STATE *of the* NORTHWEST

Revised 2000 Edition

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State of the Northwest

STATE *of the* NORTHWEST

Revised 2000 Edition

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NEW REPORT **9**
NORTHWEST ENVIRONMENT WATCH ◆ SEATTLE

NORTHWEST ENVIRONMENT WATCH IS AN INDEPENDENT, not-for-profit research center in Seattle, Washington, with an affiliated charitable organization, NEW BC, in Victoria, British Columbia. Their joint mission: to foster a sustainable economy and way of life throughout the Pacific Northwest—the biological region stretching from southern Alaska to northern California and from the Pacific Ocean to the crest of the Rockies. Northwest Environment Watch is founded on the belief that if northwesterners cannot create an environmentally sound economy in their home place—the greenest corner of history's richest civilization—then it probably cannot be done. If they can, they will set an example for the world.

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PREFACE

to the Revised Edition

IN PUBLISHING *STATE OF THE NORTHWEST*, ITS FIRST book, in 1994, Northwest Environment Watch aimed to help our region avoid the fate of the legendary Swedish naval captain lost in a fogbank during World War II. When asked of his ship's progress, the fogbound captain radioed back, "We are utterly lost but making great time."

Only by knowing where we are can we know where we need to go. This logic was behind *State of the Northwest*, the first state-of-environment report for the entire Pacific Northwest. It portrayed ecological conditions in our biologically diverse and interconnected region without prescribing bold new directions for it. The book was an important precursor to Northwest Environment Watch's later, more prescriptive books—ten to date. This touchstone for all our work defined the Pacific Northwest as a biological region and demonstrated that it is a globally important test case for sustainability: if we cannot build a sustainable way of life here, it probably cannot be done.

Six years later, knowing where we are is no less important. Much new information has surfaced in the 1990s, and many environmental controversies have intensified. This

revised edition incorporates new research to reflect the state of our ecosystems at the very end of the twentieth century. Among recent changes documented in the following pages:

- Since 1990, the Pacific Northwest's population has grown by 2.2 million people (to a 1998 total of 15.3 million).
- Since 1990, the economy has boomed by some $90 billion, with most of the boom benefiting the richest fifth of northwesterners.
- Salmon have continued their serious decline from California to central British Columbia, to the point that 20 stocks throughout the Northwest states are federally listed as threatened or endangered species.
- Roughly 1.5 million more cars and trucks occupied Northwest roads in 1998 than in 1990.
- Since 1990, the Northwest's climate-damaging carbon dioxide emissions have increased by at least 13 percent.
- The pace of sprawl more than doubled in the Northwest states from the mid-1980s to the mid-1990s.

In short, many pivotal environmental problems have continued or worsened.

Nevertheless, the basic optimistic finding of the original *State of the Northwest* holds true. The Pacific Northwest is still a global test case: less degraded than the rest of the industrial world, it has a better chance at sustainability than perhaps anywhere else.

Perhaps more important, the cultural and political landscape—especially when it comes to salmon—has shifted dramatically. Leading politicians now consider breaching major dams to save Columbia and Snake River salmon from extinction, an unthinkable proposition just a few years ago. And with the 1999 endangered species listings of salmon runs

in the urban heart of the Northwest, environmental issues have begun to hit home as never before.

Though political battles over the environment are nothing new to this part of the world, the biggest struggles have usually focused on lands whose protection demanded little change or sacrifice from the majority of the population. Most northwesterners had little at stake when they argued over the fate of remote locales like Vancouver Island's Clayoquot Sound or the towering forests that support the northern spotted owl. But now the people, governments, and businesses of the Seattle and Portland areas have begun to look in the mirror, not to others, for solutions to their environmental problems. (If Canada had an Endangered Species Act, Vancouver might be in the same boat: fewer than 50 native salmon return to the city each year.)

With the Northwest's signature species nearing extinction across much of the region, the time has come for us to choose. We can follow the rest of the world down the path toward biological impoverishment, or we can seize the rare opportunity that our region has: to lead the world in reconciling people with nature. I hope that this updated *State of the Northwest* can help burn away the fog of ignorance that keeps us from making great time toward that reconciliation.

J. C. R., Seattle
January 2000

Metric equivalents are given for the convenience of Canadian readers; dollars are U.S. dollars unless noted otherwise. Scientific names of species have been added only where their common names alone might cause confusion.

"Meet the Producer"

Every day on my way to work, I pass Seattle's famous Pike Place Market, a busy trading center for local farmers, fishers, and craftspeople. An old wooden sign above the market's historic facade invites passersby to "Meet the Producer"—buy local foods and crafts direct from their source. But the sign, standing before a dramatic vista of Puget Sound and the Olympic Mountains, has taken on another meaning for me. While the market's vendors add greatly to the value of their wares, the ultimate producer of their halibut, apples, or driftwood sculptures is the world beyond the sign—the sea, the land, the Earth itself.

The Pacific Northwest is important beyond the 1 percent of the Earth's land surface that it covers. Rising consumption, growing populations, and increasingly powerful technologies challenge societies everywhere to provide for their people while living within the Earth's means. The Pacific Northwest is poised to lead in this quest for sustainability. Though the region's economy is badly out of balance with the ecosystems it draws upon, its environment is probably less degraded than any populated part of the industrialized world. No place on Earth has a better shot at reconciling people and nature than the Pacific Northwest, the greenest

corner of history's richest civilization. And with most of the planet's people aspiring to our North American standard of living, no one has a greater responsibility to set new standards for an ecologically endangered world.

With this book, Northwest Environment Watch invites you to get to know our region and the profound alterations of its environment. *State of the Northwest* is an introductory audit of the region's ecosystems. In contrast to its rigorously tracked economy, the Northwest's natural capital remains in many ways a mystery, monitored in a piecemeal fashion. Better understanding our economy's natural foundation is a first step toward making our economy and way of life ecologically viable. So come—Meet the Producer.

A Salmon's-Eye View

A life begins one March morning in the Sawtooth Mountains. Here, near the headwaters of Idaho's Salmon River, where 10,000-foot peaks stand guard over hundreds of crystalline streams and alpine lakes, a chinook salmon hatches from its pea-sized egg on the gravel bottom of Stanley Creek.

One of thousands of fry to hatch in the creek, this chinook is among a lucky few that will survive the perilous journey that is the life of a salmon. Even by hatching in the Salmon River basin, this fish is lucky. Though grazing impacts are great—cows outnumber people four to one in the basin—the Salmon River's watersheds are among the least degraded in the United States. Less than 2 percent of the river's water is diverted for irrigation. On the entire Salmon River, which drains nearly half of Idaho, the only dam ever built was blasted apart by a mysterious dynamite-laden raft in 1934.

This salmon, of course, is a fish, an aquatic animal. But during its life, the chinook will be a forest denizen, desert creature, mountain climber, farm animal, and even city dweller. Salmon draw sustenance from, and return it to, the land through which their waters cascade. Almost anything done on the land—a light bulb turned on, a mile driven, a forest cut—will eventually affect those waters.

IMAGINE AN ANIMAL THAT COMES TO LIFE IN THE mountains, floats backward to the sea, puts on weight while swimming thousands of miles in the open ocean, muscles its way up rapids and waterfalls without eating, and mates only when it is half dead. This is the Pacific salmon, symbol and biological indicator for the Pacific Northwest.

This book follows one salmon—a female Snake River spring chinook (*Oncorhynchus tshawytscha*), to be precise—as she moves through the Pacific Northwest. The salmon journey presented here is an imaginary composite of what a spring chinook from Idaho's Salmon River (a tributary of the Snake) might face during her lifetime (see "Appendix: About the Salmon Story").

The seven species of salmon native to the Pacific Northwest—chinook, chum, coho, pink, sockeye, steelhead, and sea-run cutthroat trout—are powerful icons, in part because they are powerful swimmers. Their swimming strength and ability to home in on natal streams have enabled them to spread through most of the Northwest and to adapt to the particularities of the region's varied habitats. Each local salmon population, or "stock," evolves in place, seldom interbreeding with its neighbors; each carries the natural history of its birthplace in its genes.

Though the story presented here is a plausible account of a salmon's life, it cannot be called a typical one. A typical salmon would die before reaching adulthood. Even under the best conditions, only a tiny percentage of salmon eggs survive to spawn the next generation; salmon lay thousands of eggs to ensure that a few will beat the odds. But completing the journey to the ocean and back, past dams and reser-

voirs and through degraded watersheds, is a challenge to which fewer and fewer fish rise.

Despite good conditions in much of the Salmon River, salmon stocks there are drastically reduced, primarily because of the eight downstream dams along the Snake and Columbia Rivers. Idaho once produced a million spring and summer chinook salmon; by the late 1990s, an average of 3,500 were returning to spawn in Idaho rivers each year. Listed as "endangered" under the U.S. Endangered Species Act, these chinook have fared better than other Idaho salmon: each year's returning sockeye can usually be counted on one hand, while Snake River coho went extinct in 1986.[1]

During her migration, our spring chinook will pass through a variety of habitats, some unspoiled, some transformed beyond recognition. She will enter Idaho, Oregon, and Washington, in water that ran off mountains in seven states and two nations. She will spend three years off the Washington, British Columbia, and Alaska coasts before swimming the 900 miles (1,400 kilometers) to her native Idaho stream. More than any other natural phenomenon, her voyage testifies to the biological unity of the Pacific Northwest. And in the demise or recovery of her kind, we can read much about the health of the place—and the prospects of its inhabitants, ourselves included.

A Northwest Profile

The Pacific Northwest is a region bound by climate, geology, and living things into an eclectic yet coherent whole. Encompassing the Pacific slope of North America, from northern California to Prince William Sound in Alaska (roughly 40 degrees to 60 degrees north latitude) and from the ocean to the continental divide, the Pacific Northwest is ten times the size of New England. Spanning deserts and rainforests, glaciers and kelp beds, fjords and prairies, the tremendously diverse Northwest is nonetheless one biological region (see map inside front cover). Its rivers flow to the Pacific, and salmon leap toward the headwaters, regardless of state lines they cross. The rainforests of its coastal strip and the mountain ranges throughout recognize no political boundaries.

Some call the region "Cascadia" for its roaring cascades and the mountains named after them. Author Timothy Egan loosely defines it as "wherever the salmon can get to." Northwest Environment Watch defines the region more precisely: the Pacific Northwest embraces the watersheds that flow through North America's temperate rainforest zone. At its core lie the province of British Columbia and the states of Idaho, Oregon, and Washington. Southeast Alaska; western

Montana; the north coast of California; and small chunks of Nevada, Utah, Wyoming, and the Yukon also fall within the watersheds of the rainforest rivers.[2]

The Pacific Northwest's defining features include four of the continent's largest rivers—the Columbia, Fraser, Skeena, and Stikine—as well as countless smaller streams and rivers racing to the coast. All flow into the cold, highly productive waters of the Northeast Pacific Ocean, stretching from the Pioneer and Mendocino fracture zones off the California coast, north along the abyssal plain of the Cascadia Basin and the perpetually dark ecosystems of the Juan de Fuca Ridge, to the seamounts rising from the ocean floor off the B.C. and Alaska coasts. On land, three great young mountain ranges—the Cascades, Coast Range, and the Rockies—dominate the rugged, folded topography.

The interplay of sea and land, as moisture-laden air masses from the Pacific encounter the landscape's repeated folds, defines weather in the Northwest. Some of the continent's heaviest rainfall drenches the west sides of the Coast and Cascade Ranges, while the inland Northwest has a desert heart. But wet "westsides" (where winds forced up over mountains dump their moisture) and arid "eastsides" (in mountains' rain shadows) are found throughout. Rain shadows make eastern Vancouver Island an oasis of sun on a drizzly coast, while lush stands of western red cedar grow not only near the sea but in scattered moist patches all the way into Montana and the Canadian Rockies.

The Endowment

From thermal vents on the ocean floor to roadless areas at the crest of the Rockies, our region is biologically rich. The

world's most massive conifer forests grow here, containing the biggest and longest-lived spruces, firs, and hemlocks found anywhere. The canopies and soils of these forests support thousands of unidentified species. Just offshore lie some of the world's most productive waters. The waters of the Northeast Pacific are home to more than 7,000 species of marine animals, including the largest octopuses, starfish, sea slugs, and other marine invertebrates; the greatest diversity of starfish (70 species); and the greatest salmon runs in the world.[3]

The Pacific Northwest has fewer plant and animal species than regions closer to the tropics, but its deep-furrowed topography—and the consequent variety of local conditions—have made it exceptionally diverse for its latitude. British Columbia contains a greater diversity of species and distinct ecosystems than any other province in Canada and far more species of mammals than any country in Europe. With less than 10 percent of Canada's land area, the province supports more than half the nation's higher plant species. Richest of all Northwest regions, Oregon is home to 3,370 plant species (more than any other state that far north). Nearly half of Oregon's plants are found in the Klamath-Siskiyou Mountains straddling the California-Oregon border, the major center of plant evolution in western North America.[4]

Endowed by nature with rich ecosystems, the Northwest's biological good fortune is also an accident of history. Because Europeans colonized North America mostly from the east, the Northwest lagged two centuries behind the East Coast in transformation of the landscape. By the time explorer George Vancouver saw the Coastal Salish Indians' thickly wooded homelands in 1792 and marveled at "the abundant fertility that unassisted nature puts forth," Euro-

pean settlers had deforested much of the East Coast. It would be more than a decade before Europeans would even set eyes on Idaho.[5]

Despite millennia of use by native peoples, even at the turn of the twentieth century western Washington had expansive lowland rainforests, thick with trees that would dwarf most old growth left a century later. Bathed in near-constant mist and growing on deep valley-bottom soils, these were the densest forests in the world, containing more living and dead plant matter than even tropical rainforests. The largest Douglas-fir in the world today, the "Red Creek Tree" on southern Vancouver Island, is nearly 14 feet (4.2 meters) wide; worldwide, there are ten Douglas-firs known to exceed 12 feet (3.7 meters) in diameter.

In the nineteenth century, Scottish botanist David Douglas reported that in some valleys of the Cascades, the trees that would later bear his name often reached 17 feet (5 meters) in diameter. Standing near streams and rivers, these giants were the first to go, accessible to loggers even without roads or heavy machinery. Today, such forests are gone, their implausible cedars and firs surviving only in old photographs and historical accounts that read like tall tales.[6]

The marine life of the Pacific Northwest was once so rich that it supported the densest, and possibly wealthiest, aboriginal populations in North America. For centuries, Northwest fishing tribes pulled in more salmon than late twentieth-century fleets. When the Lewis and Clark expedition first encountered the salmon-filled Columbia River, seasoned explorer William Clark marveled, "The multitudes of this fish are almost inconceivable." Even in the 1930s, salmon were still so abundant that they were the only high-protein

food many Americans could afford during the Great Depression. An average of 60 million salmon annually—and twice that number in good years—would return to the Fraser River alone. Unguessable millions once crowded streams throughout the region, enriching people and the land with tons of nutrients from their ocean-fed carcasses. Though salmon's ecological contributions have plummeted in much of the Northwest (see Figure 1), recent isotope studies in Alaska have found that one-sixth of the nitrogen in streamside forests still originates from salmon carcasses (most of which are digested and dispersed by bears before their nutrients return to the soil).[7]

Chinook salmon could reach 145 pounds (65 kilograms), and stories abound of sockeye and coho "swimming so thick you could walk across their backs." Even so, salmon were not the most outlandish denizen of Northwest rivers. Imagine instead white sturgeon of frightening proportions: a single fish could cruise the depths for a century, stretch 20 feet (6 meters) from whiskers to sharklike tail fin, and weigh well over half a ton. Once so abundant they were often burned or used as fertilizer, sturgeon (North America's largest freshwater fish) were only one of the shocking manifestations of nature's tremendous fecundity in the Pacific Northwest.[8]

The People

People have long been drawn to the Pacific Northwest by its natural wonders, whether to explore, exploit, or simply live near them. After severe population crashes around the turn of the nineteenth century, as epidemics of smallpox and other European diseases decimated Native American communities, waves of immigration and natural increase have consistently

