish also occurs when fish are entrained into hopper dredges at the mouth of the Columbia River (Larsen and Mohl, 1990). Timing guidelines are now in place to help reduce this problem.

Hazardous Materials Transport

Increased volumes of materials, especially hazardous goods and fuel powering trains, vessels, and trucks, are moved through the Columbia River Basin in response to demands of growing human population. Summarized data on hazardous material spills could not be located. However, two transcontinental railroads (Canadian Pacific in British Columbia, Union Pacific in the United States), several local railroads, and several major Interstate or Interprovincial highways are co-located on the Columbia River corridor. With increased movement of goods via all three modes, more accidents and spills are likely, for example the 2004 Rowena oil spill from a locomotive (Oregon Department of Environmental Quality 2004) and the 2006 Vancouver Washington bilge oil spill from a merchant vessel (Washington Department of Ecology 2006b).

Airborne Pollution

There is increasing evidence of the "intercontinental" nature of manmade, airborne, chemical pollution that undermines the effectiveness of domestic controls. With the increased industrialization in Asian countries levels of these pollutants and their associated environmental effects on marine, freshwater and terrestrial habitats of the Columbia River Basin are likely to become greater (Macdonald et al. 2003).

A series of articles in *The Oregonian* (2006) detailed the airborne deposition of pollutants. About one-third of all the mercury released in the United States comes from fossil-fuel burning in Asia, principally China. This pollutant can take less than a week to reach the Pacific Northwest. Mercury is insoluble when released but transforms by the time it reaches the West Coast into a reactive gaseous material that dissolves in cloud water and is deposited in precipitation. The mercury washes into the river, where microbes convert it into a form that is readily introduced into aquatic food webs, and eventually, concentrates in fish. Studies of the Willamette River indicate that most of the mercury entering the Willamette comes from Oregon's volcanic soil and from sediment churned up on the river bottom. But the Oregon Department of Environmental Quality estimates that global sources beyond the state's control contribute 18 percent -- more than four times the share from local air deposition (Oregonian 2006).

Pesticides that have been banned in the United States (including DDT, toxaphene and dieldrin) are part of the fallout from dust blowing off farmland in China. Most of the pollution blows across the Pacific in the spring. After a 1998 dust storm in China, particle pollution levels across much of the interior West tripled. An additional 20 to 50 micrograms of particles were detected in valleys along the West Coast -- equivalent to 1/3 to 3/4 of the allowable particulate matter under EPA pollution standards. Ozone also has been tracked moving across the North Pacific (Polakovic 2002).

Ozone and fine particles and their precursors, even compounds with reasonably short lifetimes, can be detected at great distances from their sources. NOAA’s Intercontinental Transport and Chemical Transformation (ITCT) program is addressing the intercontinental transport and transformation of pollutants to understand its air quality and climate consequences. ITCT is a coordinated international research program focusing on the Northern Hemisphere, which contains most of the world's landmasses, population, and anthropogenic pollution emission sources, to investigate intercontinental transport of manmade pollution with an emphasis on ozone, fine particles, and active "greenhouse" compounds, and to determine the chemical transformation that occurs during this transport. The project will track pollutants reaching the West Coast through wind and pollution sensors installed at coastal outposts from California to the Olympic Peninsula in Washington. (www.esrl.noaa.gov/csd/ITCT/).

VI. Incorporating Human Population into Fish and Wildlife Restoration Planning

The Northwest Power and Conservation Council's mandate enables it to be an influential force in forging strategies by which human impacts can be addressed in the Columbia Basin and the Pacific Northwest. The ISAB made a similar observation in regard to climate change (ISAB 2007-2). The Council's responsibilities for regional power planning and for fish and wildlife program implementation places it in a position to influence the use and management of natural resources that affect fish and wildlife populations. The three primary tasks of the Council are:

1. Develop a 20-year electric power plan that will guarantee adequate and reliable energy at the lowest economic and environmental cost to the Northwest
2. Develop a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin
3. Educate and involve the public in the Council's decision-making processes

All three tasks relate to how the region will address human population growth. The production, distribution, and consumption of power are important factors influencing economic development. Fish and wildlife recovery plans that include human population projections are more likely to promote measures that buffer Columbia Basin ecosystems from intensified patterns of land and water use. Public education provides a mechanism for encouraging Basin residents to become engaged in coordinated efforts and ensure that the progress in restoring fish and wildlife populations is not undermined by population growth.

Studies of current patterns of land use and their impacts on such natural values as wildlands, fish and wildlife, and water quality, have emphasized the need to better integrate socioeconomic and ecological knowledge. Such integration is needed both to understand and to manage human-dominated ecosystems (Dale et al. 2000; Theobald 2004).

Four basic elements appear to be necessary for incorporating changes in human population into land use planning to preserve ecosystem values, including fish and wildlife and their habitat:

1. stakeholder involvement,
2. explicit spatial modeling of critical resources (habitat, species, water quality and quantity, etc.) and development patterns to provide a scientific basis for decision-making,
3. investigation of alternative development scenarios, and
4. evaluation and monitoring to enable adaptive management (cf. Dale and Haeuber 2001; Theobald and Hobbs 2002).

These elements can be employed at any level of planning: county greenspace, subbasin, or state.

Theobald and Hobbs (2002) identify two major impediments to implementation of such planning on private lands. First, they caution that it is not always clear what ecological and landscape metrics will be robust predictors of the impacts of development. This problem can be addressed with ongoing research, monitoring, and evaluation. Second, they caution that monitoring and evaluation of the consequences of agreed-upon patterns of development will be difficult to implement unless landowners regard the management process as fair and predictable and are able to overcome the fear of negative consequences of monitoring information.

They suggest that the best way to resolve the aversion to monitoring would be to focus on its use to inform habitat-enhancing housing and development design rather than looking only for negative effects of human actions and assuming these will necessarily degrade the environment. A significant problem in predicting the impacts of the human population is the often large cumulative effect of the many small land use changes that accompany population change and associated settlement and development, each of which might itself have negligible impacts on fish, wildlife, or habitat (Theobald et al. 1997, Dale et al. 2005). Although such cumulative outcomes are easy to document after they occur, better tools to predict such impacts before they occur are needed.

