United States Environmental Protection Agency
Office of Research and Development Washington, DC 20460
EPA 600/R-02/045(a)
August 2002

Willamette Basin Alternative Futures Analysis

Environmental Assessment Approach that Facilitates Consensus Building

Alternative futures analysis is an environmental assessment approach for helping communities make decisions about land and water use. Its role is to provide a long-term, large-area perspective on the combined effects of the multiple policies and regulations affecting the quality of the environment and natural resources within a geographic area.

The alternative futures process helps community members articulate and understand their different viewpoints, priorities, and goals. The product of the process is a suite of alternative "visions" for the future expressed as maps of land use and land cover that reflect the likely outcomes of the options being advocated. Potential effects of these alternative futures are then evaluated for a wide array of ecological and socio-economic endpoints (i.e., things people care about). By capturing the essential elements of a complex debate in a fairly small number of alternative futures, and combining them with an objective evaluation of the consequences of each choice, this process can help groups move toward common understanding, and possible resolution and collective action.

Here we summarize results from an alternative futures analysis conducted in the Willamette River Basin in western Oregon. The project was funded by the U.S. Environmental Protection Agency (EPA) and conducted by the Pacific Northwest Ecosystem Research Consortium, consisting of scientists from EPA, Oregon State University, and the University of Oregon. More details on the project can be obtained from Hulse et al. (2002); data can be downloaded from http://oregonstate.edu/dept/pnw-erc/.

Why the Willamette River Basin?

The Willamette River drains an area of nearly 30,000 km^2 between the Cascade and Coast Range Mountains in western Oregon (Figure 1). Although the Basin accounts for only 12% of the land area in Oregon, it produces 31% of the State's timber harvests and 45% of the market value of agricultural products, and is home to 68% of Oregon's population. At the same time, the Basin contains the richest native fish fauna in the State and supports several species federally listed as threatened or endangered, including the northern spotted owl, spring Chinook salmon, and summer steelhead trout.

Two-thirds of the Basin is forested, predominately in upland areas. Much of the lowland valley area has been converted to agricultural use (43% of the valley area) and urban and rural development (11%). Oregon's three largest cities, Portland, Salem, and Eugene-Springfield, are located in the Valley, adjacent to the Willamette River. About 2.0 million people lived in the Basin in 1990. By 2050, the Basin population is expected to nearly double, placing tremendous demands on limited land and water resources and creating major challenges for land and water use planning.

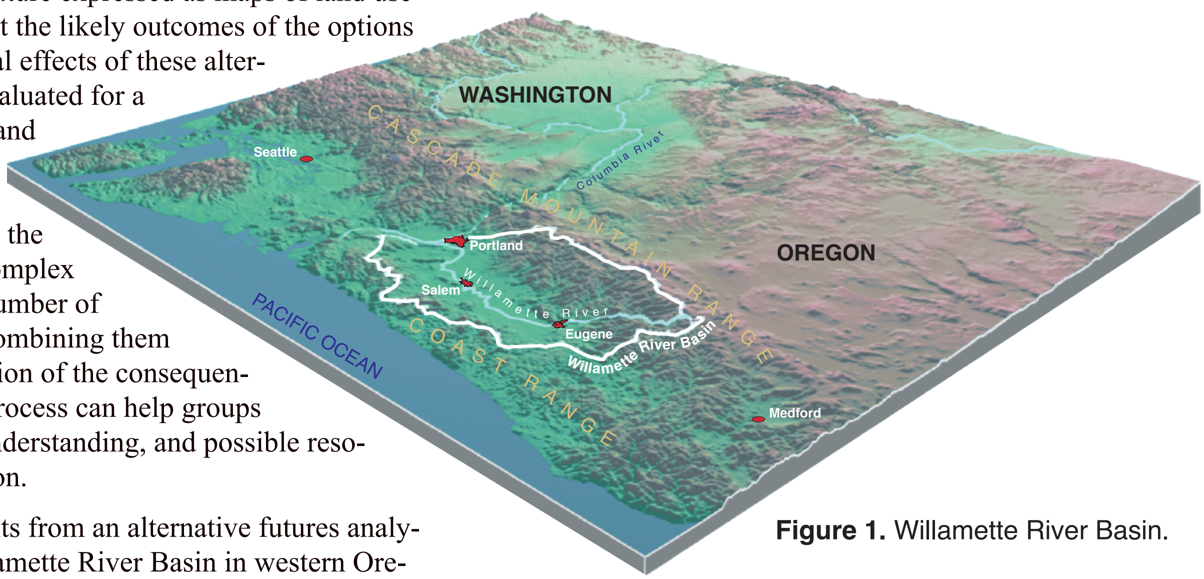


Figure 1. Willamette River Basin.

Recognizing the need for an integrated strategy for development and conservation, Oregon Governor John Kitzhaber initiated several basin-wide planning efforts in the mid-1990s. Kitzhaber created the Willamette Valley Livability Forum in 1996 to develop and promote a shared vision for enhancing the livability of the Basin (http://www.wvlf.org). Members of the Forum were selected by the Governor to represent the cross-section of interests in the Basin. Members included private citizens, as well as representatives of industry and business, nonprofit organizations, and local, state, federal, and tribal governments.

The Willamette Restoration Initiative was established in 1998 to develop a basin-wide strategy to protect and restore fish and wildlife habitat, increase populations of declining species, enhance water quality, and properly manage floodplain areas – all within the context of human habitation and continued basin growth (http://www.oregonwri.org). The Forum and Restoration Initiative served as the primary clients ("stakeholders") for the alternative futures analysis, providing input into design of the futures and, hopefully, benefiting from the results.