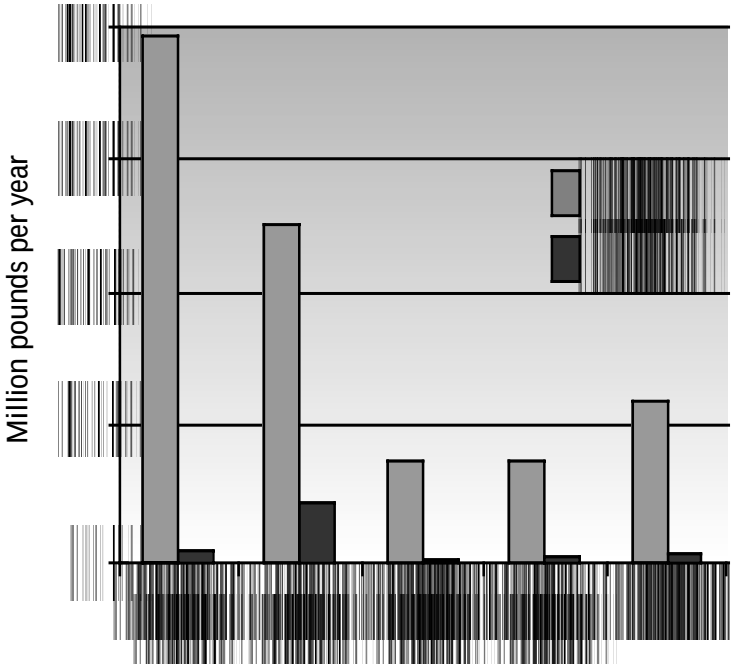

Figure 1. Nutrients Contributed by Salmon to the Land, Northwest States

The pulse of salmon-borne nutrients to the land has nearly stopped. Source: see endnote 7.

swelled the Northwest's ranks. Today 15 million people live in the region; nevertheless, fewer live here than in the New York City metropolitan area alone (see Figure 2).[9]

Overall population density is quite low in the Pacific Northwest, with its vast areas of mountains and desert where few people live. People, and their cities and farms, have crowded into fertile lowlands and near protected coastlines—notably, the areas that support the most diverse and productive ecosystems. Three-fourths of B.C.'s population squeezes

into the province's southwest corner, just as more people live in the Seattle area than in all of Idaho and Montana.[10]

Population in the Northwest is rising faster than Canadian and U.S. averages primarily because people are moving to the region rather than being born into it. In British Columbia, for example, 50 percent of population growth is due to immigration from other parts of Canada and 25 percent to immigration from other countries, mostly Asia. No end is in sight for the region's rapid expansion. At current growth rates, the Northwest's population will double in the next 32 years.[11]

The rapid influx from other, less homogeneous regions is making the Northwest a polyglot mix. Hispanics are the region's largest ethnic minority; Asian and African-American populations are most concentrated in the Northwest's big cities. Asians are the largest nonwhite ethnic group in Seattle and in Vancouver, which is expected to become the first major North American city with an Asian majority. Idaho, Montana, and the B.C. interior have large indigenous populations but otherwise lack the cultural diversity of their coastal neighbors. Native American (or First Nations) populations, after generations of disease, war, and poverty, are small compared with those of immigrants and their descendants: today roughly 1 out of 50 northwesterners is truly native to the region.[12]

The Economy

The Northwest economy has always flowed from its natural bounty: abundant salmon and furbearing mammals; towering forests; deep soils and mineral lodes; and, most recently, the power of cascading water and the pull of beautiful landscapes. These raw materials, along with those imported from

ecosystems around the world, have helped make the Pacific Northwest one of the wealthiest places in history. In 1997, the gross regional product of the Northwest was nearly $400

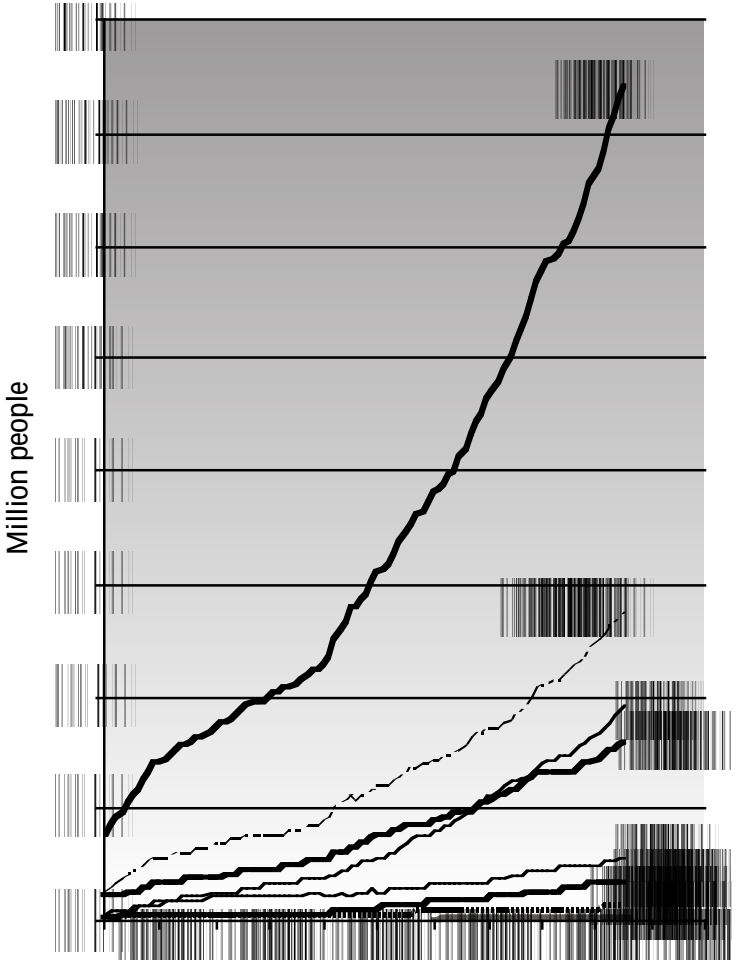

Figure 2. Pacific Northwest Population, 1900–1998
The Northwest's population has doubled since 1960.
Sources: see endnote 9.

billion, more than the entire nation of India, home to 65 times as many people. The Northwest generates more wealth each year than the entire world did two centuries ago.[13]

Like population, wealth is unevenly distributed in the Northwest. It is easy to see the Northwest as two distinct economies: high-tech, wealthy metropolises along the "I-5 corridor" from Eugene, Oregon, north to Vancouver, B.C., and poor, resource-dependent communities in the hinterlands. Greater Seattle is, after all, home to the world's first-, third-, and fourth-richest people, as well as five other billionaires. Together these eight men control more wealth than the bottom two-thirds of households in the Northwest combined. Meanwhile, nearly two million northwesterners—including one out of every six children—live below the poverty line (see Figure 3). But poverty here is urban as well as rural. In Vancouver, B.C., by some estimates, as many as one in three children lives in poverty. And rural economies have brought fantastic wealth to some, like Idaho potato billionaire J. R. Simplot, while others have used their fantastic wealth to build or buy luxury homes in rural areas, in the process transforming the landscape and society of places like Bend, Oregon, and Flathead Lake, Montana.[14]

Almost without interruption over the past century, the Northwest economy has grown rapidly. The rising tide of money flowing through it has reflected the tremendous growth in resources consumed and discarded by it. Logging rates in British Columbia, for example, grew exponentially between 1912 and 1989, in 1964 passing the B.C. Ministry of Forests' estimate for "sustained-yield" cutting. Loggers have sawed more timber in British Columbia since the mid-1970s than in the province's entire history up to that time.[15]

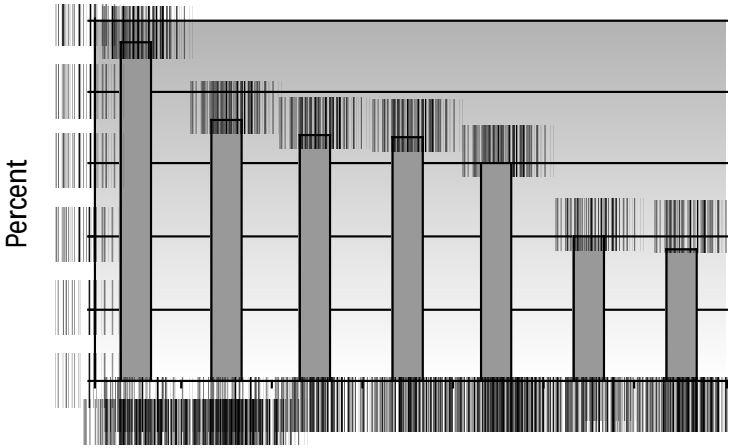

Figure 3. Share of Pacific Northwest Children Living in Poverty,[2] Mid-1990s

One out of six Northwest children lives in poverty. Sources: see endnote 14.

[1] B.C.'s child poverty rate is roughly 10 percent by U.S. standards, 21 percent by Canadian standards.

[2] U.S. Census poverty figures do not correct for lower cost of living in rural areas.

Like other North Americans, modern northwesterners consume, and waste, natural resources at tremendous rates. On average, we consume roughly our own body weight in basic raw materials each day. Despite regional pride in our recycling programs, the typical northwesterner throws out 5 pounds (2.4 kilograms) of municipal solid waste each day, about three times the rate in Sweden or the United Kingdom.[16]

Energy flows fast through the regional economy as well. Just as cascading streams are a defining feature of the Northwest landscape, cheap hydroelectric power has become a defining characteristic of the economy. Because electricity prices are unusually low, the Pacific Northwest supports energy-intensive industries, such as aluminum manufactur-

ing, and has one of the world's highest rates of electricity consumption. British Columbians use 20 percent more energy per person than the average Canadian, or three times more than the Japanese average. In total, the Northwest consumes nearly five quadrillion Btu (British thermal units) of energy annually, or more than 20 times the energy consumption of Côte d'Ivoire, an African nation with the same population as the Pacific Northwest.[17]

The Northwest economy grew up around resource-intensive industries that provide some of its most enduring icons: the logger, the cowboy, the fisherman, and the miner. But these images are anachronisms; today's economy might more accurately be represented by the software programmer, the executive, the "temp," and the waitress.

In the Pacific Northwest, and even in most of its rural communities, resource extraction no longer drives the economy (see Figure 4). Since the early 1970s, market forces and, often, resource exhaustion have closed more than 500 Northwest sawmills and pulp mills; shrunk the fleet of fishing boats by 8,000; and driven more than 15,000 farms and ranches out of business. As elsewhere in North America, our economy has shifted away from its traditional roots and toward the service and high-tech sectors. In Idaho, for example, the timber industry's share of gross economic product fell from 8 percent to 4 percent between 1977 and 1996. British Columbia continues to depend the most on the timber industry, which provides more than 6 percent of its gross domestic product and half of Canada's lumber. Yet even in B.C., timber's contribution is barely one-fourth that of the service sector.[18]

Employment in extractive industries has diminished more dramatically than their cash receipts, primarily because of

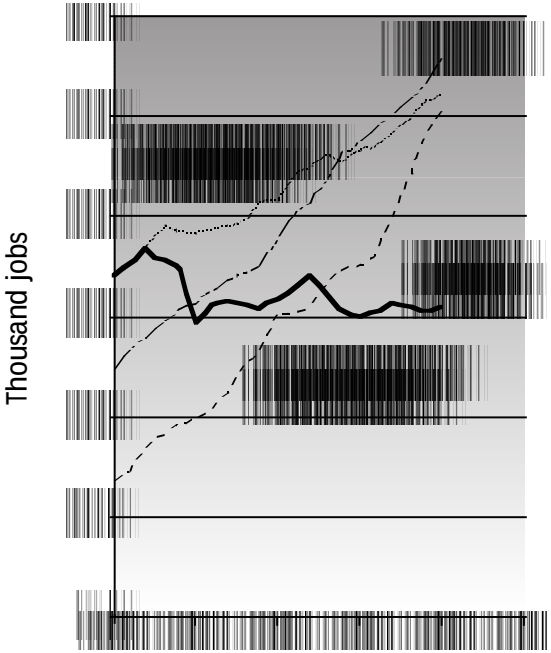

Figure 4. Jobs in Selected Industries, Pacific Northwest, 1977–1997
The Northwest economy has moved away from its historic roots. Sources: see endnote 18.

mechanization. Despite record timber cutting, timber industry jobs in Oregon and Washington fell during the 1980s; in British Columbia, timber jobs fell by a third even as the volume of wood cut in the province rose 16 percent. The share of jobs provided by mining, timber, and agriculture in Montana dropped by half over the past 50 years.[19]

Even more than most regions in a global economy, the Northwest depends on foreign trade, especially with Asia. Vancouver, B.C., is the largest port on the eastern Pacific Rim, while one in three jobs in Washington is tied to overseas com-

merce, more than in any other state. It's no accident that the World Trade Organization and the Asia-Pacific Economic Cooperation consortium held their first, controversial North American meetings in the Pacific Northwest.[20]

The largest economic sector in the region is services, also the source of almost all new jobs in the past 30 years and the main reason the Northwest economy has been growing faster than the economies of the rest of the United States and Canada. Many service jobs are "footloose": their locations do not depend on any particular raw materials nearby. Yet no less than logging or mining, these jobs exist because of the region's natural bounty. People and businesses able to set up shop anywhere choose to locate in the Northwest because of its quality of life. And even a telecommuting Web designer needs to breathe, drink, and eat from the ecosystem around her: nature remains the foundation of the Northwest economy.[21]

MOUNTAIN AND SKY

The clear waters of Stanley Creek course through the hatchling chinook's redd, a protective gravel nest dug by its mother for the 5,000 eggs she laid before dying. The redd protects the eggs and hatchlings from predators. It also blocks the sun's ultraviolet rays, which burn with unusual strength as spring approaches.

The hatchling will live between bits of gravel and coarse sand for several weeks, feeding off the yolk sac attached to its belly, breathing oxygen dissolved in the flowing waters. The banks of the creek are lush with grass; little sediment washes into the redd. A mild winter has left less snowpack in surrounding peaks and less snowmelt in the stream. Though groundwater percolating up through the gravel keeps this redd well washed, many of its eggs never hatch. Some were never fertilized; others, buried too shallow, are swept downstream. Hatchlings emerge from fewer than half the eggs deposited in the gravel.

ALMOST EVERYWHERE IN THE PACIFIC NORTHWEST, mountains loom above the land. Three great ranges—the Cascades, Coast Range, and the Rockies—define horizons, shape weather, and provide rivers with snowmelt across the

region. Their high peaks, often covered with snow or glacial ice, stand as regional icons as well as the centerpiece of some of the continent's most spectacular parks, among them Crater Lake, Glacier, Grand Teton, North Cascades, Olympic, and Yoho (a Cree expression of awe). Centered on the world's tallest coastal mountains, the world's largest protected area is formed by the expanse of Glacier Bay, Kluane, Tatshenshini-Alsek, and Wrangell–St. Elias parks along the Alaska-B.C.-Yukon border.[22]

Alpine areas are generally in better ecological condition than the lands below them, but they have not escaped degradation. Sheep and cattle have overgrazed some slow-growing alpine meadows; tourists have trampled others. In many naturally fishless mountain lakes, introduced trout prey upon and often deplete the salamanders and crustaceans native to the lakes. Decades ago, hunters stocked Washington's Olympic Mountains with mountain goats, hundreds of which now roam the peninsula's isolated peaks. In the absence of wolves (eliminated by hunters early in the twentieth century), the nonnative goats flourish at the expense of rare plant species found nowhere else on Earth. Olympic National Park biologists have removed some goats with helicopters, but doing so has proved dangerous and expensive. Simply shooting them arouses public protest, so the goats remain.[23]

Wolves, grizzlies, and other top predators have been eliminated from most of their ranges in North America, including many mountain areas in the Northwest. Yet in the Columbia Mountains, North Cascades, and Northern Rockies, all straddling the U.S.–British Columbia border, and in other mountainous areas farther north, ecosystems still sustain their full array of predators and other known species—a rarity in the

industrial world. The greater Yellowstone ecosystem, since wolves were reintroduced there in 1995, also sustains the full array of species known to inhabit the area when Europeans encountered it.[24]

It is no accident that mountains end up in parks: they are scenic, often pristine, and few economic interests oppose the protection of their unproductive slopes. Nearly 14 percent of the Northwest's land surface lies in protected areas, including national, provincial, and state parks; wilderness areas; and wildlife refuges (see Table 1). Most of this area is high-elevation land: snowfields, barren rock, alpine tundra, and subalpine forests of limited productivity. On Vancouver

Table 1. Protected Areas in the Pacific Northwest

	Total area (million acres)	Protected area (million acres)	(percent)
Southeast Alaska[1]	40	17.8	45.0
W. Montana[2]	16	2.6	15.8
Washington	43	5.3	12.2
Idaho	53	6.4	11.9
Northwest California[3]	14	1.6	11.4
British Columbia	234	26.4	11.3
Oregon	62	4.2	6.8
Total	463	64.2	13.9

[1] Includes Prince William Sound and Copper River watersheds.
[2] Eleven counties west of the continental divide.
[3] Del Norte, Humboldt, Mendocino, Siskiyou, Sonoma, and Trinity Counties.
One acre equals 0.405 hectare. Sources: see endnote 25.