1000 Friends of Oregon, in a report on rural sprawl and threats to working farms and ranches in Oregon, recommends actions that apply to the Columbia River Basin as a whole. They recommend promoting efforts to reduce the loss of ranchlands in Central and Eastern Oregon. To assist this promotion, tools such as conservation easements and transferable development credits should be used to keep working ranches at economically viable scales and to protect strategic land. And, important to the planning process, they recommend increasing the dialogue among ranchers, environmentalists, and policy-makers in order to increase understanding of the economic and ecological value of ranchlands and the economic costs of rural sprawl.

Natural Resource Planning Processes

Future population increases are certain and the trend is clear. Greater population levels will exert greater pressure on natural resources, and will require innovative approaches to fish and wildlife habitat planning and protection. Human population growth is now an explicit consideration in a wide range of innovative natural resource planning processes. These processes are described below. Lessons learned and methods developed in these processes could address the ISRP and ISAB's suggestions and inform future planning for the Council's fish and wildlife program and NOAA Fisheries' salmon recovery plans.

Subbasin Plans

In 2005, the Council completed one of the largest locally led watershed planning efforts of its kind in the United States, an effort that resulted in separate plans for 58 tributary watersheds or mainstem segments of the Columbia River.[1] The plans guide the implementation of the Council's Columbia River Basin Fish and Wildlife Program, which directs more than $140 million per year of Bonneville Power Administration (BPA) electricity revenues to protect, mitigate and enhance fish and wildlife affected by hydropower dams. The subbasin plans provide this guidance by identification of priority restoration and protection strategies for habitat and fish and wildlife populations. The plans are not intended to regulate land use.

[1] See the Council's Web site for a complete description of the subbasin planning process, ISAB and ISRP review, and the adopted plans: www.nwcouncil.org/fw/subbasinplanning/Default.htm.

Subbasin plan development was guided by a template that described the various elements needed in subbasin plans to provide contextual information for selection and prioritization of habitat restoration actions. One of the elements requested for subbasin plans was to identify macroclimate and human occupation and use trends that may affect hydrological or ecological processes in a subbasin over the long-term (50 years into the future and beyond). Thus, treatment of human population in the plans was germane. As part of the planning process, the ISAB and Independent Scientific Review Panel (ISRP) reviewed the plans and considered the question of future effects from human population. The ISRP and ISAB review (ISRP and ISAB 2004-13[2]) concluded that, with the exception of the Willamette Plan, most plans did not address the issue of population growth. The ISRP and ISAB considered this deficiency to be a moderate to significant problem in over 65% of the subbasin plans, and overall considered this a major omission for a forward-looking planning initiative.

The ISRP and ISAB emphasized that alternate scenarios for the future are the essence of planning and are crucial to defining realistic restoration opportunities for the future. The Boise, Payette, and Coeur d'Alene subbasins were prime examples of areas where current trends, unlikely to change in the near future, substantially constrain future management options. However, those plans did not adequately address the issue. The ISRP and ISAB held out the Willamette Subbasin as a model for how other subbasins may incorporate expectations about future human conditions and their likely effect on achieving the vision for the subbasin.

In addition, a survey of subbasin plans was conducted for this ISAB review. The survey confirmed that, other than the Willamette Plan, none of the plans dealt with human population growth in depth; some did not address it at all. The majority of plans acknowledged increased growth but did not directly factor it into planning. The survey revealed three levels of human population integration in the plans: 1) planners noted that they were in a sparsely populated subbasin where population growth was not likely an issue; 2) planners recognized tremendous potential for population growth but did not account for future changes in the plan, or 3) planners identified they were in highly urbanized areas and still are working from piece-meal approaches to address specific land uses or key geographic areas. For example, the Bruneau Subbasin Plan mentioned low human population and low growth rate in the subbasin. The Deschutes and Owhyee plans recognized that increased recreation activities, including use by out-of-basin residents, has led, and could lead to further, habitat degradation. And the Chelan, Flathead, and Wenatchee plans provided context on human demographics with county planning and census information.

The ISRP and ISAB recommended including the implication of population growth into subbasin management plans through:

- Projections of human population growth and its impact on land prices and patterns of land use
- Projections of agricultural land use conversions and the implications these may have for using habitat protections targeted at the agricultural sector and funded primarily through USDA

[2] Scientific Review of Subbasin Plans for the Columbia River Basin Fish and Wildlife Program, www.nwcouncil.org/library/isrp/isrpisab2004-13.htm.

- Assessment of options that provide incentives to landowners to make habitat improvements and other actions, including practices such as no-till
- Analysis of social and economic tradeoffs among options for achieving objectives: e.g., to enhance instream flow, an assessment of the cost-effectiveness and distributional consequences of a water exchange program versus buying or leasing water rights versus increasing irrigation efficiencies
- Assessment of social and economic impacts of specific protection and restoration actions (ISRP and ISAB 2004)

State of Washington Columbia River Water Planning

In 2006, Washington's Legislature passed legislation charging the Department of Ecology to aggressively pursue new water supply in the Columbia Basin to benefit the state's economy, communities, and natural environment. The law links the state's efforts to address instream and out-of-stream needs and emphasizes the importance of local and tribal governments, water users, the environmental community, federal agencies, and other stakeholders in developing a long-term, integrated, and strategic water supply plan for the Columbia River. The law also directs decision-makers to work across jurisdictional boundaries to address a variety of needs: fish, agriculture, economy and environment. However, the state has embarked on a $200 million program to build and fill reservoirs with water from the Columbia River. The National Research Council warns that "if additional permits are issued, they should include specific conditions that allow withdrawals to be discontinued during critical periods…" for example during downstream or upstream migration during low flow periods for subyearling Chinook, adult Snake and Columbia River summer Chinook, adult Snake and Columbia steelhead, and adult sockeye salmon (NRC 2004).