Island, for example, 64 percent of high-elevation tundra is protected in parks, while 10 percent of the island's low-elevation rainforests are protected.[25]

Though popular with hikers, alpine terrain supports fewer species than lowland ecosystems. Protected areas are central to the conservation of life's variety at all levels—genes, species, ecosystems, and large landscapes. But protected areas today, most established before the word *biodiversity* even existed, are neither large enough, interconnected enough, nor inclusive of enough habitat types to protect Northwest species in the long term. For example, Washington's Mount Rainier National Park, surrounded by heavily overcut national forests, is known to have lost four large mammal species since the 1930s. And sometimes protection is stronger on paper than on the ground: in 1999, British Columbia allowed a logging road to be built through Strathcona Provincial Park, Vancouver Island's largest protected area.[26]

In 1992, the B.C. government set a goal of doubling its protected areas (from 6 to 12 percent of the provincial land base) by the year 2000. Since then, the province has come close to achieving its ambitious goal by declaring dozens of new parks covering 5 percent of the province and a wide variety of ecosystems, from semidesert grasslands to glacier fields. Yet more than 40 percent of the protected areas established between 1991 and 1999 are alpine tundra, further biasing the region's landscape protection toward high-elevation areas and away from richer and more-threatened low-elevation ecosystems.[27]

With less air above them, mountain landscapes experience stronger sunlight and wider temperature extremes than those below, and changes in the global atmosphere may affect

them more. Human activities around the globe have added heat-trapping greenhouse gases to the atmosphere and have introduced wholly new chemicals that deplete the stratosphere's protective layer of ozone. First discovered above the South Pole, ozone depletion now lets harmful amounts of ultraviolet-B (UV-B) radiation reach the world's midlatitudes as well, including the Pacific Northwest. On average, stratospheric ozone over our region has fallen about 6 percent below its pre-1980 values, with the biggest drop occurring each spring. If ozone depletion, and the amount of time people spend in the sun, continue unchanged, rates of carcinoma (a type of skin cancer) at the latitude of Portland will rise 10 to 20 percent over the coming decades. Across the Northwest, this trend could mean several thousand additional carcinoma cases each year. Environment Canada reports that a Canadian born in 1970 faces a 1 in 12 lifetime risk of developing skin cancer; one born today faces a 1 in 7 risk.[28]

People, of course, can avoid the sun; other species cannot. In 1993, scientists discovered that UV-B radiation was killing amphibian eggs in the Oregon Cascades. Increased ultraviolet radiation is probably a major cause of many of the widespread die-offs in the world's frog populations, especially in seemingly pristine habitats, where other suspected frog killers (such as wetland losses, introduced predators and diseases, and pesticides and other hormone-mimicking pollutants) are less likely to do harm. Another recent study showed that ambient UV-B is killing midge larvae—a major food source for salmon and other fish—in a tributary of B.C.'s Fraser River. We can only guess at the impacts on other species.[29]

International agreements have succeeded in slashing world chlorofluorocarbon (CFC) production nearly 90 per-

cent since its historical peak in 1988. But because of the lag between the release of these chemicals at ground level and the time they reach the upper atmosphere, stratospheric concentrations of ozone-consuming chlorine (from CFCs) are expected to peak around the year 2000 and will not subside to 1990 levels for several decades. And in 1998, the U.S. Congress postponed a ban on the ozone-depleting pesticide methyl bromide—heavily used, among other places, on vineyards and strawberry fields on California's north coast and cherry orchards in Oregon—until 2005, further delaying healing of the ozone layer. Ozone depletion is likely to remain a problem until late in the twenty-first century.[30]

Global warming too will bedevil humanity for decades, if not centuries, to come. Carbon dioxide, methane, and other greenhouse gases added to the atmosphere are already changing the global climate with unprecedented speed. The global burning of fossil fuels and vegetation has raised carbon dioxide concentrations 30 percent over the past 150 years and has already warmed the Earth's average surface temperature at least half a degree Fahrenheit (0.3º Celsius), slightly raised sea levels, and probably caused or accelerated other dramatic changes, such as the shrinking of mountain glaciers around the world. The ten warmest years since record keeping began in 1850 have all come since 1983; 1998 was very likely the warmest year in the past 1,000 years. The Northwest has done more than its share to contribute to the problem: northwesterners generate nearly their own body weight in greenhouse gases every day—three times the global rate (see Figure 5).[31]

Projections of future climate will always be uncertain, especially at anything smaller than the global level. The United Nations Intergovernmental Panel on Climate Change pre-

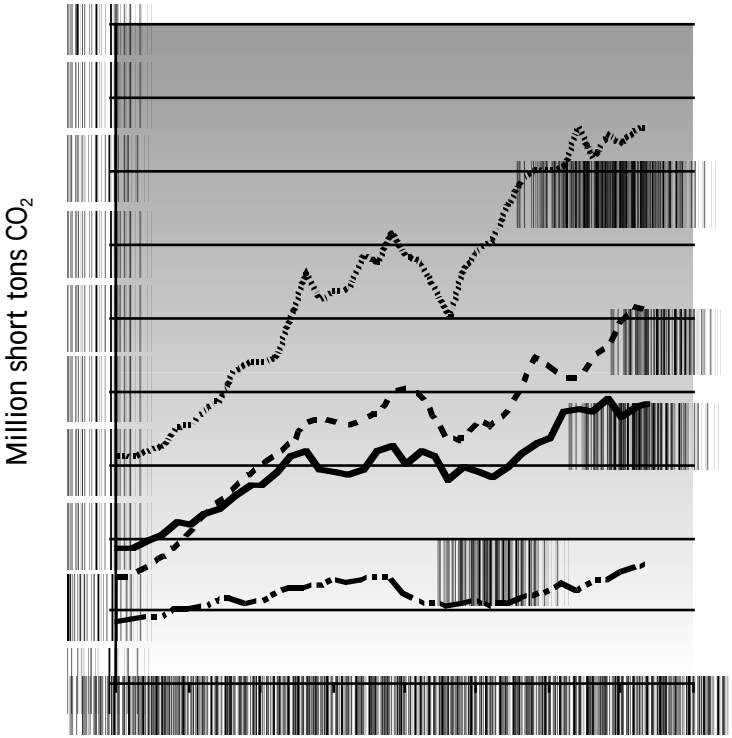

Figure 5. Emissions of CO_2 from Fossil Fuels, Pacific Northwest, 1960–1997
The Northwest's emissions of heat-trapping carbon dioxide have doubled since 1965. Sources: see endnote 31.

dicts that greenhouse gas emissions, if uncontrolled, will raise the planet's average temperature 2 to 6ºF (1 to 3.5ºC) over the next century, making the earth warmer than it has been for 160,000 years. Scientists project at least as much warming locally for the Pacific Northwest. These changes may sound small, but they are not: during the last Ice Age, when British Columbia and much of Washington were entombed

under thick glacial ice, temperatures were only 5 to 9ºF (3 to 5ºC) lower than today.[32]

If the world does not greatly reduce its greenhouse gas emissions, the Pacific Northwest can expect not only higher temperatures but a whole suite of disruptive changes. Many of these revolve around the region's snowpack—a threatened regional treasure just like salmon or ancient forests but even more important ecologically and economically. Winter warming of 5ºF (3ºC) would raise freezing level (the borderline between rain and snow) about 1,700 feet (500 meters)—enough to reduce the area of snowpack in the Columbia Basin by half, as well as put ski areas like Washington's Snoqualmie Pass and Vancouver, B.C.'s northshore resorts out of business. More than closing a few ski resorts, however, a shrunken snowpack will harm irrigation, hydropower, fish, and forests across the Northwest. With more rain and less snow, water will tend to run quickly off mountains instead of melting slowly throughout the year. Winter floods and landslides in much of the region will become more severe and numerous; interior rivers—whose flow comes mostly from snowmelt—will dwindle in the summer. As snowpack melts earlier in the spring, forests will dry more quickly during the summer, leading to more frequent forest fires.[33]

Our wealthy and technologically advanced economy may be able to adapt to many of the impacts of climate change—with costly seawalls, more firefighters, new crops. Indeed, where water scarcity is not a problem, longer growing seasons could boost the productivity of many farms. But the region's natural systems will not be so lucky: as temperatures rise, many natural communities will have to retreat north or uphill to survive; most alpine meadows will contract—or even

be squeezed out altogether. Forests will probably shrink overall in the Northwest; warmer water in streams and at sea could chase salmon from much of their natural range. As local climates change faster than many native species can adapt, biodiversity will greatly diminish. In general, ecosystems and societies accustomed to a particular range of climate conditions will experience greatly increased stress.[34]

GRASSLAND

On a clear April night, the young chinook emerges from the gravel. Still attached to its dwindling yolk sac, the fry is a poor swimmer, quickly swept downstream. Eventually it is carried to one side of the creek, where it can hold its own in the slower current. As beetle larvae and adult insects wash by, the fingerling feeds and grows.

This stretch of Stanley Creek has been fenced off for several years, and cows no longer wade in the water. Widened and muddied by decades of heavy grazing, the creek is slowly regaining its old form. Tall fescue grasses and willows reclaim the banks and anchor exposed bars of mud, restricting the stream to a deep, shady channel where the water stays cold, as salmon prefer. Each year, some silt laid down in previous years is flushed out by spring freshets, exposing more of the natural gravel bottom.

Predators are a constant hazard. The salmon darts into a tangle of roots to escape a hungry whitefish but fails to escape a technician from the Idaho Department of Fish and Game. He injects a computer chip—smaller than a grain of rice—into the salmon's body and returns it to the creek. It is the 736th spring chinook to be electronically tagged this year;

thousands more will follow. Radio signals from these tags tell scientists how many salmon survive each stage of their life cycle.

Through summer, fall, and a frigid Idaho winter, Chinook 736 lingers in a deep stream pool. Then the days grow longer and the stream flows faster, signaling 736's body to begin preparing for the ride to the sea. An air sac along its backbone fills so it can float downstream; its body chemistry begins to change to that of a saltwater creature. It starts becoming a smolt. Once this process begins, 736 needs to reach salt water quickly. The clock starts ticking.

HIGH ON A TREELESS RIDGE OVERLOOKING AN undammed stretch of the Columbia River is the rarest of treasures. In this forbidding landscape, beyond a locked gate, bunchgrasses, sagebrush, and desert wildflowers wave in an unrelenting breeze, above a crust of lichens and mosses anchoring the windblown soil. Like many places in the wide-open dry country of the inland Northwest, this one is seldom visited by people—especially in the five decades since it became part of the security perimeter for the Hanford nuclear weapons complex. What makes this parcel of grass and sage so rare is that cows have not visited or trampled it for at least half a century: it is a healthy grassland.

Livestock have grazed on almost every patch of rangeland in the Pacific Northwest—from alpine meadow to desert to the grassy floors of its drier forests—and continue to graze heavily the vast majority of remaining grasslands. While large blocks of uncut forest remain, unaltered grassland is extremely rare. As a federal report on biodiversity in British Columbia

concluded, "'Ancient' grasslands represent a much more endangered space in British Columbia than do 'ancient' or old-growth forests."[35]

Cows and sheep have grazed the drier portions of the Northwest for more than a century, transforming practically every grass-growing place in the region. Yet the ecological well-being of rangelands is little monitored and much disputed. The U.S. Bureau of Land Management (BLM) reported in 1990 that its rangelands (which cover one-fourth of the western United States) are in the best condition in half a century. In 1996, BLM and the U.S. Forest Service rated only 6 percent of rangelands in the interior Columbia Basin as having "high ecological integrity"; most rangelands had "low" integrity. And several government studies have echoed the findings of a 1990 report on livestock grazing for the U.S. Environmental Protection Agency (EPA): "Extensive field observations in the late 1980s suggest riparian [streamside] areas throughout much of the West were in the worst condition in history."[36]

These statements are not necessarily inconsistent. Historical overgrazing was so extreme that grasslands are almost by definition in better condition today (old photographs from eastern Oregon and Washington show summer rangelands so densely packed with sheep that they look like snowdrifts). Yet past and continued overgrazing leaves many areas severely degraded. And riparian areas, though they are critical habitats in arid lands, cover less than 1 percent of the western United States: their demise might not register in measures of overall rangeland condition.[37]

In 1994, the U.S. National Research Council (NRC), the research arm of the National Academy of Sciences, reported

that despite decades of research, range scientists have yet to adequately monitor the health of rangelands. Range science has focused more on producing forage for cattle than on understanding or conserving dryland ecosystems. NRC found that current rangeland assessments fail to adequately evaluate the state of even such basic ecological processes as nutrient cycles, energy flow, and soil stability. Rangeland studies in British Columbia have been similarly myopic.[38]

Despite the lack of reliable information on the health of drylands, there is little dispute that grasslands' biological diversity—crucial to their continued functioning—has been greatly reduced. Native perennial grasses have been practically eliminated across vast areas and replaced by sagebrush, juniper, or various exotic species less palatable to cows. The Eurasian plant cheatgrass (*Bromus tectorum*) has probably replaced big sagebrush (*Artemisia tridentata*) as the most common plant between the Rocky Mountains and the Cascades; in the intermountain U.S. West, cheatgrass predominates on about 17 million acres (7 million hectares), an area the size of West Virginia. Large areas of Idaho's Snake River plain, including much of the Snake River Birds of Prey National Conservation Area, have become near monocultures of cheatgrass.[39]

Less than 10 percent of grassland in the south Okanagan region of British Columbia remains in a relatively natural state; the south Okanagan harbors more threatened and endangered species than all other parts of the province. While grasslands cover less than 2 percent of British Columbia's land base, roughly one out of four species at risk of extinction in the province depends on them. To the south, more than half the once dominant shrub-steppe habitat of eastern

Washington—like 94 percent of the Palouse Prairie region of southeastern Washington and 99 percent of big sagebrush communities on the Snake River plain—has been converted to crops; most of the rest is overgrazed, invaded by nonnative weeds, or fragmented into small parcels vulnerable to outside influences such as pesticides drifting in the wind.[40]

Other than alpine meadows, very little Northwest grassland is protected in parks or wilderness areas. British Columbia alone in the 1990s has worked to reverse this trend:

HANFORD

Along the Hanford Reach of the Columbia River in eastern Washington lies some of the finest remaining native grassland in the Pacific Northwest—and likely the most polluted place in North America. The Hanford Nuclear Reservation, where more than half the plutonium for U.S. nuclear weapons was made, still contains more than 10 tons of the deadly element, 1,400 separate contaminated sites, and groundwater beneath 120 square miles (190 square kilometers) polluted by a wide array of toxic and radioactive chemicals. During four decades of plutonium production, Hanford engineers poured 1.7 trillion liters of chemical and nuclear waste into the ground (enough to fill Seattle's Lake Union 70 times) and released thousands of times more radiation than the 1979 accident at Pennsylvania's Three Mile Island nuclear power plant, affecting human health over broad areas of eastern Washington.[42]

The outer perimeter of this toxic wasteland contains some of the least-degraded arid lands in the Northwest and the last remaining spawning grounds for fall chinook and steelhead along the main stem of the Columbia River. For 50 years, much of Hanford was a security buffer, its native plants and

by late 1999, the province had officially protected 9 percent of its grassland, up from less than 1 percent in 1994. In both Canada and the United States, however, many "protected" areas allow continued livestock grazing. In southern Oregon's Hart Mountain National Antelope Refuge, for example, overgrazed wet meadows were found to support half the wildlife species they could if cattle were removed.[41]

Though cattle and sheep have transformed Northwest grasslands most profoundly, other factors, including range

184 bird species inadvertently protected from livestock grazing and conversion to cropland. In 1999, the U.S. Fish and Wildlife Service took over the pristine southwestern edge of the reservation, and the grasslands of the Wahluke Slope, across the Columbia River from Hanford's reactors, were added to the Saddle Mountain National Wildlife Refuge.[43]

A multibillion-dollar cleanup launched in 1989 is now the largest public works project in the United States. Workers are stabilizing explosive waste tanks and have cut production of liquid effluent by 90 percent. Yet the volume of radioactive waste still grows, thousands of tons of uranium and other wastes remain, and contaminated groundwater—with chromium levels 25 times higher than those known to harm juvenile salmon and strontium-90 concentrations eight times higher than drinking water standards—has started seeping into the Columbia River within 100 feet (30 meters) of salmon spawning grounds. In addition, "cleanup" is a bit of a misnomer: it mostly means moving waste from one place to another. Cleanup is expected to take at least 50 years; the wastes themselves will be deadly for millennia.[44]

reseeding programs and off-road recreation, have had heavy impacts in smaller areas. In B.C.'s Chilcotin-Cariboo region, fire suppression has allowed trees to encroach on roughly one-third of the area's grasslands since 1960; in B.C.'s Okanagan Valley, suburban sprawl has greatly reduced the extent of riparian grassland. Eighty-five percent of the Okanagan's riparian grassland has already been eliminated.[45]

Grasslands are not limited to the drier, eastern portions of the Pacific Northwest. Prairies of native grasses and wildflowers, sometimes sprinkled with Douglas-firs or Garry oaks (*Quercus garryana*, also called Oregon white oak), once covered much of the north-south band of lowlands running from southern Vancouver Island to Oregon's Willamette Valley. Originating during a period of drier climates several thousand years ago, these meadows were largely maintained by fires set by the region's indigenous inhabitants. As Indians were killed off, forcibly removed, or otherwise prevented from using fire to manage their lands, trees and shrubs began to replace the grasses. Farms and, more recently, suburban sprawl have replaced most of the remaining grassland. The region's biggest remaining prairies lie near Tacoma at the U.S. Army's Fort Lewis, where exploding artillery sets off fires that mimic Indian fire regimes. It is estimated that less than 1 percent of native prairie survives in the Willamette Valley; Canadians consider Garry oak meadows one of the nation's most endangered ecosystems.[46]

Though less obvious to the untrained eye, the transformation of Northwest grasslands has been much like that of its forests. Whether their dominant species are centuries-old trees or grasses that live for decades, "ancient" ecosystems are badly depleted in the Pacific Northwest.

F O R E S T

With the flush of spring snowmelt, Chinook 736 begins its journey to the sea, tumbling through the canyons and pine forests of central Idaho. The swollen Salmon River sweeps it briskly past the town of Stanley—quiet until summer tourist season—and the hulking wreckage of the Sunbeam Dam. Nearby, the Yankee Fork joins the main stem of the Salmon River, carrying sediment and traces of cyanide leaking from tailings ponds at the Grouse Creek gold mine. This "state-of-the-art" mine was mothballed in 1997, after only three years' operation and repeated cyanide spills. The mine's cyanide-laced ponds will remain hazardous for decades.

Downstream, the Lemhi River enters the Salmon, bearing soil from the heavily logged watersheds of the Salmon National Forest. But for the most part, the river runs clean and fast. Just past the town of Salmon, the north-flowing river turns sharply west and carries Chinook 736 past the rugged terrain and impassable rapids that forced the Lewis and Clark expedition to find another route to the Pacific. But the raging currents and 180-mile (300-kilometer) canyon present no problem for the diminutive smolt, exquisitely adapted to this sort of travel. Most of the mile-deep canyon is protected as part of the "Frank" (the Frank Church–River

of No Return Wilderness), the largest protected wilderness in the lower 48 states.

As each day breaks, 736 moves out of the main channel current into a back eddy or deep pool to hide from predators and hunt for prey. Just below the confluence of the Salmon and its Middle Fork, the canyon widens; spring floodwaters roaring over the floodplain, and groundwater percolating up through gravel, carry a rich mix of nutrients into the river. The chinook holds here, feeding on everything from swimming midges to ants fallen from the branches of streamside willows. As late-afternoon shadows flood the canyon, 736 moves back into the mainstream and is swept west, across the mountainous heart of Idaho.

As it leaves the "Frank," the ever-larger Salmon River is joined by its South Fork, a river where silt from massive landslides nearly 30 years ago still buries spawning beds. Road building and logging on steep slopes caused the slides, and erosion continues, years after logging was stopped. Few fish emerge from the South Fork.

From its source, the Salmon drops more than a mile (1,800 meters) before joining the Snake River inside Hells Canyon. The wild ride abruptly ends just downstream; the Snake hits the pool of Lower Granite Dam, and the rushing wall of snowmelt slows to a 0.6-mile (one-kilometer)-per-hour crawl. Chinook 736 has entered the 300-mile (500-kilometer) chain of slackwater reservoirs that we still call the Snake and Columbia Rivers.

FORESTS COVER HALF THE PACIFIC NORTHWEST AND produce much of North America's timber. A fraction of these forests have escaped logging and hold global as well as

local ecological importance. The region supports most of the world's remaining temperate rainforests. Carbon stored in soils and in massive trees represents millions of tons of climate-disrupting carbon dioxide kept out of the atmosphere. And the Northwest presents the best opportunity anywhere in temperate latitudes to study and protect fully functioning, large-scale forest ecosystems—with all their native species and various ecological processes still intact.[47]

Forests are born of change and disturbance: wildfires lay vast tracts bare; storms and avalanches knock over trees; species compete, migrate, and evolve. Even in their natural state, Northwest forests were never uniformly carpeted by ancient trees. But groves of giant conifers that have stood for centuries, in some cases millennia, have always been the region's signature landscape. These older forests, by any name—ancient, late-successional, or old-growth—have been most depleted by logging and are the most contested today.

On the west side of the Cascade Range, old-growth forests—with centuries-old trees alive and in various stages of decay—once covered perhaps half the land. Today 90 percent of this old growth in Oregon and Washington is gone. Most of what remains stands at higher elevations, on publicly owned land. On the Olympic Peninsula, for example, logging and human-caused fires have eliminated about 80 percent of old-growth forests, but fully 97 percent of the low-elevation Sitka spruce and western hemlock old growth is gone.[48]

Beyond the intensively studied forests of "the westside," it is more difficult to know how much old growth once existed or survives today. Frequent fires and other natural disturbances ensured that forests seldom grew as old in the drier interior. In the inland U.S. Northwest, old growth may have

covered 20 to 50 percent of forest areas before European settlement; it is now far below historic levels, especially at lower elevations.[49]

Some types of forest have been especially hard hit. Around 95 percent of California's coastal redwood forests—dominated by the world's tallest trees—have been logged. A 1986 search for old-growth western red cedar in northwestern Montana found only two undisturbed groves large enough to be considered functional ecosystems. Ponderosa pine old growth, once common throughout the inland Northwest, is among the region's most endangered ecosystems. Logging of the biggest pines, along with a half century of firefighting in the fire-dependent forests of the interior West, has replaced almost all ponderosa pine old growth with dense young stands of fir and Douglas-fir, which are more susceptible to pest outbreaks and catastrophic fires. Insects or fungi can spread easily through the uniform stands of trees; also, habitats for pests' natural enemies—such as cavities for woodpeckers—are usually lost after logging.[50]

British Columbia contains more forest wilderness overall than anywhere in the Northwest. According to the B.C. Ministry of Forests, less than one-fifth of the province's forests has ever been logged. Vast areas of wilderness remain in the province's far north, but in coastal and southern B.C., where forests are more diverse and their trees bigger and more accessible, uncut forests are becoming rare. Logging and urbanization have altered one-half to two-thirds of Vancouver Island's old growth and all but eliminated Douglas-fir old growth on the drier eastern side of the island.[51]

Logging's impacts extend far beyond the area actually cut down. Forests along the edge of a clearing experience

edge effects: changes in temperature, humidity, and other physical conditions that determine the suitability of habitat for different species. Edge effects can extend several tree lengths into old-growth forests—far-reaching impacts given the tremendous height of the region's conifers and the small patches in which they are often found. Eighty percent of old growth in eastern Oregon and Washington, for example, occurs in patches smaller than 100 acres (40 hectares).[52]

Logging and logging roads divide forests into scattered fragments, unable to provide habitat or otherwise function as well as contiguous forest. In the U.S. Northwest, the checkerboard pattern of clearcuts is familiar to anyone who has flown in an airplane; in B.C., loggers and their roads often advance along valley bottoms, leaving upper parts of watersheds uncut but isolated. Less than 10 percent of the province's coastal Douglas-fir, interior Douglas-fir, and ponderosa pine forests remains in large blocks unfragmented by roads (see Figure 6).

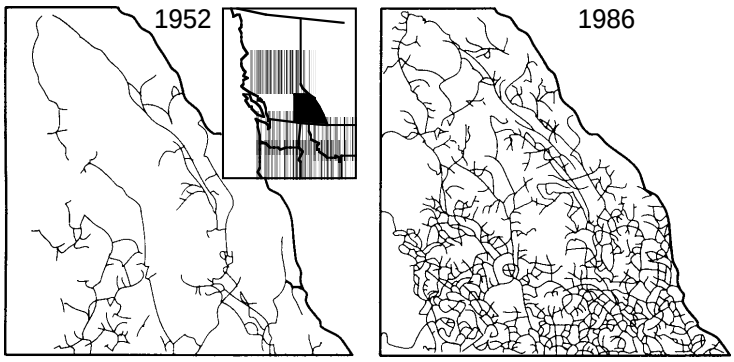

Figure 6. Roads, Kootenay Mountains, British Columbia
The degradation of the Kootenays is written on the land.
Source: see endnote 24.

On the B.C. coast, only 1 of 25 watersheds larger than 250,000 acres (100,000 hectares) has escaped logging. No such watersheds remain undeveloped in the lower 48 states. The Kitlope Basin, a protected area jointly managed by British Columbia and the Haisla Nation (in whose homeland it is found), is probably the largest undeveloped coastal watershed in the world's temperate latitudes.[53]

Though vast roadless areas still extend across Alaska and northern B.C., a spaghetti-like network of logging roads crisscrosses most forests in the rest of the region. Public lands alone in the Pacific Northwest are dissected by at least 330,000 miles (530,000 kilometers) of logging roads—more than the region's streets and highways combined. In Oregon, Washington, and western Montana, roads have even surpassed streams as a defining feature of the landscape: south of British Columbia, motor vehicles have access to more of the Northwest than fish do (see Figure 7).[54]

Roads can trigger landslides and severe soil erosion, accelerate the spread of exotic species and forest diseases, and open once-inaccessible forests to hunters. In Idaho, logging roads have caused soil erosion more than 200 times greater than on undisturbed sites; now Idaho's national forests have 33,000 miles (53,000 kilometers) of logging roads—more than enough to circle the planet. Road building has slowed in Idaho and elsewhere as roadless areas with marketable timber have dwindled and foresters have acknowledged the tremendous harm forest roads can do. The U.S. Forest Service and the B.C. Ministry of Forests have embarked on modest road removal programs, and in 1999 the Clinton administration followed up a moratorium on road building in most national forests with an initiative to protect remaining

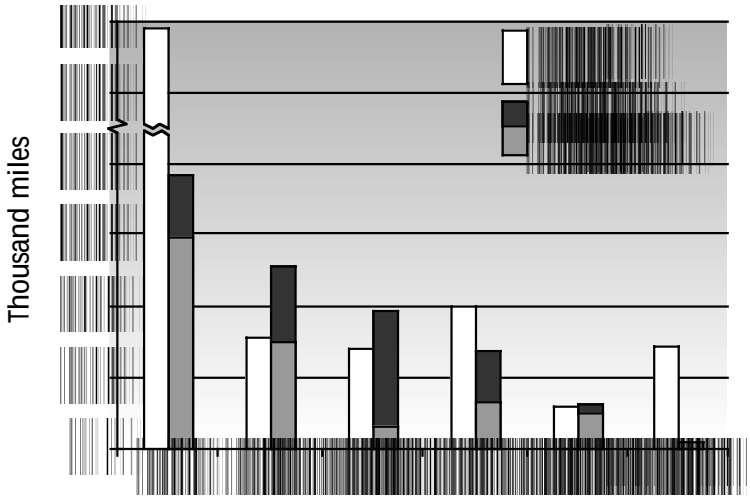

Figure 7. Road vs. Stream Length, Pacific Northwest, 1994
South of B.C., motor vehicles have access to more of the Northwest than do salmon or trout. Sources: see endnote 54.

[1] Includes intermittent streams; data unavailable for northwestern California.
[2] Only U.S. national forest roads; all public forest roads in B.C.
[3] Eleven counties in Columbia River basin.
[4] Includes Prince William Sound and Copper River watersheds.

roadless areas larger than 5,000 acres (2,000 hectares). But given the labyrinthine networks of logging roads snaking across public and private timberlands—and, in B.C., continued large-scale road building—roads will erode hillsides and threaten sensitive species for years to come.[55]

Logging as usually practiced in the Northwest profoundly affects every part of the forest, down to the soil. Ninety percent of logged areas in B.C. are clearcut, and half are either tilled or burned after trees are removed. Such intensive techniques, designed to hasten the growth of planted seedlings, can hinder forest growth by damaging the variety of fungi and other soil organisms that help trees survive. Most plants

and all major timber trees in the Northwest (except cedars and maples) depend on mycorrhizal fungi attached to their roots to absorb nutrients and fix nitrogen. Reforestation often fails when the soil's biological community is irrevocably damaged, especially in drier and high-altitude forests.[56]

Public pressure at home and abroad has secured a number of changes in how forests are managed in British Columbia in the 1990s, including a near doubling of the province's protected areas, improved (but poorly enforced) protections for streams and wildlife in the province's Forest Practices Code, the development of state-of-the-art ecosystem management in Vancouver Island's hotly contested Clayoquot Sound, and even timber giant Macmillan Bloedel's official renunciation of clearcutting in its timber operations. Despite these reforms, little has changed in the most important determinant of logging's impact on the land—*how much* logging occurs. Cutting rates have stayed near their all-time, and wildly unsustainable, highs. According to the B.C. Ministry of Forests' own estimates, the "allowable annual cut" exceeds the province's long-term ability to grow timber by roughly 20 percent; in some heavily logged regions like the Bulkley, Lillooet, and Nass Valleys, as well as the rainforest coast between Vancouver Island and Alaska, forests are being overcut by 50 to 100 percent or more. In other words, no matter what the province does in the future to liquidate or protect its remaining old-growth forests, its timber cutting will inevitably topple by at least 20 percent.[57]

Timber cutting in U.S. national forests that harbor the northern spotted owl has declined by 85 percent or more since its heydays in the 1970s and 1980s: loggers ran out of big trees worth removing and ran afoul of laws protecting

the owl and other indicator species for coastal old-growth forests. Logging in federal forests west of the Cascades all but stopped after a 1991 federal court ruling that the U.S. Forest Service was "willfully" violating environmental laws in these forests. Timber sales resumed on a much smaller scale with the Northwest Forest Plan (also known as Option Nine, intended to bring westside forest management into compliance with environmental law). But even before Option Nine was implemented, scientists and environmentalists challenged it as insufficient to maintain forest biodiversity over the long term. Spotted owl populations declined at an accelerating rate from 1985 to 1993; as of 1998, owl populations were declining at an average rate of 4 percent a year, suggesting that spotted owls—and, likely, other old growth–dependent species—cannot tolerate any further reduction of their habitat, as Option Nine has allowed.[58]

Worse, a 1995 congressional rider authorized species-endangering clearcuts in the spotted owl forests, overriding Option Nine and all other environmental laws. Politicians and industry pushed the rider through as part of a campaign to use logging to solve problems of "forest health" in fire-suppressed, overlogged, and overgrazed inland forests. Though the rider expired in 1996, old-growth logging has continued on both the west and east sides of the Cascades. On the east side, logging for "forest health" continues despite the evidence that logging usually does little to improve forest or stream health and often does great harm. And on the west, as of late 1999 federal court rulings had all but shut down the U.S. Forest Service's timber sales for failing to inventory rare species as required under Option Nine. These rulings, along with the Clinton administration initiative to

protect remaining roadless areas, have largely stopped old-growth logging on federal lands from the Washington Cascades to the California redwoods, at least temporarily.[59]

Few old-growth forests remain except on federally or (in B.C.) provincially owned lands. In 1999, the U.S. government purchased and protected most of the nation's largest remaining parcel of privately owned ancient redwoods, the Headwaters Grove in California's Humboldt County. In exchange for selling 10,000 acres (4,000 hectares) of land with trees as old as 2,000 years, Maxxam–Pacific Lumber can continue to cut redwoods elsewhere on its lands despite the

LICHENS

Lichens drape tall branches and carpet flat surfaces in all sorts of ecosystems, but in the Pacific Northwest, lichens dwell predominantly in forests. The coastal Northwest is one of the world's hot spots of lichen diversity: westside forests may harbor an even greater diversity and biomass of lichens than do tropical forests.[61]

Logging poses the greatest threat to Northwest lichens and the nutrient recycling, nitrogen fixing, and wildlife food they provide. Many of the 1,000 lichen species in British Columbia, Oregon, and Washington persist only in undisturbed, older forests. In B.C. these are being cleared at a rate of roughly 400,000 acres (160,000 hectares) per year. Nonetheless, the province is probably one of only a few regions in the world whose lichen flora remains essentially intact.[62]

Air pollution does little harm to lichens in most of B.C., but in the province's urban southwest corner, where 18 pounds of sulfates fall annually on an acre of land (20 kilograms per

harm that cutting will do to at least two federally protected species: the coho salmon whose streams run through the groves and the marbled murrelets that nest atop them. In another multimillion-dollar deal, environmentalists raised $16.5 million to purchase logging rights in Loomis State Forest in north-central Washington, thereby protecting much of the state's best habitat for the threatened Canada lynx.[60]

To the north, the Queen Charlotte goshawk (an old growth–dependent predator) may become an indicator species for coastal forests from Vancouver Island to Glacier Bay. If environmentalists succeed in having the goshawk listed as an

hectare), many lichen species have already declined. Because lichens take their mineral requirements directly from the air, they quickly accumulate airborne pollutants, one reason most urban areas support very few lichens. In Port Alice, on northern Vancouver Island, a pulp mill's sulfur dioxide emissions have eliminated nearby lichens and reduced forest growth as far as a mile (a kilometer and a half) away.[63]