The first report of this strategic planning effort (Washington Department of Ecology 2006a) contains both an inventory of water supply and forecasts of water supply and demand. The Columbia River Water Supply Inventory, to be updated annually, lists the conservation and storage projects available for acquiring water for instream flows and withdrawals for irrigation and drinking. The Long-Term Water Supply and Demand Forecast is intended to help the State of Washington keep abreast of changes that will affect supply and demand of Columbia River water. On the supply side, the forecast will account for changes in interstate, intergovernmental, and international agreements with Idaho, Oregon, tribal governments and Canada. It will track changes in climate that affect the timing and quantity of water in the Columbia River. On the demand side, the forecast will track changes in population growth, agricultural cropping practices and other economic activities that affect demand for water. (www.ecy.wa.gov/biblio/0611043.html)

The state planning effort is introduced into what is already a complex water context of competing demands for limited supplies, as exemplified by the Yakima Subbasin. Concerns about future water supplies to meet irrigation and drinking water demand are leading to initiatives that focus not only on water storage but also on the need to improve efficiencies of water use through minimum instream flow targets, water use efficiency improvement programs, and voluntary transfers of water rights (Kent 2004).

Deschutes River Basin Water Management Convening Assessment Process

The Deschutes River Conservancy, Deschutes Water Alliance, and other stakeholders in the Deschutes River Basin requested assistance from the Oregon Consensus Program of the Hatfield School of Government at Portland State University in developing a collaborative process and finding a neutral forum for addressing water management in the Deschutes Subbasin. The Deschutes is experiencing increasing demands for both surface and groundwater. The Oregon Consensus Program asked RESOLVE, a nonprofit facilitation organization, to conduct an independent convening assessment of stakeholder perspectives on issues and concerns related to water management in the Deschutes River Basin. A convening process or feasibility assessment is a method to assess and potentially assist stakeholders in organizing a collaborative process.

The goal of the convening and assessment process was to assess the potential for initiating a collaborative, consensus-based process to address identified water issues and, if feasible, to recommend a process design. A wide range of people representing differing perspectives on Deschutes River Basin water management were interviewed. A Convening Report summarizes issues explored in the convening assessment interview process. The report concludes that a collaborative process does have potential for addressing water management issues in the Deschutes Basin and recommends how such a process might be structured. (www.ci.bend.or.us/depts/public_works/dwa/docs/Deschutes_Assessment_Convening_Report.pdf)

The Willamette Partnership

Building on information and approaches developed in the Willamette Subbasin Plan, the Willamette Partnership is a coalition organized around the goal of improving the function of ecosystems by developing the Willamette Ecosystem Marketplace. The Marketplace is envisioned to be a mechanism where regulated industries, developers, and other investors can pay land managers to manage for ecosystem services such as clean abundant water, healthy populations of fish and wildlife, and a stable climate. Some market-based programs already exist, such as wetland mitigation and endangered species conservation banking. The Willamette Ecosystem Marketplace will assist buyers and sellers in these programs to leverage the additional resources of factories, developers, transportation agencies, cities, and sewer and water ratepayers to expand the scale and effectiveness of conservation areas. The idea behind the Marketplace is that conservation investments will be more strategic, coordinated and lower cost than could be accomplished under individual fragmented programs.

The marketplace is seen as an effective mechanism to protect areas with high potential for recovery where people are likely to support restoration. The basic principle is to restore low-cost, high-return areas of the Willamette River. The Willamette Partnership (Sinclair 2005) specifically recommends looking for ways to:

- Minimize development on 100 year floodplains
- Conserve water
- Voluntarily convey out-of-stream water rights while maintaining their original priority date

- Conserve high quality wildlife habitat, cluster poor habitats, and avoid habitat fragmentation
- Expand habitat value of refuge areas by managing adjacent land for conservation objectives
- Avoid barriers to wildlife movement across good habitats
- Cluster human activities that alter habitat or convert land to new uses

Watershed Councils

Oregon, Washington, Idaho, and Montana all use watershed councils as an organizational mechanism for restoration planning and implementation. Watershed councils are locally organized, voluntary, non-regulatory groups representing the range of interests in a watershed, established to improve watershed conditions in their local area. In addition, there are four Salmon Recovery Boards in Washington, which are larger, more formalized watershed councils created by the Washington State Legislature. The idea behind these planning groups is to vest local residents in the assessment and improvement of watershed conditions and to create restoration partnerships with state and federal agencies to manage riparian and upland areas. Among the benefits of watershed councils as planning entities are the potential to craft a common vision for a watershed, integrate local knowledge across municipal boundaries in ways that make sense for the ecological boundaries of watersheds, and create a forum for local state and federal discussions and decisions.

Coastal Landscape Analysis and Modeling Study

The Coastal Landscape Analysis and Modeling Study (CLAMS) is an integrated ecological-socioeconomic approach to understanding the pattern and dynamics of provincial ecosystems and to analyzing the aggregate ecological and socio-economic consequences of different forest policies and strategies across multiple ownerships of the Coast Range of Oregon. The idea is to provide policy makers, landowners, and the public with spatial projections of the consequences of various management options and interact with them to help inform debate and facilitate collaborative learning.

The approach is based on the assumption that by knowing landscape structure and dynamics of vegetation we can project consequences of different forest policies on ecological outputs, such as biological diversity, and socio-economic outputs, such as employment and recreational opportunities. The major elements of the study are (1) high resolution spatial models, (2) surveys and interviews of forest landowners, simulations of expected successional changes in forests under different management regimes, (3) simulations of landscape change, and (4) models of habitat suitability, socio-economic response, and land use change. Ecological and socio-economic consequences of current forest policies are estimated as are the effects of population growth on land-use change. (www.fsl.orst.edu/clams/intro.html).

Columbia Basin Trust

The Columbia Basin Trust was created to benefit the region most adversely affected by the Columbia River Treaty (CRT), ratified by the United States and Canada in 1964. The purpose of the Treaty is to coordinate flood control and optimize electrical energy production in the Columbia River Basin in the United States and Canada through the construction and operation of three storage dams in British Columbia (Keenleyside, Duncan and Mica) and one in Montana (Libby). In return for the storage of water, Canada is entitled to one half of the additional power generated at the U.S. power plants on the Columbia River. The Province of British Columbia owns this "Canadian Entitlement of Downstream Benefits."

The Columbia Basin Trust was formed in 1995 as a result of negotiations with residents in the region of the Canadian dams, in recognition of inequities in the distribution of benefits and costs of the Columbia River Treaty within and outside the areas of the dams. Local governments in the Basin coordinated their efforts at the regional district and tribal council level under the Columbia River Treaty Committee, which first met in 1992. The Committee, in partnership with elected officials from the region, negotiated an agreement that includes the creation of a trust governed by a board of Basin residents and the allocation of funds representing a fair share of the ongoing downstream benefits earned under the Columbia River Treaty, to be managed by the trust.

The Trust's mandate is "to support the efforts of the people of the Basin to create a legacy of social, economic, and environmental well-being, and to achieve greater self-sufficiency for present and future generations in the region most affected by the Columbia River Treaty."

The Trust has taken a strategic approach to planning for future water supplies and accommodating climate change, based on acceptance of uncertainty, development of flexible management, and adaptation to change. The Water Initiatives Strategy has eleven guiding principles that emphasize collaboration with Canadian Columbia Basin communities. These are to:

- Advocate for common concerns of Basin residents
- Facilitate the identification of trade-offs
- Focus on the Basin as a whole with an emphasis on the Columbia Basin Trust region
- Include the people of the Basin in the actions taken
- Maintain a leadership role in Basin water initiatives in the Columbia Basin Trust region
- Promote intergenerational principles
- Support adaptive management
- Support consensus planning while recognizing this may not always be possible
- Support an ecosystem approach to water initiatives
- Support the use of the best information possible
- Think and act in a proactive manner

(www.cbt.org/Files/CBT%20Water%20Intiatives%20Final%20Feb%2007pdf.pdf)

The Trust has been forward looking in addressing climate change in the Columbia River Basin. In 2006, it contracted the Pacific Climate Impacts Consortium at the University of Victoria to analyze climate change impacts in the geographic area encompassed by the Trust. The study, *A*

Preliminary Assessment of Climate Trends, Variability and Change in the Canadian Portion of the Columbia Basin – Focusing on Water Resources, concluded that climate change will alter the way people derive their livelihood in the Basin and that planning for the social, economic and environmental future will need to take these changes into account. (www.cbt.org/Files/ColumbiaBasinClimateChangeDialogueBrochure[3].pdf)

Metro's Open Spaces Acquisition Program

Metro, a regional government encompassing 25 cities within the Portland metropolitan area, used funds from a 1995 natural areas bond measure to purchase more than 8,000 acres within the region, including nearly 74 miles of stream and river frontage. Metro manages these properties or enters into intergovernmental management agreements. Metro's objective has been to preserve land for its habitat value with passive recreation (e.g., bird watching and interpretive centers) occurring on some properties. Target areas are identified using a scientific assessment of their habitat value.

Metro has primarily used fee simple acquisition although it has entered into conservation easements, life estates, estates for years (where Metro owns the property and allows the original owner to live in the house for a specified period of time), and lot line divisions (where the property is divided so the house and land are in different parcels, and the land is protected).

In November 2006, Metro passed a $227 million bond measure to purchase land for natural areas and to protect rivers and streams. It is anticipated that 80% of the funds will be used for fee simple acquisitions. Metro will seek to leverage funds from other sources which could provide a partnering opportunity for BPA with the limited dollars that BPA spends in the Willamette relative to the rest of the Basin (IEAB 2006).

Modeling Development Patterns in Puget Sound

The Urban Ecology Research Laboratory at the School of Architecture, University of Washington, conducts a research program based on the idea of humans as dominant agents of ecosystem change. Directed by Marina Alberti, the laboratory studies how interactions of human and ecological processes affect urban landscapes as well as the environmental implications of alternative urban development patterns. Ecological indicators, such as macroinvertebrates, birds, and shellfish are used to study relationships between landscape patterns and ecological conditions. Models linking urban patterns to the ecological resilience of urban ecosystems are used. Simulation modeling is also used to assess the effects of alternative development scenarios on land cover change (www.urbaneco.washington.edu; also see www.urbansim.org).

Arizona Decision Theatre

Arizona State University has recently opened a "Decision Theater" funded by the National Science Foundation to promote scientifically informed decision making about public policy. Using computer models and computer visualization techniques, the Decision Theater provides policy makers an interactive forum to identify and assess probable outcomes of real-world decisions, review the potential impacts of varying policy decisions, and generate visualizations of alternative scenarios and scientific analyses produced by complex and integrated computer models. Decision topics could include population growth, water demand, and environmental quality. (Derra 2005)

Major Landscape Change Studio

Carl Steinitz at Harvard University Graduate School of Design combines research on land use planning with a “Major Landscape Change Studio” to improve the methods by which planners and designers organize and analyze information about large land areas and how they make major design decisions. One study is of the Upper San Pedro River Basin in Arizona which is experiencing a number of interrelated natural resource management challenges with various legal protections that are not sufficient to ensure river's long-term viability as important habitat. Water use in the region and the commensurate lowering of the ground water table is threatening critical habitat and other environmental values. Understanding the hydrologic processes that define the relationships between land use, ground water re-charge, stream flow, and vegetation dynamics is of critical importance to the land management of the entire region. One study objective was to develop an array of plausible alternative future patterns of land uses for the region of Upper San Pedro River Basin, Arizona and Sonora, and to assess the resultant impacts which these scenarios might have on patterns of biodiversity and related environmental issues including vegetation dynamics, visual quality, and hydrologic and fire regimes. The second objective was the development of a generalized alternative futures protocol, which can be applied to other regions currently experiencing development pressures.
www.gsd.harvard.edu/people/faculty/steinitz/research.html

Strategies for Fish and Wildlife Habitat Protection

The scientific foundation of the Council’s Fish and Wildlife Program is well suited to support strategies to mitigate for human population growth and associated development. The role of biodiversity in protecting both contemporary persistence of species and evolutionary potential is recognized in the Program and in most other guidelines for mitigating the potentially damaging effects of human development and resource use.