Aside from indicating air pollution, lichens are important to many other species. Alders, cottonwoods, and maples actually send out tiny roots into the lichens and mosses growing on their own bark to capture nutrients before they wash away. The threatened mountain caribou of southeastern B.C. and the Idaho panhandle graze mainly on lichens all winter long. Oregon lungwort (*Lobaria oregana*), the bumpy lettuce-like lichen often found on forest floors below the centuries-old treetops where it grows, supplies half the nitrogen in many forests west of the Cascades.[64]

endangered species in the United States (in 1999 a federal judge ordered the U.S. Fish and Wildlife Service to reconsider its 1997 decision not to list the goshawk), logging in the Southeast Alaska lowlands could be restricted. Neither Canada nor British Columbia has endangered species legislation, and forest controversies in B.C. revolve largely around remaining unlogged watersheds rather than around any one species.[65]

Large-scale logging began only a few decades ago in Alaska, and large areas of untouched wilderness remain in Tongass National Forest, which covers 80 percent of the Alaska panhandle, and Chugach National Forest, which surrounds Prince William Sound. Most of the Tongass and the Chugach—respectively the United States' first- and second-largest national forests—is actually rock, ice, scrub timber, or bog. One-third of the Tongass is considered suitable for commercial logging, and only 4 percent contains the dense stands of giant trees preferred by both wildlife and loggers. The Tongass mirrors the Pacific Northwest as a whole: logging has affected its southern half, where trees grow larger, more than the northern half (and more than the Chugach still farther north). Loggers have cut more than half the highest-volume stands in the Tongass since 1950.[66]

Roughly one-third of the Tongass (mostly nonforest land) is designated wilderness. Between 1990 and 1999, the U.S. government set aside an additional 7 percent—much of it rich, low-elevation old growth—from logging and cut the rate of logging in the forest by a third. Still, old-growth logging continues in Southeast Alaska, on both U.S. Forest Service lands and those held by government-created "Native corporations," which are bound by law to earn a profit from the lands they own. Most of the half-million acres of high-

quality forestland returned to Native corporations in the early 1980s have since been cut; many village corporations quickly ran out of timber.[67]

Scientists and land managers increasingly view forests as ecosystems rather than as collections of standing timber. But even a single tree is an ecosystem unto itself, hosting many different species from treetop to root-tip. Fungi live within the needles of an old-growth Douglas-fir, producing alkaloid compounds that fend off tree-eating insects; *Lobaria* lichens hundreds of feet off the ground fertilize the forest by capturing nitrogen from the air; among the roots spread vast networks of mycorrhizal fungi. The ecological roles of all these species were discovered only in recent years. Who is to say what other creatures may be working anonymously to keep Northwest ecosystems together?[68]

F A R M

A grain barge, also bound for the Pacific, passes above Chinook 736. The barge has no problem negotiating the dams or the reservoirs: they were designed to enable oceangoing ships to motor upriver all the way to Lewiston, Idaho. Thousands of fish, meanwhile, become disoriented by the absence of current and fail to navigate the 40-mile (65-kilometer) reservoir of Lower Granite Dam. Others succumb to heat stress or the numerous predators that thrive in the warm, motionless water. The sun beams down on the wide, shadeless reservoir as the Potlatch pulp mill in Lewiston discharges millions of gallons of 92°F (33°C) water just upstream.

Most of the salmon face only one reservoir before they are drawn into a high-pressure pipeline and carried en masse in U.S. Army Corps of Engineers barges past the dams. Perhaps because of the stress, friction, and disease inside the holding tanks, perhaps because the barged smolts don't learn the smells or survival skills of the river, few of them will survive to adulthood. Barged salmon may have slightly better odds of survival than fish that run the gauntlet of dams, but salmon barging has failed to stop the salmon's decline. It also does nothing for the sturgeon, lamprey, and other creatures that thrive in fast-flowing water.

Chinook 736, no longer carried downstream fast enough, swims toward the dam. It burns precious fat reserves it cannot rebuild: invertebrate prey in the reservoir are less nutritious than the midges and caddisflies found in swiftly flowing water. Other smolts that reach the dam are pulled into the power-generating turbines and crushed. Instead, 736 spills over the top. The rapid drop and churning water beneath form nitrogen bubbles in its blood—like a diver with the bends. But the bubbles are not fatal. Chinook 736 has survived the first dam.

The next reservoir extends to the base of Lower Granite Dam; 736 must start swimming again. It takes several days to move through the warm, slack water—and a few seconds to go over Little Goose Dam. Just below, oxygen-depleted water from Washington's Palouse River joins the reservoir, carrying soil eroded from the wheat fields of the Palouse Hills. Already stressed by high temperatures, the smolt coughs repeatedly to clear its gills.

At each of the eight dams that stand between the Salmon River and the Pacific, about one out of ten of the chinook's peers will be killed—in all, more than three out of four will fail to reach the sea. Before the dams, a smolt's trip to the ocean took roughly two weeks; now it takes two months.

Past six more dams—Lower Monumental, Ice Harbor, McNary, John Day, the Dalles, and Bonneville—the smolt must endure these hazards. Somehow it survives.

FARMLANDS, COVERING 7 PERCENT OF THE LAND IN the Pacific Northwest, spread ecological impacts much farther. Soils and agricultural chemicals are carried downwind and downstream, while water sprayed on crops often

depletes rivers and aquifers, preventing fish from inhabiting places upstream.

No regional figures are available, but agricultural soil erosion in the United States slowed by one-third in the late 1980s, as farmers enrolled erosion-prone croplands in the federal Conservation Reserve Program (CRP) and took soil conservation measures. In the Northwest, one-third of farms in Idaho, and nearly one-fourth of those in Oregon and Washington, now practice conservation tillage, a catchall term for methods that minimize soil losses between harvest of one crop and planting of the next. But fewer farmers have participated in CRP in the Northwest than in other states: in none of the Northwest states has more than 5 percent of highly erodible cropland been retired under the plan. Most of the cropland in the Snake River plain of Idaho and the Columbia Basin of Oregon and Washington is eroding at at least twice the rate considered tolerable by soil scientists.[69]

The Palouse River basin of eastern Washington is among the most erosion-prone areas in the United States. Resembling a wheat ocean, the intensively farmed basin has shed an estimated 40 percent of its wind-deposited loess soil over the past century. On 10 percent of land in the Palouse, all the original topsoil has washed or blown away, exposing the clay and hardpan beneath. Clay particles in turn blow onto adjacent areas of fertile soil, reducing their productivity. Soils also end up in the water: three million tons of sediment (containing unknown amounts of farm chemicals) wash out of the basin each year, damaging lake fisheries and filling hydroelectric reservoirs in the Snake River. Farmers' erosion control techniques have slowed the basin's rapid soil loss by 10 percent or more since the late 1970s.[70]

Partly because contaminated soil continues to erode into nearby waters, farm chemicals both old and new cause problems for people and wildlife. Ten of the 25 pesticides most commonly found in the waters of Oregon's Willamette River basin can disrupt the endocrine system by mimicking or blocking hormones that regulate growth, behavior, and sexuality. Though concentrations of the pesticide DDT—banned because of its lethal effects on birds of prey—are declining over time, DDT sprayed more than 25 years ago lingers in Northwest ecosystems. Recent studies found DDT or its toxic breakdown products, such as DDE, in every fish sampled in the upper Snake River basin and farming areas of eastern Washington. In B.C.'s south Okanagan Valley and upper Fraser River, osprey eggs still contain levels of DDE high enough to impair embryo development and to thin eggshells.[71]

Consumers face small, though not negligible, risks from residues of the pesticides used to produce their food, but farmworkers, directly exposed to pesticides in large amounts, endure the highest chemical exposures of any occupational group. For example, the organophosphate insecticide guthion frequently sickens and injures farmworkers in Washington, where more of the chemical is sprayed than in all other states combined. Farmworkers spray guthion on 90 percent of the state's apples, usually three times a year. A University of Washington study found guthion—a nerve poison—in the dust of every home sampled in the Wenatchee area; levels were five times higher in farmworkers' homes than in other homes. One-third of farmworkers' children were exposed at levels deemed unsafe by the U.S. EPA. In Oregon's Hood River valley, where roughly 80 percent of apples and pears are sprayed with guthion, some streams have concentrations of the

insecticide as much as 90 times higher than state pollution laws allow. Though a growing number of farms in the Northwest have turned to organic and other chemical-reducing techniques, the vast majority still depend heavily on pesticides.[72]

Pests and pesticides might not be so problematic if farmers' crops were more diversified. With large acreages planted in genetically uniform crops, pests and diseases can spread rapidly. Ninety percent of Idaho's potatoes are one variety, the Russet Burbank (preferred by fast-food chains: russets stay stiff after deep frying). With some crops at least, the trend toward homogenization has reversed in recent years: half of Washington apples picked in 1998 were Red Delicious, down from two-thirds in the early 1990s. Fewer than one-third of B.C. apples are Red Delicious.[73]

Fertilizers, pesticides, and livestock wastes often drain into adjacent water bodies, both above and below ground. Pesticides contaminate groundwater supplies in 51 out of 200 counties in the U.S. Northwest. Nitrate concentrations (from fertilizers, manure, and food-processing plant wastes) in 20 percent of migrant farmworker camps in Washington, and in nearly 20 percent of all wells sampled in the Palouse basin and neighboring areas of eastern Washington and Idaho, exceed the U.S. EPA's drinking water standards. Nitrates and pesticides also taint the Abbotsford-Sumas aquifer, a major underground water body that straddles the U.S.-Canada border north of Bellingham, Washington. Most of the pollution apparently comes from the Canadian side, which is more densely settled and farmed than the U.S. side.[74]

Irrigation using groundwater and river water made large-scale agriculture possible in the high deserts of western North America. Today, one out of three acres of cropland in the

Pacific Northwest, including half the cropland in Idaho, is irrigated. In Idaho, Oregon, and Washington, irrigation withdraws four times more water than all other human activities combined. In the desert soils of the Snake River plain, Idaho potatoes are irrigated by up to ten feet (three meters) of water a year—or about 7 gallons (26 liters) to grow a single potato. Farmers use such large volumes—six times what a rain-fed potato in Maine would receive—because water percolates quickly through the loose soils and because federal dam and irrigation projects deliver cheap water paid for mostly by taxpayers. These subsidized "reclamation" projects have eliminated nearly 49 percent of Idaho's wetlands.[75]

Farmers and federal irrigation projects have drained or plowed 75 percent or more of wetlands in the Klamath Basin, straddling the Oregon-California border. More than 250 species of birds visit the basin's lakes, marshes, and fields, including the largest concentration of bald eagles in the contiguous United States, more than a million waterfowl, and four out of every five birds that migrate along the Pacific Flyway between the tropics and Alaska. The Klamath Basin's seven national and state wildlife refuges today are watered largely by pesticide- and fertilizer-laden runoff from irrigated fields, many of which are located on the wildlife refuges themselves.[76]

Irrigated farms are, of course, an important part of the economy in the rural Northwest and provide food for consumers far and wide. Yet most irrigated farms use far more water than they need to. Only 1.5 percent of irrigated acres in Northwest states use water-saving techniques (trickle and drip systems as opposed to sprayers and open ditches); in Idaho, more water is lost on its way to farm fields than is consumed by crops. And most irrigation water in the North-

west goes not to apples, potatoes, or other food for humans but to grass and alfalfa, feed crops that are processed—and mostly wasted—by the digestive tracts of cows. Farmers take so much water from the Snake River—the largest tributary of the Columbia—that for much of the year, several miles of riverbed below Milner Dam near Twin Falls, Idaho, are dry.[77]

Farms and feedlots return much of the water they use to the land, but seldom before adding soil, wastes, or chemicals to it. The 50,000 dairy cows in the Yakima River basin of eastern Washington—more than twice the number a decade ago—produce more waste (manure, urine, and tainted water) than the city of Seattle; fewer than one in five Yakima dairies properly manages its manure. Where the depleted Snake River still flows, its water quality is usually poor. Five endemic species of aquatic snails—indicators of clean, well-oxygenated water—are endangered in the Thousand Springs area below Twin Falls. Thick mats of algae that flourish on agricultural wastes cover miles of the Snake's once pebbly bed.[78]

C I T Y

Having survived the gauntlet of dams and reservoirs, Chinook 736 enters the free-flowing final stretch of the Columbia, and metropolitan Portland. Floating beneath the interstate highway bridges, it passes golf courses and Portland International Airport on the river's floodplain. Small amounts of motor oil, pesticides, and airplane deicing chemicals trickle into the river. Here water, salmon smolts, and pollutants from the Willamette River join the Columbia. Near the confluence, Southeast Asian and Eastern European immigrants fish for dinner, though their catch may be poisoned.

No longer depleted of oxygen and rust-colored with sawdust and sludge as it was for much of the twentieth century, the Willamette is far cleaner than before. Yet sewage, toxic chemicals from various industrial facilities, and runoff from streets throughout the Willamette Valley still taint the river. The six-mile stretch nearest the shipyards and docks of Portland Harbor is even a proposed Superfund hazardous waste cleanup site.

A heavy rain falls, and water runs rapidly off pavements, lawns, and roofs in the Willamette Valley. Their floodplains walled off and their spongelike wetlands paved, the urban streams flood quickly. The extra flow scours stream bottoms,

washing fish eggs away. Portland's sewers cannot handle the extra water; raw sewage overflows into the Willamette and the Columbia.

The little chinook avoids areas where sediments are concentrated. Even so, suspended solids—some natural, some added—will damage its gills, and a few mineral particles (from upstream sediments) will lodge in its spleen. It ingests infinitesimal amounts of heavy metals and PCBs. Unluckier fish will consume more toxic waste. They will develop tumors and lesions, suffer suppressed immune systems, and perhaps lose the all-important sense of smell that enables them to find their way back to the streams of their birth.

CITIES, SUBURBS, AND TOWNS COVER ONLY 1 PERCENT of the Pacific Northwest. But buildings and pavement tend to occupy the best land for growing crops or timber and the most diverse natural habitats. Moreover, human settlements are engines of environmental degradation. Their demand for energy and materials drives the transformation of landscapes throughout the region and beyond; exhaust rising from the estimated 12 million cars and trucks on the Northwest's streets and highways affects the entire planet's climate.[79]

The area occupied by Northwest settlements is growing faster than their populations, as suburbs sprawl across the countryside. Census reports show that metropolitan Seattle's population, for example, grew by 38 percent from 1970 to 1990, yet the area of developed land grew by 87 percent. The Puget Sound region lost 11 percent of its private forestland to sprawl in the 1980s alone. And sprawl has accelerated in the 1990s (see Figure 8). Around the Northwest, minimally planned subdivisions, office parks, and vacation homes are

proliferating, taking over prime farm- and forestland near major cities as well as around smaller "quality-of-life" towns like Bend, Oregon; Kamloops, B.C.; and Missoula, Montana. Sprawl covers an average of 75,000 acres (30,000 hectares) of private timberland in Oregon and Washington each year—more than the area of old-growth forest cut annually in spotted owl territory during the 1980s logging boom.[80]

As low-density, pedestrian-unfriendly development expands, people drive farther and more often, using more energy, polluting more air and water, and having more accidents.

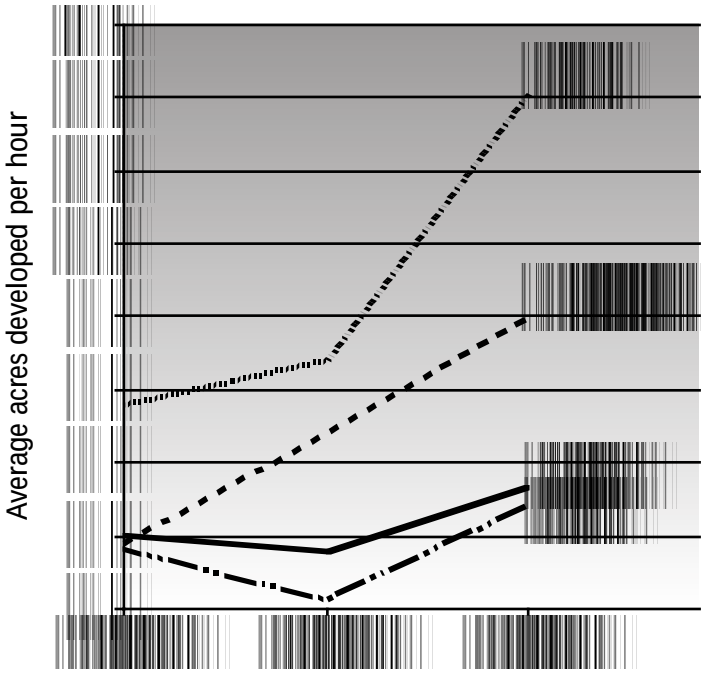

Figure 8. Pace of Sprawl, Northwest States, 1982–1997
Sprawl consumes about an acre of land every four minutes in the Northwest states. Source: see endnote 83.