A good example of the value of biodiversity in promoting persistence, evolutionary potential, and various ecosystem functions comes from the literature on Pacific salmon (Hilborn et al. 2003). The sockeye salmon fishery of Bristol Bay is famously productive. Population-scale variability in responses of the salmon to environmental conditions appears to be responsible for maintaining this productivity, as different stocks contribute disproportionately to the spawning complex of fishes in years of different conditions. Ecological theory supports the interpretation that presence of diverse stocks in diverse sites is responsible for the robustness of the Bristol Bay fishery to changing conditions (Chesson and Huntly 1997).

The Columbia River Basin is a dynamic environment of conservation and restoration practices, with a number of examples of creative application of tools to the preservation and restoration of habitat. Many are funded through the Fish and Wildlife Program. Numerous conservation tools exist to promote the Fish and Wildlife Program’s objectives to build from strength, create wild salmon refuges, and protect habitat that support diverse fish and wildlife populations.

Mitigating for increased human population will involve many of the same approaches that have been initiated in the basin to date. Many of the issues and treatments related to population growth also relate to climate change. The IEAB (2006) summarized tools applicable to areas of high population growth or related population-environment problems, for urban and rural areas, for increasing land prices and decreasing water availability. These and newly emerging tools are briefly described below.

Fee Simple Acquisitions

This is the most straightforward of the approaches to habitat acquisition and protection. Fee simple acquisition of property for fish or wildlife habitat means the entire bundle of rights associated with the property are acquired, through purchase or donation, and can therefore be protected. In its 2006 scoping investigation of approaches to preserving habitat, the IEAB noted that fee simple acquisition accounts for about 82% of the 170.8k habitat acres acquired by the Bonneville Power Administration. The cost per acre of habitat acquired varies widely and would be expected to continue to vary in future as land markets change (IEAB 2006).

Conservation Easements

Conservation easements are legal agreements between a landowner and either a nonprofit organization, such as a land trust, or a government agency. A conservation easement affects only some of the bundle of rights associated with land ownership but can be designed to protect habitat values of the land by placing limits on how the land can be used. The easement runs with the land, so all future owners are also bound by the terms of the agreement. A public entity may retain ownership of easements, or an easement may be developed in cooperation with a non-profit land trust that will assume ownership of the easements and assume the responsibility for seeing that the terms of the easement are followed. Passing ownership, management, and enforcement to a land trust relieves the agency of these responsibilities, but management and enforcement costs remain. Potential loss of control over how the land is used may also be a concern.

Kiesecker et al. (2007) note that conservation easements have become the principal tool used by land trusts to preserve habitat. They analyze a sample of 119 easements held by The Nature Conservancy over a 20-year period to assess the extent to which easements are effective in achieving "conservation value." They identify a trend over time toward larger easements that are strategically purchased rather than donated. Almost all easements have identified biological objectives, but the authors find that information to assess whether the easements are meeting their objectives is lacking. They find that less than 20% of conservation targets are quantitatively monitored on Conservancy easements and that like other managers of protected areas, the Conservancy has no explicit guidelines on effectiveness monitoring of conservation easements. While they have no explicit effectiveness monitoring guidelines, The Nature Conservancy has ongoing monitoring programs on the land it manages as well as many of its partnership areas (M. Powleson, The Nature Conservancy, personal communication).

Settlement and Land Management Agreements.

A settlement agreement resolves a legal dispute or a lawsuit. They are usually negotiated by the parties, and may be subject to approval by a court. In some cases a settlement agreement is a useful tool to meet a required habitat mitigation quota. For example, BPA reached a lump-sum agreement with the State of Montana which Montana uses to acquire and manage habitat. Similarly, BPA reached agreement with the State of Idaho and the Nez Perce Tribe that a lump sum payment used to acquire and manage land would satisfy the wildlife habitat mitigation obligations incurred for the construction of Dworshak Dam and Reservoir.

Habitat Conservation Plans

Habitat conservation plans (HCPs) are agreements between a non-Federal entity (usually private landowners and/or local governments) and the "Agencies" (the U.S. Fish and Wildlife Service and/or National Oceanic and Atmospheric Administration) responsible for Endangered Species protection. If the landowners and local governments can collaboratively agree with the Agencies on a habitat conservation plan that will conserve the species, they are granted an "incidental take" permit and will not later be charged with unintended taking. The Agencies encourage the development of habitat conservation plans as a means to collaboratively promote habitat protection and improvement for listed species on private land.

For example, a negotiated settlement agreement in the Walla Walla Basin addresses dewatering of the Walla Walla River and competing needs for river water among municipalities, agriculture, and the two ESA listed species in the Walla Walla basin: Summer Steelhead and Bull Trout. The settlement agreement, reached in 2000 between U.S. Fish and Wildlife Service (FWS) and three irrigation districts in the Walla Walla basin, brought about a short-term resolution and initiated the HCP process. With federal funding, a bi-state HCP effort has brought together Oregon and Washington stakeholders with the federal agencies (FWS and NOAA) to plan for agreed-upon actions to minimize potential take of endangered fish and provide participants with federal assurance to continue their HCP-covered activities (Walla Walla County Watershed Planning Department 2007).

Water and Land Leases

Leasing is an alternative to acquiring fee simple title. A lease is a contract that conveys specified uses of land or water to the lessee for a specified time period. Some owners of land or holders of water rights with desirable habitat values may be willing to lease, but are not willing to sell or put it (in the case of land) into a conservation easement. The terms of the lease will stipulate the duration of the agreement, the rights acquired by the lessee, the rights retained by the lessor, and the payment required. A lease may convey only some of the land use rights, such as hunting, public access to a stream or building a fence to exclude cattle from a stream. Leases can be used in conjunction with other tools; for example, a landowner might be willing to lease land for 5 years, at which time a sale or a conservation easement is anticipated. It is also possible to imagine creating a portfolio of habitat leases that may change through time (IEAB 2006).