Most northwesterners now live in suburbs, where, typically, transportation accounts for 72 percent of household energy use; a typical suburbanite drives 50 percent farther daily than a city dweller. Households in the Boise suburbs average ten vehicle trips per day. According to a national survey in 1999, the average motorist in the Seattle-Everett area sits in congested traffic 69 hours a year: by this measure, only Los Angeles and Washington, D.C., have worse traffic congestion.[81]

Vancouver, B.C., is a continentwide leader in arresting sprawl, with aggressive redevelopment of pedestrian-oriented central city neighborhoods turning much growth inward rather than outward. During the late eighties (the last time comparable data were gathered), the city was spreading at one-third the rate of Seattle despite similar rates of population growth. Vancouver converts less rural land to urban uses per new resident than any other Canadian metropolis. Nonetheless, the metropolitan area is expanding onto forest- and farmland, and car dependence is on the rise. The number of cars insured for driving to work in greater Vancouver grew twice as fast as the region's population between 1984 and 1994; between 1985 and 1994, the number of Vancouver-area elementary school children being driven to and from school increased by 53 percent. One out of nine passenger trips in greater Vancouver takes place by transit.[82]

With its efficient mass transit, pedestrian-friendly downtown, and legally enforced urban growth boundary, Portland has enjoyed more success than most western cities in confining itself to a compact area and minimizing the pollution and traffic that come with sprawl. No more cars enter downtown Portland than in the early 1970s, yet downtown jobs are up 50 percent. Portland's use of public transporta-

tion is among the highest in the West, with four out of ten downtown employees taking buses and trains to work. A growing network of bicycle lanes has spurred a doubling of bike riding in the city since 1991. Yet even this city renowned for its progressive planning has not escaped sprawl: suburbs now contain most of the area's residents and half its jobs. During the 1980s, the total miles driven in the metropolitan area increased by 55 percent. In the mid-1990s, sprawl continued to overtake Portland-area lands, but at less than half greater Seattle's rate.[83]

Despite the relentless worsening of traffic—the Pacific Northwest's dominant source of air pollution—the region's air is, in general, cleaner than in many parts of North America. Idaho, for example, ranked first in air quality in a national environmental health comparison. And while more gasoline use inescapably means more carbon dioxide emissions, tighter controls on tailpipes and smokestacks have succeeded in reducing emissions of many common pollutants. Northwest cities no longer suffer from the darkening clouds of coal and wood smoke of the early twentieth century; experts compared breathing in 1960s Portland to smoking a pack of cigarettes a day. Burning grass-seed stubble in the Willamette Valley—but not in eastern Washington, where field burning remains a major public health concern—has been slashed by nearly 90 percent since the 1960s, and many small towns have dramatically improved their wintertime air quality with tighter regulations on woodstoves and their use. Lead concentrations in urban air have dropped dramatically with the phaseout of leaded gasoline.[84]

In many Northwest cities, air quality has been improving steadily for a decade or more. By the mid-1990s, few

areas in the Northwest states exceeded federal air quality standards for ozone, carbon monoxide, or small particulates—three common health-threatening pollutants. Yet after dropping for years, the region's emissions of carbon monoxide have stabilized (at more than two million tons annually) as the growing number of tailpipes swamp regulatory and technological progress. Moreover, breathing is still a health-threatening activity for many northwesterners. Studies in Greater Vancouver have found that a 25 percent reduction in particulate matter in the air would prevent more than 2,700 premature deaths and 33,000 emergency-room visits over the next 30 years. Indoor air pollution consistently ranks as one of the top environmental threats to human health in the Northwest. Hospitalization rates for asthma—a disease associated with both outdoor and indoor pollution—are rising much faster in Washington than elsewhere in the United States, and dramatically faster among minority children in inner-city neighborhoods.[85]

Actual monitoring of most airborne substances, other than the few chemicals that lead to smog or acid rain, is rare. Pollution modeling by the U.S. EPA suggests that residents of Portland and much of western Oregon may be breathing in concentrations of 12 hazardous air pollutants (including benzene, carbon tetrachloride, and formaldehyde) that are more than 10 times higher than health standards set in the 1990 Clean Air Act. Car and truck exhaust, especially diesel, is a leading source of benzene and many of the other hazardous substances.[86]

Urban pollutants also find their way underground, into water supplies. Two-thirds of 100 shallow wells sampled since 1991 in the Boise area tested positive for bacteria, a sign that

waters have been fouled by human or animal wastes. Most Boiseans draw their water from a deep, uncontaminated aquifer that has escaped carcinogens and bacteria found in parts of the shallow aquifer. But accelerated pumping of deep water could suck pollutants down from the upper aquifer.[87]

One noticeable improvement in the health of urban environments is that many cities have cleaned up their most polluted rivers and lakes. For much of this century, the Boise River was a floating dump, reeking of dead fish, rotten bark, and garbage. Free of the raw sewage and factory waste that once poured into it, the river is now a recreation destination and source of civic pride for Boise's people (just as the Willamette River and Lake Washington are now sources of pride in Portland and Seattle). The Idaho Power Company's impassable dams still lie downstream, however, and Boise remains devoid of the salmon it is now clean enough to welcome home.[88]

C O A S T

Past the pulp mills, fog-shrouded clearcuts, and small towns of the Coast Range, Chinook 736 enters the Columbia River estuary, the violent tumble of waters where the Columbia hits the Pacific Ocean. Even for a fish that has waited for weeks to get here, the mouth of the Columbia is a shock, as the environment changes quickly from fresh water to salt.

The new arrivals tend toward brackish (less salty) waters as they develop saltwater survival skills. Chinook 736 moves with the tide to stay near a marsh's edge. The grasses of the marsh help hide it from hungry mackerel and shorebirds, especially in the churned-up tidal waters, where visibility is limited. Marshes also house its favored prey—insects, sand fleas, and Dungeness crab larvae. Compared with salmon that migrated at a younger age to the estuary, 736 progresses quickly to eating fish. Before long, it will head for the open ocean.

In the middle of the broad estuary, U.S. Army dredges haul up tons of sand and silt from the 40-foot-deep navigational channel. At the estuary's mouth, two jetties jut into the ocean, straining to tame the great river's flow. Constant digging, dumping, and building have made the river mouth safer for ships but less hospitable to fish. About a third of the estuary's area has been walled off from the influence of the tides; diking

and filling have eliminated two-thirds of its tidal marshes. Millions of cubic yards of dredged materials have buried underwater habitats for crabs, sturgeon, and other species and even created islands near the mouth of the Columbia. The new islands have become home to what may be the world's largest colony of Caspian terns, black-capped seabirds that feast on young oceanbound salmon as they pass the islands. The colony will likely grow even larger if the Army Corps of Engineers goes forward with plans to deepen the river channel another three feet.

SINCE HUMANS FIRST WALKED OR PADDLED TO THE Pacific Northwest, fertile lands and waters have drawn people and settlements to the coast. Relatively few live on the exposed outer shore. Nearly half of the region's 15 million people live along one great inland sea, called Georgia Strait in British Columbia and Puget Sound in Washington, in which pollution and destruction of marine ecosystems are most pronounced.

Heavy runoff from the rain-soaked land and strong tides at this edge of the Pacific Ocean—the difference between high and low tide in Seattle is nearly 12 feet (4 meters)—push large volumes of water in and out of regional estuaries and bays. As a result, Northwest estuaries, where river water and tidewater mix, are some of the most productive living systems on Earth. In addition, the region's relatively well flushed waters have been spared the large-scale fish kills and algal blooms common on the East Coast.[89]

Yet large estuaries rank among the region's—and the world's—most endangered ecosystems; few remain in a natural state. Industrial activity anywhere upstream can affect

them; cargo ships regularly dump invasive species by the gallon into them, and the flat coastal land where they lie has long been favored for industrial and real estate development. In Alaska and British Columbia, much of the jagged, steep-sided coastline remains wild, and large intact estuaries like the Copper River and Stikine River deltas still support millions of shorebirds, anadromous fish, and other coastal species. But because of the steep terrain along this coast, most of its intertidal zones are relatively narrow and unproductive.[90]

Washington's Willapa Bay is one of the cleanest and least-degraded large estuaries in the lower 48 states and one of the world's five largest oyster-producing regions. But the loss of 30 to 50 percent of the bay's wetlands and the uncontrolled spread of a few species threaten the ecology and economy of the area. An alien cordgrass (*Spartina alterniflora*) has dispersed widely over shallow mudflats and could cover half the bay in 20 years, overgrowing habitat for shellfish, salmon, and various mudflat-dwelling organisms; it has spread as far north as Puget Sound. Less notorious but similarly disruptive are two native species, mud shrimp (*Callianassa californiensis*) and ghost shrimp (*Upogebia pugettensis*), whose populations have exploded—perhaps because chum salmon and sturgeon, both shrimp predators, have been badly depleted in Willapa Bay. By loosening sediments with their digging, the burrowing shrimp have converted 40 percent of the bay's mudflats to "shrimp deserts" that support a tenth the species they once did. Attempts to control *Spartina* and the shrimp with pesticides have sparked controversy in this area of clean water and rich fisheries.[91]

With a few notable exceptions—like the 9,000 escaped Atlantic salmon recovered from coastal waters between Wash-

ington and Alaska since 1994—scientists know very little about the extent of species invasions in Northwest waters (and even, in some cases, which species are native and which alien). Where researchers have done surveys, they have found

Plants on the Loose

Purple loosestrife (*Lythrum salicaria*), a Eurasian plant with striking magenta flowers and a talent for displacing native grasses and sedges as well as the waterfowl, mammals, and songbirds that depend on them, has invaded wetlands in British Columbia, Idaho, Oregon, and Washington. Idaho has reported this "noxious weed," known for its ability to spread quickly after years of relative dormancy, in 21 of its 44 counties. In 1977 biologists reported a "handful of plants" in eastern Washington; by 1990, loosestrife covered more than 25,000 acres (10,000 hectares). It can resprout from broken stems or roots, and a mature plant can produce more than two million seeds a year. Despite a state quarantine against growing, selling, or transporting purple loosestrife, some Washington nurseries still sell it.[92]

Other than a few nuisance plants, such as the motorboat-snagging Eurasian water milfoil, species invasions are little monitored or documented. But alien plants—such as *Spartina* grasses in coastal marshes, Scot's broom and English ivy in urban lowlands, and knapweeds and cheatgrass in interior drylands—have affected most habitat types in the region. One out of five plant species in Oregon is a recent invader. Hundreds of invading plant species have compromised livelihoods ranging from oystering to cattle ranching and pose one of the most intractable threats to the preservation of native biodiversity.[93]

invaders—52 nonnative species in the waters and tidal areas of Puget Sound and five nonnative plants in Prince William Sound—but relatively few compared with many estuaries outside the Pacific Northwest. Native species probably still dominate the waters of Puget Sound and Prince William Sound, unlike the Great Lakes and San Francisco Bay, which have been overwhelmed by invading life-forms.[94]

Alien species do continue to arrive and to spread in Northwest waters, especially around major harbors. A single large cargo ship can discharge millions of gallons of ballast water—as well as plants, invertebrates, and microorganisms—taken on in a port thousands of miles away. Studies of Japanese ships docked in Coos Bay, Oregon, found 367 Asian species in their ballast water. To limit the chances of aquatic stowaways' surviving and spreading to Canadian waters, the Port of Vancouver in 1998 became the first in North America to require midocean ballast exchange; California followed suit in January 2000. Since 1999, the U.S. Coast Guard has requested (but not required) international cargo ships to exchange their ballast water before entering U.S. waters.[95]

At Vancouver's sprawling southern edge, the Fraser River delta is the largest river estuary on the west coast of North America and a key link in the Pacific Flyway. Several million ducks and shorebirds from 3 continents and 20 countries stop in the delta every year. The Fraser Delta is also British Columbia's most valuable farming area. Three-fourths of wetlands in the delta have been converted to agriculture. Burns Bog, the largest remaining wetland, is partially covered by the 1,000-acre (400-hectare) Vancouver city landfill, western Canada's largest garbage dump. Burns Bog's sole nature reserve contains less than 2 percent of the bog.[96]

Marshes, bogs, and other wetlands make up a small portion of the Pacific Northwest but play a large role in its ecological health by moderating floods, trapping sediments, and providing important wildlife habitat in both coastal and interior landscapes. Agricultural and urban development have greatly shrunk wetlands in the southern half of the region (see Table 2), but wetlands to the north remain largely untouched. About 70 percent of Puget Sound's tidal wetlands have been developed, and more than half the current annual loss of wetlands in Washington occurs in the Puget Sound basin.[97]

The Northwest coast generally has good water quality, but toxic chemicals and fecal bacteria contaminate sites scattered throughout the region. Millions of toilets in the Puget Sound–Georgia Strait basin send their contents, after vary-

Table 2. Wetland Losses in the Pacific Northwest

	Wetlands circa 1800 (thousands of acres)	Present wetlands	Wetlands lost (percent)
Idaho	880	390	56
Oregon	2,260	1,390	38
Washington	>1,350	940	>33
Southeast Alaska	4,670	4,660	0.3
British Columbia	n.a.	13,060	n.a.
W. Montana	n.a.	2,600	n.a.

One acre equals 0.405 hectare. Data for northwestern California not available; California as a whole has lost 91 percent of its wetlands. Sources: see endnote 97.

ing degrees of treatment in sewage systems, to the sea. Vancouver-area governments have upgraded two of their four sewage plants, thereby cutting by more than half the volume of combined sewage overflows (CSOs) that well up when heavy rains overwhelm sewage systems' capacity. Still, Vancouver-area CSOs dump 6 billion gallons (24 billion liters) a year into the surrounding salmon-filled waters, enough to fill Vancouver's B.C. Place stadium 12 times. Despite the upgrades, Vancouver's largest treatment plant, Iona Island, still provides only primary treatment (settling and skimming of solids) before releasing wastewater into Georgia Strait. Victoria does not treat its sewage at all, dumping more than 20 million gallons (76 million liters) of raw sewage into the Strait of Juan de Fuca every day. In contrast, wastewater treatment plants (featuring a series of artificial marshes) installed in the northern California towns of Eureka and Arcata in the 1980s have virtually eliminated the once-chronic CSOs into shallow Humboldt Bay.[98]

Sewage, among other substances, contaminates shellfish beds. Since the 1980s, close to one-fourth of Puget Sound's commercial shellfish harvesting areas have been closed because of fecal coliform bacteria. On the B.C. coast in recent years, health authorities have closed 230,000 acres (94,000 hectares) of shellfish beds (less than 2 percent of the provincewide total) because of the bacteria. Shellfish closures due to dioxin contamination in the province peaked in 1995 at nearly 300,000 acres (120,000 hectares); nearly half this area has now been reopened. The primary sources of dioxin in British Columbia, pulp and paper mills, have reduced their discharges provincewide by 85 percent or more since 1990; dioxin concentrations in great blue heron eggs, whitefish muscle tissue,

and Fraser River sediments have also dropped steeply. By law, all mills in B.C. will eliminate dioxin and other organochlorine discharges by 2003.[99]

Unlike dioxins, other toxic and persistent contaminants of coastal waters tend to settle to the bottom. This settling leaves the water column clean but sediments heavily contaminated. Bottom-feeding organisms—and the animals that eat them—are especially susceptible to toxic poisoning. At the top of the food chain, marine mammals are most at risk of consuming harmful amounts of pollutants. In 1999, scientists discovered that the orcas of northern Puget Sound and southern B.C. are among the most contaminated marine mammals on Earth. Their flesh contains far more PCBs than even the famously contaminated beluga whales of the St. Lawrence River, which flows out of the heavily industrialized Great Lakes, and up to 500 times more than the average North American human being. PCBs emitted before Canada and the United States banned the highly toxic chemicals in the 1970s linger in Northwest ecosystems; wide-ranging salmon preyed upon by some orcas may also transport PCBs of recent Asian origin from the North Pacific Ocean back to the inland waters of British Columbia and Washington.[100]

Near harbors and industrial sites, sediments are laden with heavy metals and organic chemicals that can cause varied illnesses in marine life and seafood consumers. Juvenile salmon in parts of Puget Sound ingest enough contaminants to suppress their immune systems. Most sole near oil refineries in Port Moody, B.C. (outside Vancouver), have precancerous tumors and lesions. Every female whelk (a sea snail) collected within a kilometer of 21 marinas and harbors throughout the Puget Sound–Georgia Strait basin in 1989

had developed male genitalia, apparently because of the highly toxic chemical tributyltin, found in antifoulant paints. Canada and the United States in 1989 banned the use of tributyltin paints on small boats but not on large ones. Follow-up studies in 1994 found fewer deformed whelks on the west coast of Vancouver Island but little or no recovery near major ports like Victoria and Vancouver.[101]