A shortcoming of leasing for the Fish and Wildlife Program is that it doesn't achieve permanent mitigation for the effects of some of its dams. In practice, the Bonneville Power Administration has interpreted permanent as being 60 years or more. This has meant that leasing has not been extensively used by Bonneville as a means of habitat protection (IEAB 2006).

The Oregon and Washington water trusts have recently brokered a number of annual water leases for the purpose of augmenting instream flows (Jaeger 2002). These water trusts have apparently been quite successful in changing the nature and location of water use and increasing instream flows. Much of this work occurs within the Columbia Basin Water Transactions Program. Some states have placed such short-run transactions on a formal footing as water banks. Idaho bank transactions move stored water that is excess to farmers' needs to other water-short farmers, to utilities to generate hydropower, and to fish agencies for instream flow augmentation (IEAB 2001). The Columbia Basin Water Transactions Program has also used temporary leasing or split-season leasing to meet short-terms needs for instream flow (Columbia Basin Water transactions Program 2007).

Options to Purchase and Right of First Refusal

An option to purchase gives the holder the right to buy a parcel of land at a specified time and predetermined price. A right of first refusal gives the holder the right to meet any other purchase offer before the proposed offer is accepted. Options can preserve the ability to purchase or lease land in the future, in situations where procedures for purchase or lease can be lengthy. Purchase of options might be linked to subsequent fee simple property acquisition, or to anticipated acquisition of a conservation easement. Land trusts sometimes use options to encumber land for later acquisition.

Purchase of Development Rights (PDR) and Transfer of Development Rights (TDR)

PDR and TDR programs generally operate locally and are usually financed by local taxes. In a PDR program the local government acquires the development rights from landowners, involving both buyers and sellers of the rights to develop, to preserve agricultural land, open space, and habitat values. The municipality usually designates TDR selling areas where it wants to promote low density and open space, and TDR buying areas where it wants to promote development of a higher density than would be allowed as a use of right. Because they are local, PDR and TDR programs are closely tied to local land use planning and zoning processes. In order for a market for TDRs to function, development regulations must be quite restrictive to force developers to buy development rights to achieve a desired development intensity.

A new TDR program in Blaine County Idaho certified its first eight TDRs in April 2007. The program, established to protect farmlands and wetlands in the "sending" area, allows landowners to transfer the right to develop these lands to a designated "receiving" area, and then sell those rights. The purpose of the program is to allow spatially managed growth by providing landowners the economic incentive to maintain conservation protections on designated parcels of land. Shortly after its initiation the program certified an additional six TDRs from the Wood River Land Trust. The Blaine County Planning and Zoning office will include a public education effort of open houses and web-based information to help residents and landowners understand the range of options under the TDR ordinance (Jackson 2007).

Tradable Environmental Credits

Tradable environmental credits generalize TDR programs into markets for other environmental attributes. The idea behind ecosystem markets is that environmental regulations set standards to protect natural resources. Activities must either meet these standards or provide compensation. For example cities and industries must clean and cool wastewater before releasing it into a river. Ecosystem markets provide a way for regulated parties to pay others -- farm and forest land owners and managers -- to restore wetlands, plant trees along streams, or provide other ecosystem improvements.

The Willamette Partnership lists environmental credit markets already in practice in Oregon. (www.mwvcog.org/WillamettePartnership/)

- Wetland and stream mitigation banking (very active)
- Carbon emissions trading (active)
- Renewable energy credits and green tags (active)
- Water quality trading (one example)
- Endangered species mitigation banking (one example)
- Water supply trading (one example)

As described above in the Willamette Partnership section, the Partnership is developing the Willamette Ecosystem Marketplace to leverage conservation expenditures from factories, developers, transportation agencies, cities, and sewer and water ratepayers. In 2006 the Partnership began the development of components necessary to build a marketplace trading structure and complete a water temperature trade. One of the first tasks was to explore supply and demand, identifying likely initial buyers in the Willamette Ecosystem Marketplace, their drivers, and where they will most likely find available credits.

USDA Programs

The USDA has a number of programs for voluntary land retirement and land conservation, many of which are designed to preserve and enhance the habitat value of cropland. From the perspective of long-term habitat protection, the USDA programs are vulnerable to limits on contracts of from 10-20 years. Some of the USDA programs (the Wetlands Reserve Program (WRP) and the Farmland Protection Program (FPP)) allow the possibility of 30 year or even perpetual contracts. It might be possible to coordinate USDA programs with other habitat acquisition programs; for example, a landowner agrees to enroll in a USDA program for ten years, after which the owner implements a conservation easement with BPA and a local land trust.

Since 2001 the Fish and Wildlife Program has leveraged funding (with OWEB and USDA) to take advantage of these conservation programs. The funding mechanism is intended to enhance the capacity of the USDA Natural Resource Conservation Service (NRCS) to expedite program enrollment in areas with fish and wildlife habitat benefits. This mechanism has proven to be a cost-effective approach to program enrollment; however, the issue of documenting the effectiveness of riparian buffer contracts in improving physical status of habitats and the biological status of fish populations remains. In 2006 the ISRP commented that although the number of acres under contract is impressive, sites at different areas should be monitored for factors such as parr utilization.

Under the Conservation Reserve Program in Washington, about 1.5 million acres of converted farmland has been planted to perennial grasses, forbs, and shrubs on land that was historically shrub steppe. The current acreage of CRP land in eastern Washington is equal to about 10% of the state's total agricultural lands (Schroeder and Vander Haegen 2006). However, recent proposals to allow use of CRP lands for the production of biofuel material threaten the reliability of CRP lands for long-term habitat protection.

Certification Programs

Green certification programs are drawing attention as market-based tools to promote environmental protection, conservation, and sustainability. The intent of these programs is to facilitate consumer selection of products that experts have judged to be environmentally sustainable.