Contaminants usually enter the sea in small but ubiquitous pulses: every parking lot is an oil spill, for example. North America's largest incident of coastal pollution occurred in 1989 when Captain Joseph Hazelwood's drunk driving turned Bligh Reef in Alaska's Prince William Sound into a giant can opener. An estimated 11 million gallons (42 million liters) spilled out of the thin-hulled *Exxon Valdez* and into the unspoiled waters of Prince William Sound, eventually oiling some 1,500 miles (2,400 kilometers) of wild Alaskan coastline and killing as many as half a million birds and untold numbers of other animals. Ten years later, Prince William Sound appears clean and healthy to the untrained eye, but oil remains below the surface of some beaches and bays, and the majority of studied species—including Pacific herring, an important food source for 40 other species in the sound—have yet to recover fully. Today, all oil tankers running through Prince William Sound are escorted by two tugboats for safety. Yet only 3 of 28 tankers plying the sound have double hulls. These same tankers, along with a much greater number of giant container ships, motor unescorted through the narrow Strait of Juan de Fuca on their way to refineries and ports in Puget Sound.[102]

As with pollution impacts, information on the abundance or depletion of marine life is generally limited to species of

known economic importance. Marine fish populations have declined in Puget Sound since the mid-1980s: catches are at their lowest levels since World War II. Most marine fish populations appear to be healthy in B.C. waters, but lingcod and rockfish numbers have plunged in Georgia Strait. A variety of factors, including overfishing and continued loss of habitats like shallow-water eelgrass beds, have caused marine fishes' declines in the inland waters of both B.C. and Washington.[103]

Many seabird populations along the Pacific Northwest coast have also declined, some apparently responding to climatic fluctuations like El Niño, others to human impacts. Populations of Puget Sound's most common diving duck, the surf scoter, have fallen by at least half since 1979, possibly from feeding on heavy metal–contaminated shellfish. The most abundant breeding seabird in the Pacific Northwest is the common murre. Tuxedoed like penguins and shaped like footballs with wings, murres nest in large colonies on cliffs and inaccessible rocks. Their populations in Oregon and northern California are stable or rising, but along Washington's Olympic Peninsula, one of the longest undeveloped coasts in the United States, murre populations have plummeted by nearly 90 percent since 1979. Big oil spills in 1984, 1988, and 1991, along with fishing boats' gillnets (which snag the birds as they dive for fish) caused much of the decline. Warm seas during El Niño years in the 1980s and 1990s diminished the birds' food supplies and populations from California to Alaska, yet it is only on the Washington coast that common murres no longer live up to their name.[104]

O C E A N

Swept to sea by the plume of the Columbia, Chinook 736 swims north along the Washington and Canadian coasts to the Gulf of Alaska. It will spend three years in the ocean, moving with the gyre of the Alaska Current around the Northeast Pacific before returning to inland waters. An occasional glob of oil notwithstanding, the open ocean is the least-polluted habitat encountered by this well-traveled fish.

At first, 736 swims in the upwelling current that provides the Northwest coast its dense summer fog and draws cold, nutrient-rich water from the depths. Tiny plants, phytoplankton, flourish in these waters and become the flesh of filter-feeding crustaceans, then herring, then salmon. In this La Niña year, the waters stay cold and the upwelling currents strong, allowing the chinook to grow—and become less vulnerable to predators—quickly.

The chinook stays mostly near the coast, over the continental shelf, for a year, foraging for fish and crustaceans some 200 feet (60 meters) below the surface. As it matures, 736 swims far out to sea, where chinook, largest and fastest of the Pacific salmon, have few predators. A salmon shark catches 736's scent and briefly pursues the chinook but cannot match its sprinting speed of 15 miles (24 kilometers) per hour.

Chinook 736 also manages to avoid occasional orcas and the most advanced of salmon predators: fishing boats. Some trail nets; others, long lines barbed with hooks. The boats catch few Idaho fish, but many salmon, crabs, and other "non-target species" will be caught in trawlers' nets and tossed back to die. Mixed schools of fish often congregate in good feeding areas, as do the radar-equipped, satellite-linked boats above them.

After three years at sea, Chinook 736 heads south. The flow of the Columbia into the ocean is so great that hundreds of miles from its mouth, the fish already smells diluted clues that draw it back toward its final inland destination.

LIKE THE NORTHWEST'S HIGHEST MOUNTAIN PEAKS, the deepest reaches of its ocean floor are little degraded. Only recently have scientists discovered rich and bizarre ecosystems—fueled not by sunlight but by heat and chemicals from thermal vents—in deep waters off the Northwest coast. Bacteria discovered at the Endeavour Vents off Vancouver Island thrive at above-boiling temperatures in water devoid of oxygen. They may represent a distinct kingdom of life, separate from the animal, plant, fungus, and microbe kingdoms of the sunlit world.[105]

Closer to the surface, human activities have had greater impact. From estuaries to the continental shelf, trawlers scrape the ocean floor. Abnormally strong ultraviolet light bathes the shallows each spring. Toxic contaminants, though rare in the open sea, accumulate in the ocean's thin surface microlayer, where the buoyant eggs of many bottom-dwelling fish hatch. Plastic debris—from litter to cast-off fishing nets—also snags or chokes marine life.

The waters of the Northeast Pacific are relatively clean. The farthest-reaching human impacts have come from efforts to tap their living riches. The modern economy of the Pacific Northwest started at sea, with British and Russian fur traders chasing sea otters for their pelts. Overhunting eliminated the otter between southern California and the Aleutian Islands in the nineteenth century. It also catalyzed transformations of the offshore environment. Sea urchins, no longer controlled by otters, flourished and ate their way through coastal kelp beds. Large expanses of the coastal ocean floor, once kelp forest, have become barren rock.[106]

Some marine mammals—such as the gray whale, taken off the U.S. endangered species list in 1994—have largely recovered from past hunting, but others have not. Despite a half century's protection, the Northeast Pacific population of right whales (the "right" whales to hunt) may remain as low as a few dozen animals. Reintroduction of sea otters off the Oregon coast has failed, though populations off Southeast Alaska, Vancouver Island, and Washington have grown rapidly after otters were transplanted there. Where otters have returned, kelp beds have grown back, though they lack the biomass and diversity of seaweed in pristine kelp forests.[107]

Hunting fish and shellfish has replaced hunting marine mammals as the dominant economic activity in Northwest seas. The Northeast Pacific Ocean is enormous, and many of its species can withstand heavy fishing. Because of shifting ocean conditions associated with the long-term oceanic cycle known as the Pacific Decadal Oscillation, the mass of salmon in the Gulf of Alaska actually doubled from the late 1950s to the 1980s. Even so, industrial fishing fleets are depleting many fish species. Thirty-six of 38 types of fish caught off the U.S.

Pacific coast (excluding Alaska) are "fully utilized" or "over-utilized," according to the U.S. National Marine Fisheries Service: "There are simply too many boats and gear for the fish available."[108]

North of Oregon and Washington, where diminished salmon stocks have forced the closure of almost all salmon fisheries, salmon fishing remains a major industry. But bottom-dwelling fish (such as flounder; Pacific whiting, or hake; and various species of rockfish) are the industry's mainstay. Fishing for groundfish, especially, is a stab in the dark: boats haul up a wide range of species in their nets. To save room for the most profitable fish or shellfish, trawlers dump the rest, considered "bycatch," back into the sea, usually dead or injured. Bycatch tonnages are unknown but suspected to be much greater than the figures reported by the industry. New fishing regulations in British Columbia and Southeast Alaska in the mid-1990s greatly reduced the bycatch of at least one species, Pacific halibut, in those two areas. Still, boat owners in the central Gulf of Alaska reported throwing back roughly 300,000 dead halibut (weighing up to a quarter ton apiece) in 1997, equal to about an eighth of the area's intentional halibut catch. Shrimp trawlers have the highest bycatch rates of all: off the British Columbia coast, they commonly throw back 70 to 90 percent of the marine life they pull up.[109]

Most fishing boats do little harm to the habitats of the creatures they catch. But bottom trawlers and shellfish dredgers disturb huge areas of the ocean floor each year. These ships drag wide, massively weighted nets for miles across the ocean bottom, in the process filling them with tons of assorted marine life, rocks, and mud in addition to their target

catches of prawns and bottomfish like cod, sole, and rockfish (12 species of which are sold as "red snapper"). Studies are almost nonexistent for the Northeast Pacific, but if experience elsewhere is any guide, the trawlers working our offshore waters crush, bury, or expose bottom-dwelling organisms and profoundly disturb their habitats on a massive scale—possibly scouring more acres of productive habitat per year than are clearcut on land. As a recent review of trawling worldwide concluded, "There are few places in the world's continental shelves with commercially valuable fishery resources that have not been trawled or dredged."[110]

Overfishing during the past few decades has greatly reduced rockfish populations from California to Alaska. Slow-growing and long-lived (some up to 140 years), the 68 brightly colored species of Northeast Pacific rockfish are especially vulnerable to overfishing. Federal authorities drastically reduced the allowable catch of many rockfish species in California, Oregon, and Washington in 1999. In the Gulf of Alaska, Pacific ocean perch, shortraker rockfish, and other "slope" rockfish have not recovered from heavy foreign fishing in the 1960s because domestic boats still exploit them heavily. In Puget Sound, where more than 20 species of rockfish once thrived, one species, the Puget Sound rockfish (*Sebastes emphaeus*), now dominates many rocky reefs: the smallest rockfish, it is largely immune to fishing pressure.[111]

Overfishing occurs even in marine protected areas, which are usually less restrictive than parks on land. Recreational fishing, for example, has eliminated the entire adult population of rockfish in the Baeria Rocks Ecological Reserve in Vancouver Island's Barkley Sound. Until 1988 there were no entirely protected marine reserves—ones in which *all* organ-

isms are protected from harvesting—anywhere along the 33,000-mile (53,000-kilometer) coastline of the Pacific Northwest. By 1999 there were eight postage stamp–sized "no-take" reserves, such as the two-mile (three-kilometer)-long King Range marine reserve off northern California's Lost Coast, and one large reserve: the no-take wilderness areas established in 1999 inside Alaska's Glacier Bay National Park. No such protected areas exist anywhere along the heavily trawled continental shelf. With so few unexploited areas for comparison, we cannot know precisely what marine ecosystems should look like; neither can we learn how they work. Lacking this knowledge, we cannot gauge whether we are using the sea sustainably.[112]

For the most part, environmental degradation in the open ocean has been limited to the impacts of fishing and whaling. But in a few cases, humans have managed to change basic physical characteristics of the sea as well. The Columbia River pours enough fresh water into the Pacific to affect salinity and ocean temperatures from northern California to Canada. Its flow is so great—and its seasonal variation now so altered by upstream dams—that operation of the dams apparently affects the movement of oil spills in the Strait of Juan de Fuca (along the U.S.-Canada border). The dams' biological effects on ocean ecosystems, though little studied, are undoubtedly substantial. Irrigation in the Columbia Basin has reduced the river's annual input to the sea by 7 to 10 percent; hundreds of dams throughout the basin have restricted the flow of habitat-forming and beach-replenishing sand to the Pacific by an estimated 25 to 50 percent. Spring freshets and floods, which used to have major effects on the ocean floor, have been reduced or eliminated.[113]

R I V E R

The chinook rockets forward and catches a herring: its last supper. Once 736 crosses the Columbia Bar into fresh water, its throat closes and its body changes. It becomes recognizably female, heavy with eggs and lacking the male's hooked jaw. She swims among nonnative shad, which outnumber salmon in the lower Columbia River, to the base of Bonneville Dam. Here she tries to locate the fish ladder that enables her to surmount the big dam and cruise past its reservoir. Going up the dams is easier than going down: only a third of the returning adults will die on the upriver trip. Past the dams and into the Salmon River she charges, bashing herself until she finds the exact route up each rocky cascade. She occasionally makes a wrong turn but heads back downstream until finding her way, drawn on by the familiar smells of her original journey to the sea. On the upstream trip, 900 miles against the current and 6,500 feet (2,000 meters) uphill, she will lose a third of her body weight before spawning within a stone's throw of her Stanley Creek birthplace.

Two exhausting months after entering the Columbia, 736 must fight other females for a suitable mate and a place for her eggs. She settles on a spot at the downstream end of a riffle and waits for a mate. When their courting is completed, she turns

on her side and thrashes. Her tail strokes flush away gravel, leaving a nest in which she deposits eggs. Her mate immediately fertilizes them. She moves just upstream, turns over, and snaps her tail again. Gravel flies downstream, covering the first few hundred eggs and leaving another gravel bowl in which she deposits the next batch. She and her mate repeat this dance until all her eggs are deposited, fertilized, and covered.

Her journey is complete; Chinook 736 has passed on her genes. She may guard the redd for several hours, but her decaying flesh already signals that death awaits. Even in death, her story continues: her carcass feeds animals along Stanley Creek, including insects that will nourish a new generation of salmon as they begin the cycle again.

IN MUCH OF THE NORTHWEST, THE PHYSICAL, CHEMIcal, and biological makeup of rivers and lakes has been radically transformed. With the exception of reservoirs created behind dams, these changes often go unnoticed. Temperature, water quality, and underwater habitats—all critical to the survival of aquatic life—can be fundamentally altered without much change in surface appearance.

The Pacific Northwest is a world center of hydroelectricity production, with the Columbia River and its tributaries making up the largest hydropower system ever built. From Bonneville Dam to Lewiston, Idaho, reservoirs have submerged 320 continuous miles (520 kilometers) of the Columbia and Snake Rivers' riparian habitats. Behind each of the 211 major dams in the Columbia Basin, the currents required by river-adapted species no longer flow. Below most of the dams, springtime floods no longer scour channels of sediment, replenish floodplains with sediment-borne nutrients,

or moisten the seedlings of riparian plants. A recent review of the Snake, Columbia, and other major western rivers concluded that, because of the dams, "riparian ecosystems along these major rivers have largely collapsed, and remnants occur only where local conditions favor their persistence." [114]

Dams have largely replaced salmon as a dominant feature of the Columbia and its tributaries, once home to the world's largest runs of chinook salmon and steelhead. In the Columbia Basin, dams have blocked salmon from more than a third of their former range and eliminated untold numbers of distinct salmon stocks. The Columbia once supported 10 to 16 million returning salmon; in 1997 only 1.1 million returned, and about three-fourths of these were hatchery-reared fish, lacking the distinctive genetic traits of their wild cousins. Hatcheries built to mitigate dam impacts have actually worsened pressures on wild salmon: hatchery fish compete with, interbreed with, transmit disease to, and lead to overfishing of their wild relatives as they swim in mixed schools.[115]

Both dams and diversions have altered the life-giving flows of Northwest rivers. Each year, 30 to 70 percent of water in the Nechako River in central British Columbia (third-largest tributary of the Fraser) is siphoned off and piped to the coast to power an aluminum smelter. Northern California's Potter Valley Project diverts up to 85 percent of the upper Eel River's flow, via a mile-long tunnel and a power plant, into the Russian River to its south. Until 1994, as much as 90 percent of California's Trinity River (the main tributary of the Klamath) was diverted to farms in California's Central Valley; today 75 percent is.[116]

British Columbia's Fraser and Skeena Rivers are the biggest salmon producers in the Northwest. The Fraser River's

watershed (covering one-fourth of British Columbia) has been treated much the same as the Columbia Basin to the south: protected areas in the headwaters, grazing and pulp mills midstream, dredging and urban development downstream, and logging and mining throughout. Salmon populations in the Fraser system have fallen to 15 percent of their former levels; in the 1990s, an average of nine million salmon, mostly wild, have returned to the Fraser each year. Though dramatic, this decline is less severe than in the Columbia, where wild salmon populations have fallen to 2 or 3 percent of their historical abundance. The main difference: there are no dams on the Fraser or most of its major tributaries.[117]

Like the Fraser, many undammed coastal streams have greatly reduced fish populations. Coho salmon (which spawn in small streams) have declined throughout the Northwest states and British Columbia. Even though 99 percent of salmon streams in coastal Oregon flow free, these streams produce less than half the historic level of coho, primarily because of sedimentation and other impacts of logging.[118]

Timber extraction has damaged streams and rivers across the Northwest. Surveys of the Oregon and Washington Cascades after a major winter storm in 1996 revealed that watersheds with logging roads or recent clearcuts underwent many more landslides and debris torrents (walls of water, mud, boulders, and even trees rushing downstream, scouring stream channels as they go) than unlogged watersheds. In some areas of the Idaho panhandle, logging has unleashed so much rock and sediment that streambeds go dry in the summer: all water flows beneath the rock piles. In 1990, Panhandle National Forest experienced five 200-year floods (so severe that they are expected to recur only once every two

centuries) in logged watersheds. Unlogged watersheds suffered only modest increases in stream flow. The U.S. Forest Service considers roughly two-thirds of the watersheds in national forests in northern Idaho and western Montana as "degraded" or "marginal."[119]

Logging and grazing have eliminated many rivers' and streams' deep pool habitats—a pervasive, though little-noticed, degradation. Logging eliminates the fallen logs that create pools (where juvenile fish of many species rear and survive winter's cold); along with road building and grazing, logging also fills pools with sediment. In addition, as recently as the 1970s, well-intentioned but ecologically harmful "stream restoration" projects removed logjams and other woody debris mistakenly believed to be blocking salmon's ascent to their spawning grounds. Today, most of the large, deep pools that existed 50 years ago in the Columbia River basin are gone. Oregon's heavily grazed Grande Ronde River basin and the upper Willamette Valley, extensively logged since the 1930s, have suffered especially severe losses. In streams that flow across private forestland in Oregon's Coast Range, the number of large, deep pools has declined by 80 percent since midcentury. As a result of degraded watersheds and fish habitat in Oregon, biologists consider 25 of the state's 57 native freshwater fish species as threatened with extinction.[120]

One indicator of overall watershed health is the bull trout (*Salvelinus confluentus*), a cold-water predator sensitive to changes in water quality, especially increased sedimentation. Its known range once defined a fairly precise outline of the Pacific Northwest; it now swims in about half that area. Most remaining populations are also declining: bull trout in the Klamath and Columbia river basins were listed as threat-

ened species in 1998, Puget Sound bull trout in 1999. With few exceptions, healthy bull trout populations remain only in roadless areas. Where logging or road building has taken place, bull trout are extinct or nearly so. Remaining roadless areas are exceptionally important for bull trout and a variety of other sensitive species, both on land and under water.[121]

Cities, mines, farms, and other sources have poured a wide variety of chemicals into Northwest rivers from headwaters to estuaries. The largest Superfund hazardous waste site in the United States is a 100-mile (160-kilometer) stretch of the Clark Fork River below the abandoned copper mines of Butte, Montana. Heavy metals from mine tailings have contaminated drinking water and still kill large numbers of fish in the Clark Fork after heavy rains. At the other end of the Columbia Basin, sediment concentrations of eight different metals in the lower Columbia River are high enough to harm river life.[122]

Northern Idaho's Lake Coeur d'Alene has some of the worst heavy-metal pollution ever documented, according to the U.S. Geological Survey. A century of mining in the surrounding valley has deposited 75 million tons (68 million metric tons) of sediment heavily laden with lead, cadmium, mercury, and other metals on the lake floor, and more metals continue to wash into the lake. Many of the United States' largest silver and lead producers were found along the South Fork of the Coeur d'Alene River. In 1973, a fire destroyed pollution controls at one of these lead smelters, which operated for another 18 months and poisoned people throughout the Silver Valley, including 2,000 children exposed to record levels of lead. Many of those children—now in their 20s and 30s—have severe learning disabilities and a range of other nervous disorders and health problems.[123]

Today 500 abandoned mine sites and tailings piles in the Coeur d'Alene basin send heavy-metal dust into the air, the lake, and the Spokane River downstream. Health authorities closed some recreational beaches along the Coeur d'Alene River and posted warning signs along the upper Spokane River in 1999 because of severe lead contamination. On a single day in February 1996, floodwaters washed 500 tons of lead into Lake Coeur d'Alene. Water quality in the lake remains relatively good because most of the metals settle onto the lake floor. But bottom feeders, such as swans, take in large amounts of toxic sediment. In the first six months of 1997, biologists found nearly 200 swans killed by lead poisoning. The metals can redissolve in toxic form if nutrients carried downstream from continued logging and residential development in the lake's watershed promote algal blooms and deplete the lake's oxygen.[124]

Throughout the Pacific Northwest, lakes and ponds have received much less scrutiny than rivers. Even the most cursory information on water quality is available for only about 2,000 of the 10,000 lakes in Montana. In just a few cases—such as Flathead Lake, the largest and one of the cleanest freshwater lakes in the western United States—do scientists know the basic conditions of northwestern lake ecosystems. Though scientific data are lacking, increasing impacts on lakeshore habitats and water quality are likely: residential developments in the lake regions of western Montana, especially the Seeley, Swan, and Flathead Valleys, are growing rapidly.[125]

Quite apart from unintentional pollution, many Northwest lakes have been deliberately poisoned to kill native fish and introduce trout for anglers. Fortunately, "lake rehabilitation," as this practice was called, is no longer common and

was always too expensive to carry out in large lakes. But its effects persist. In southern British Columbia, "rehabilitation" was so common that few lowland lakes now support their original fish communities. In the 1950s and 1960s, Idaho's Department of Fish and Game poisoned several lakes and installed barriers to stop sockeye, the only lake-spawning salmon, from returning. Today, despite restoration efforts, sockeye return to only one lake in Idaho. Only three times in the 1990s has more than one sockeye made it to Redfish Lake—and never more than two females in a given year. (The first year that only one fish arrived, he was nicknamed "Lonesome Larry" and mounted in the state capitol.) Dams and lake "rehabilitation" have nearly succeeded in eliminating sockeye from the state of Idaho. In contrast, Shuswap Lake and the other large lakes at the top of the undammed Fraser River were never poisoned; today they sustain the world's largest sockeye runs.[126]

Healthy salmon runs—and the healthy ecosystems they reflect—can still be found in the Pacific Northwest, but they have become rare in much of the region. A comprehensive study of salmon in California, Idaho, Oregon, and Washington concluded that in only 6 percent of their collective range are most salmon stocks in good condition. In 38 percent of this range, all salmon are extinct, and in 56 percent most stocks are imperiled or extinct. At least 106 major salmon stocks are extinct in these states, and more than 200 others face some risk of extinction.[127]

Less-comprehensive information is available farther north, though it is safe to say that salmon stocks—and aquatic ecosystems—in Alaska and northern British Columbia are faring better than those in the south (see Figure 9). Though

logging and mining have made inroads, the northern end of the Pacific Northwest still boasts large rivers—like the Alsek, Copper, and Taku—that flow clean and fast to the sea through nearly intact landscapes. Such rivers support their native species in abundance.

Little is known about the health of 90 percent of Southeast Alaska's salmon stocks, but a 1996 review of the better-documented stocks rated only 4 percent of them depressed in numbers and only 1 percent threatened with extinction. In British Columbia, information is available on roughly two-thirds of the province's 9,600 salmon stocks. Nearly 2,000 of them are either extinct or at least moderately threatened with extinction, with threatened and extinct stocks concentrated in the urbanized Georgia Strait and in heavily logged areas of Vancouver Island, the central B.C. coast, and Haida Gwaii (Queen Charlotte Islands). Provincewide, one-third of sea-run cutthroat trout stocks for which data are available, one-fifth of coho, and one-sixth of chinook are at least moderately threatened with extinction.[128]

Overfishing, unusually warm waters, and other offshore threats also reduce salmon populations. Yet the general patterns of decline among salmon and other fish make clear that loss and degradation of freshwater habitats are driving these fishes' decline in vast areas of the Pacific Northwest. In general, the farther inland a salmon stock spawns and the more time it spends in freshwater habitats, the worse off it is; many species that spend their entire lives in fresh water are in worse shape than those that, like salmon, spend most or all of their lives at sea.[129]

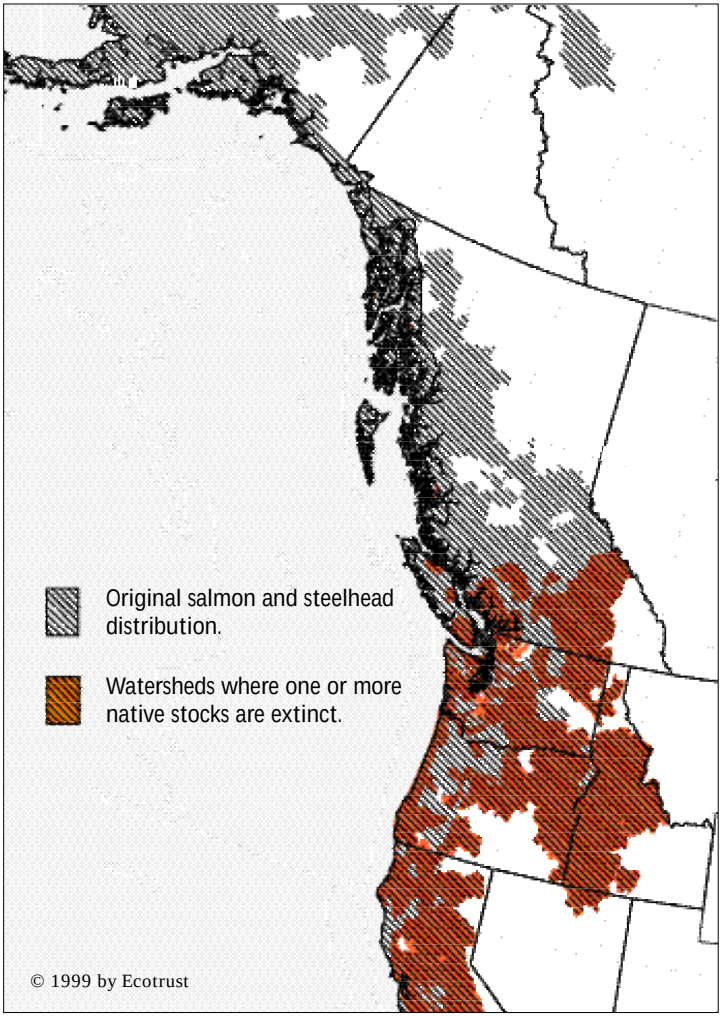

Figure 9. The Shrinking Range of Pacific Salmon
Human activities have hit salmon hard in the southern and inland watersheds of the Pacific Northwest. Source: see endnote 127.

A Northwest Transformed

Ecosystems are inherently complex, and they are poorly monitored. As a result, *State of the Northwest*—an attempt to describe overall ecological conditions across this broad region—provides an incomplete picture. How well the natural systems at the base of the Northwest economy are functioning remains to some degree unknown. And the actions northwesterners are taking to address environmental degradation, though numerous and often path-breaking, are beyond the scope of this book. (To learn what the region is—and could be—doing about its ecological predicament, see the Northwest Environment Watch titles listed at the front of this book.)

What we do know about the region's life-support systems is striking. As this book has documented, economic development in the Pacific Northwest has depleted much of the region's natural capital. In many cases, by depleting our natural assets, we have reduced both biological diversity and our economy's ability to satisfy human needs. Biological communities have been disrupted. Basic physical characteristics such as temperature and flow of water on land and at sea have been altered. The chemical composition of the atmosphere and of living things themselves has been rewritten. In

part, the Northwest economy's shift away from resource extraction industries reflects natural systems' diminished ability to support such livelihoods.

A pattern stands out. Once dominated by biological giants, the natural endowment of the Pacific Northwest has been *belittled*, made small, to a degree that few people appreciate. Stupendous lowland old growth has given way to stands of trees never destined to reach the age or size of their forebears. Old-growth forests remain mostly on thinner soils, steeper slopes, or in colder climates lacking the productivity and diversity of the lost lowlands.[130]

Just as young trees have replaced old-growth forests, grazing has converted tall perennial grasslands into swaths of short annual grasses and invasive species. Like tree farms cut every few decades, grasslands are grazed well before their longer-lived species mature, and seldom rested long enough to recover the diversity that comes with age.

Chinook salmon off the Oregon and Washington coasts are, on average, half the size of their ancestors 75 years ago. Likewise, sturgeon are smaller and less abundant. In many taxonomic groups, the largest species have been the most depleted: grizzly bears among the Carnivora, humpbacks among the whales, lingcod among the bottomfish. Former *Seattle Times* writer Bill Dietrich's observation on forests is apt for Northwest flora and fauna as a whole: "We have downsized our vegetation and are living in a pygmy world."[131]

The point here is not to bemoan irretrievable losses but to combat our social amnesia concerning what the land *can* look like, to provide context for the present state of the Northwest environment. Bigger is not necessarily better, but smaller organisms often reflect ecosystems whose productivity has been

degraded. Downsizing has also meant the loss of ecosystem functions, many of which we can only guess. If drastically fewer and smaller salmon give their ocean-fed flesh back to the land, how will that loss eventually impoverish the forests, deserts, or human communities to which they return?[132]

Nonetheless, the Pacific Northwest has yet to entirely liquidate its natural inheritance. It still offers more old-growth forest than any other part of North America. More temperate rainforest than anywhere in the world. Ecosystems that, as far as we know, still sustain the full complement of lifeforms—from top predators on down—that European settlers encountered. Unlike major estuaries elsewhere in the United States, the waters of Puget Sound and Prince William Sound are apparently still dominated by native species, not invaders from afar. And the Northwest's air is generally cleaner than elsewhere in North America.[133]

In Southeast Alaska live the world's densest concentrations of grizzly bears and bald eagles; the continent's densest concentrations of birds of prey nest in the Snake River basin. British Columbia and Idaho encompass some of the largest roadless areas in North America. Though greatly reduced, salmon runs and conifer forests in the Northwest have no equals.[134]

In short, options long lost to most of the industrial world still exist here. The Pacific Northwest still possesses much of its wealth of wild genes, native species, and natural processes. With this endowment we have a chance—fleeting, but still better than perhaps anywhere in the world—to revive tattered ecosystems and to build a durable economy, one that can be sustained indefinitely by its Producer.

APPENDIX

About the Salmon Story

UNTIL THE TIME OF UPSTREAM MIGRATION, A salmon's sex is not apparent to a casual observer. Accordingly, the pronoun *she* is not used until near the end of Chinook 736's story. The salmon story is based on the author's personal observations, conversations with biologists and conservationists, and the following published sources:

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124. Michael Satchell, "Taking Back the Land That Once Was So Pure," *U.S. News and World Report,* May 4, 1998. Swans from Laura Shireman, "CdA Basin Scoured for Dead Birds," *Spokane Spokesman-Review,* March 29, 1998. Spokane River from *Transitions* (Lands Council, Spokane), June 1998. Closures and signs from Karen Dorn Steele, "Warnings Posted on River," *Spokane Spokesman-Review,* July 14, 1999; and Zaz Hollander, "Kids' Lead Levels Prompted Campsite Closings," *Spokane Spokesman-Review,* July 9, 1999.
125. Montana Environmental Quality Council, *House Joint Resolution 17: Lakeshore Development Study,* Helena, 1992.
126. Lake poisoning from J. D. McPhail, "The Nature and State of Biodiversity in the Freshwater Fishes of British Columbia," in Fenger et al., eds., op. cit. note 3; and Barker, op. cit. note 78. Redfish Lake returns from Peter F. Hassemer et al., "Idaho's Salmon: Can We Count Every Last One?" in Stouder et al., eds., op cit. note 7; Jeff Heindel, Idaho Dept. of Fish and Game, Eagle, private communication, April 21, 1999; and "Sockeye Make It Back to Idaho," *Spokane Spokesman-Review,* Nov. 22, 1999. Largest sockeye runs from Northcote and Atagi, op. cit. note 7.
127. *Pacific Salmon and Federal Lands,* op. cit. note 118; Willa Nehlsen et al., "Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington," *Fisheries,* March–April 1991. Figure 9 courtesy Dorie Brownell, Ecotrust, Portland; used with permission.
128. Timothy T. Baker et al., "Status of Pacific Salmon and Steelhead Escapements in Southeastern Alaska," *Fisheries,* Oct. 1996; T. L. Slaney et al., "Status of Anadromous Salmon and Trout in British Columbia and Yukon," *Fisheries,* Oct. 1996. Slaney et al. counted

as extinct only stocks not observed for at least a decade and gave 920 salmon stocks, last observed in the late 1980s, a status of "unknown." I count these stocks as moderately threatened with extinction. Cutthroat, coho, and chinook from *Environmental Trends in British Columbia 1998,* op. cit. note 16.

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130. Old growth from Norse, op. cit. note 3.
131. Chinook size from Alkire, op. cit., note 7. Sturgeon from Andrew Harcombe, "Describing Rarity: The Ranking Dilemma and a Solution," in Harding and McCullum, eds., op. cit. note 3; Apperson, op. cit. note 8; and Charlie Ray, Idaho Rivers United, McCall, Idaho, private communication, May 25, 1994. Other species from Harding, op. cit. note 90; and Dietrich, op. cit. note 6.
132. Degraded productivity from Harding, op. cit. note 90.
133. Old growth based on Sandra Postel and John C. Ryan, "Reforming Forestry," in Lester R. Brown et al., *State of the World 1991* (New York: W. W. Norton, 1991). Rainforest from Moore, op. cit. note 47. Life-forms from Friedman and Lindholdt, eds., op. cit. note 24. Waters from Hines et al., op. cit. note 94; and Berry, op. cit. note 94. Cleaner air based on sources in note 81.
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