Certification of forest land and forest products in the Basin has increased dramatically in the last 10 years. The "Salmon Safe" certification program focuses on vineyards, farms, and urban areas, certifying practices that meet water quality standards that are safe for salmon; for example, planting trees in riparian areas, growing cover crops to control run-off, and using natural weed and pest control methods. The certification process is rigorous, developed by the Pacific Rivers Council; with guidance from University of Washington, Oregon State University, regulatory agencies and farmers. Salmon-Safe has certified more than a third of Oregon's vineyard acreage, mostly in the Willamette Valley. More than 30,000 acres of farmland have been certified Salmon-Safe in critical Northwest agricultural watersheds including the Willamette and Rogue basins of Oregon, Feather River of California, Clearwater River of Idaho, and Snoqualmie River and White Salmon River watersheds of Washington. Farms certified include both conventional and organic farms. The newer, urban certification initiative is focused on municipal parks and natural areas. Its first action was the certification of 10,000 acres managed by Portland Parks. The urban initiative now includes a corporate and university campus certification program, under which Nike's World Headquarters Campus has been certified as Salmon Safe (www.salmonsafe.org/about/index.cfm).

Acquisition and Conversion of Water Rights.

Many streams have been appropriated to the point that instream flows are a critical limit on the value of fish habitat even in average water years. In recent years, several programs have been developed to acquire water rights, and to use these rights to enhance instream flows. Transactions through the Oregon Water Trust, the Washington Water Trust, and in Idaho use salmon recovery funding to acquire and convert water rights to in-stream flow.

The Columbia Basin Water Transactions Program (CBWTP) was initiated in 2002 to address the low-flow problem on a regional level. The CBWTP is managed by the National Fish and Wildlife Foundation in partnership with the Bonneville Power Administration. The program uses a variety of tools – permanent acquisitions, leases, investments in efficiency and other incentive-based approaches – negotiated between Qualified Local Entities (QLEs) in Oregon, Washington, Idaho and Montana and willing landowners who wish to restore flows to existing habitat. In the FY03-FY06 period 144 transactions have been completed for a total of $3.6 million within the four states (www.cbwtp.org/jsp/cbwtp/library/show_all_section_items.jsp?section_id=14.) In 2007 the CBWTP initiated the Columbia Basin Riparian Conservation Easement Program to complement ongoing efforts in water transactions. The program was piloted in the Columbia Cascade Province of north-central Washington. Funding was made available to purchase two easements in the Methow Valley, Washington to permanently limit future development on a 122-acre and another similar easement on 141 acres. (www.cbwtp.org/jsp/cbwtp/index.jsp).

Salmon Strongholds

The idea behind salmon strongholds is to protect the remaining healthy native stocks of wild salmon and steelhead before they are threatened by extinction. When protected, healthy watersheds and salmon populations will function as anchors for salmon survival and act as the key building blocks for restoration efforts. The concept is compatible with the scientific foundation and guidelines of the 2000 Fish and Wildlife Program, though the current guideline to "Build from strength" requires some modification to take into account the relationships of current and anticipated future strongholds. The Fish and Wildlife Program's artificial production strategy to establish "wild salmon refuges" to protect largely intact critical habitat and to not use artificial production in those areas is also compatible with the concept of strongholds.

Identification of locations that are likely to be sensitive to climate change and human development and then establishing adequate protective measures, including reserve areas, may be the most effective strategy for maintaining diversity in the face of changing human population and climate in the Columbia Basin (regarding climate see Hansen and Dale 2001; Shafer et al. 2001; Halpin 1997). These types of efforts are already supported by the Fish and Wildlife Program, but actions have not yet been targeted to explicitly address human population and climate change concerns.

An example of the importance of identifying and protecting key habitat in the face of development pressure occurred recently, April 2007, when a marina developer damaged the primary spawning ground for the remaining wild kokanee in Lake Pend Oreille, Idaho. For over a decade, the Bonneville Power Administration has funded Idaho Department of Fish and Game's (IDFG) Lake Pend Oreille fishery recovery project to implement the Council's Fish and Wildlife Program. The project's primary focus is to restore kokanee spawning habitat in Lake Pend Oreille and reverse the decline of kokanee to support a sport fishery. Between Bonneville, IDFG, and other programs, over $2 million per year is being expended to recover the kokanee fishery in the lake.

In establishing strongholds, the interplay of human population, land uses and climate change must be considered carefully. The leading source of habitat loss, species loss and range contraction has been people and their activities (Laliberte and Rippel 2004, Knick et al. 2003, Dale 1997).

The Wild Salmon Center is working as part of the North American Stronghold Partnership, a group of state and federal government, NGO, and private sector organizations from California, Oregon, Washington, Alaska, and Idaho. The Partnership will work in 2007 to identify a stronghold network to provide for the long-term survival of the five species of salmon and steelhead in North America in a manner that is resilient to natural and anthropogenic change. Targeted ecosystems will be selected on the basis of aquatic and terrestrial species diversity, productivity, and abundance; socioeconomic and political issues; local, state, and national commitments; and resilience in the face of climate change (www.wildsalmoncenter.org/programs/north_america/north_american_stronghold_partnership_07.php).

VII. Findings and Recommendations

There are many uncertainties associated with the specific pattern of future population growth. However, the general trend in population growth and the impact of people on the landscape can be well enough anticipated to inform planning and actions for fish and wildlife. Counties and municipalities are required to have growth plans. The location of urban and suburban expansions is predictable, as is, within a range of uncertainty, the magnitude of population growth.

The location of existing transportation corridors, where they are reaching limits of capacity, and where future changes have been projected is known. We know that the zoning halos around towns and cities as well as the residential and industrial corridors along roads and highways are likely to expand. Many credible analyses of future changes in agriculture and forestry exist. All of these can be incorporated into fish and wildlife restoration actions and planning at the subbasin, province, and basin levels. Most subbasin plans made projections only within the 10 to 15-year horizon of the Ecosystem Diagnosis and treatment (EDT) tool, and most of that used only the current land use and land cover with no anticipated change over that time frame.

The inclusion of social, economic, and cultural factors is a common feature of the vision statements framing subbasin plans. Several subbasins envision healthy sustainable economies and communities as well as healthy sustainable ecosystems. Although some subbasins note, at least implicitly, the interdependence of economies, communities, and ecosystems, few, if any, include economic, social, or cultural issues in their guiding principles, and none address human population in depth.

Findings

The Nature of Population Growth

- The West is the fastest growing population region of the United States. The population of Oregon, Washington, Idaho, Montana and British Columbia is projected to continue to grow at least until 2030.
- Population densities in the Columbia River Basin are increasing, with notable changes in the interior and rural areas of central Oregon, Washington, and Idaho.

- Projections to 2030 show continuing population growth with slowing rates of growth in the Columbia River Basin.
- Projections contain uncertainty about actual population increase.
- Although much of the Columbia River basin is rural and sparsely populated, with large amounts of federal lands, some areas are experiencing rapid population growth, especially those with recreational and scenic values.
- Population growth is associated with increases in land prices.

The Impact of Population Growth on Fish and Wildlife

- Population growth will increase demand for resources key to fish and wildlife populations: water, land, and forests.
- Increased demand for residential land is accelerating the rate of conversion of forest and agricultural lands.
- Agricultural and forest land provide a large proportion of wildlife habitat.
- Changes in land use will affect water use and management and, ultimately, fish and wildlife habitat.
- Climate change will change patterns and quantity of water supply, forest cover, and landscape vegetation.
- The effects of climate change and population growth will combine to increase pressure on fish and wildlife habitats.
- Urban development causes marked changes in the physical, chemical, and ecological characteristics of stream ecosystems. In most cases, the changes caused by development are detrimental to native aquatic biota, including salmonid fishes.
- The dominant ongoing pattern of settlement in the Columbia River Basin is exurban sprawl.
- Exurban development causes loss, degradation, and fragmentation of habitat. It also increases infrastructure costs, social conflict, and harmful interactions among people and wildlife.
- A large proportion of wildlife habitat is on private land.
- Demands for fresh water from surface and groundwater will increase. Decreases in the snow pack at higher elevations, resulting from climate change, will exacerbate this situation especially during low-flow summer and fall seasons.
- Groundwater supplies are vulnerable to increased demand and lack institutional protections.
- Population-related factors external to the Columbia River Basin will affect fish and wildlife habitat. These include international trade, shipping, dredging, hazardous material transport, and airborne pollution.
- Fish and wildlife planning and restoration throughout the basin will be enhanced by consideration of human population trends.

Protections for Fish and Wildlife

- Impacts of population growth on fish and wildlife habitat in the Columbia River Basin were only cursorily addressed in the subbasin planning process. Only a small number of subbasin plans documented population trends or acknowledged the potential impacts of population growth on fish and wildlife planning.
- Although population growth is influenced by factors outside of the influence of the Basin, actions that will mitigate its impact on fish and wildlife are within the region's control.
- A wide range of innovative natural resource planning processes effectively incorporate explicit consideration of human population growth.
- Uncertainty about population growth and climate change places a premium on flexibility in fish and wildlife recovery planning.
- Urban containment can be effective in limiting exurban sprawl.
- Understanding and managing human-dominated ecosystems require better integration of socioeconomic and ecological knowledge.
- Incorporating human population growth into fish and wildlife planning requires stakeholder involvement; spatial modeling of critical resources and development patterns; investigation of alternative development scenarios; and evaluation and monitoring to enable adaptive management.

Recommendations

Planning Processes

- Explicitly address population growth in planning and prioritization of projects at the subbasin scale.
- Require subbasin plan updates to assess potential impacts of population growth and settlement patterns.
- Promote planning processes that include landowner involvement, spatial modeling, alternative development scenarios, and evaluation and monitoring.
- Create dialogue among ranchers, environmentalists, and policy-makers to increase understanding of the economic and ecological value of ranchlands and the economic costs of rural sprawl.
- Encourage Subbasin Management Plans to emphasize flexibility and contain explicit strategies for adapting to population change.
- Focus actions on "protecting the best" especially in areas of rapid population growth.
- Increase surveillance and curb movement of aquatic invasive species via shipping, recreational boating, and other pathways related to increased traffic.
- Assess the range of new market-based protection mechanisms for cost-effectiveness and permanency of protections for fish and wildlife.

Tools

- Establish permanently protected refugia “strongholds” to minimize interactions between salmon and human activities.
- Consider landscape-scale factors in the choice of reserve sites to avoid habitat fragmentation and protect against human infringement.
- Protect areas that will restore headwater sources of cool water in warm streams.
- Pursue permanent protective actions for water and the riparian zone on high priority stream reaches.
- Promote efforts to reduce the loss of ranchland, farmland, and forestland.
- Provide incentives to private landowners to protect fish and wildlife habitat.
- Provide incentives for water conservation.
- Provide incentives to modify the timing and quantity of irrigation withdrawals.
- Invest in permanent protection of instream flow.
- Promote and study aquifer storage and groundwater recharge.
- Provide incentives to communities, counties, and subbasins to plan for sustainable groundwater and surface water.
- Protect water quantity and quality in salmonid spawning and rearing habitats.
- Provide incentives to purchase or lease water rights and eliminate withdrawals of shallow groundwater in the vicinity of salmon bearing streams.
- Seek opportunities for cost-recovery through emerging markets for ecosystem services.

Coordination with other Authorities

- Encourage communities, counties, and subbasins to develop integrated water and land use plans that promote sustainable surface and groundwater use in the face of population growth and climate change.
- Encourage states and counties to develop groundwater protection ordinances that control land uses that could be detrimental to groundwater quantity or quality.
- Encourage the strengthening of regulations to protect water quality against chemical spills, toxics, bio-accumulative substances, and pharmaceuticals.
- Encourage land-use regulations to prevent development in riparian and high risk upland areas.
- Encourage the development of stricter controls on exurban development.
- Encourage the management of land adjacent to refuge areas for habitat objectives.
- Encourage measures that conserve electricity and discourage overuse.
- Avoid barriers to wildlife movement across good habitats.
- Where possible, coordinate with environmental agencies outside the Basin whose mandates affect habitats within the Basin

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