Overview of the Alternative Futures Process

An alternative futures analysis involves three basic components or steps (Figure 2): (1) characterizing the current and historical landscape in the area and the trajectory of landscape change to date, (2) developing two or more alternative "visions" or scenarios for the future landscape that reflect varying assumptions about land and water use and the range of stakeholder viewpoints, and (3) evaluating the likely effects of these landscape changes and alternative futures on ecological and socio-economic endpoints.

The current landscape of the Basin (ca.1990) was characterized, using satellite imagery to assess land cover and additional data on land use, as a map with 64 classes of land use and land cover. Based on historical data and survey records, we also mapped (1) pre-EuroAmerican settlement vegetation in the Basin (ca. 1850), (2) Willamette River channel and riparian vegetation for 1850, 1895, 1932, and 1995, and (3) human population densities in the Basin in 1850, 1930, 1970, and 1990. These historical reconstructions provide important information about bio-physical and socio-economic processes that may constrain future landscapes, and also provide stakeholders with a better perspective for interpreting the significance of projected future changes.

The future landscapes were designed with stakeholder input to illustrate major strategic choices. They were not intended as predictions, but rather to bracket the range of plausible policy options. Oregon has a strong statewide program for land use planning and a history of conservation-oriented policies. However, some stakeholders believed that even greater emphasis on natural resource protection and restoration was warranted to counteract continued loss of natural habitats and decline in native species as human populations in the Basin expand. Other stakeholders, in contrast, felt that current land and water use policies were too restrictive, unnecessary, and an infringement on individual property rights. This basic dichotomy in stakeholder viewpoints, between a desire for greater environmental conservation versus the desire for more personal freedom, set the stage for scenario development.

Three alternative futures were designed and projected at 10-year time steps through the year 2050. Plan Trend 2050 represented the expected future landscape should current policies be implemented as written and recent trends continue. Development 2050 reflected a loosening of current policies,

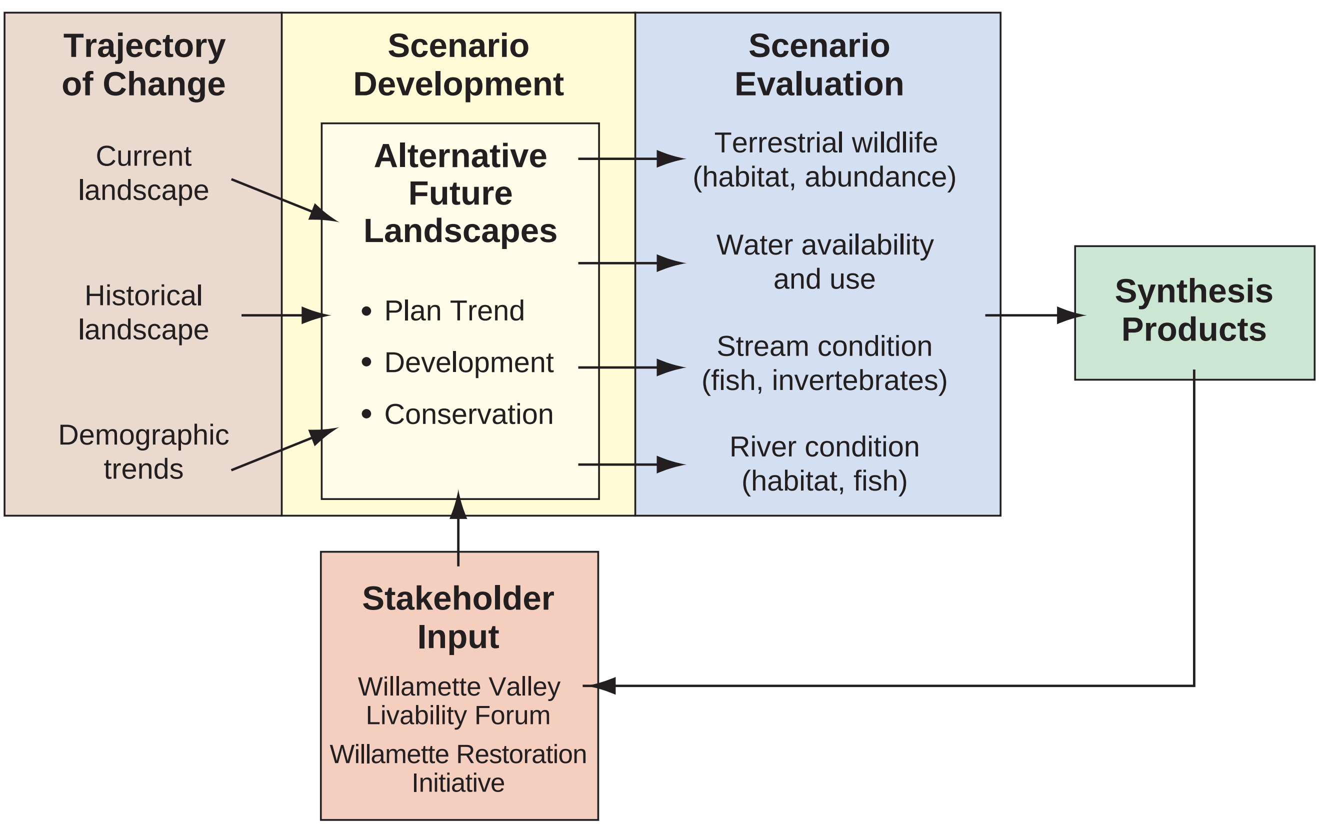


Figure 2. Alternative futures analysis process, as applied in the Willamette River Basin.

to allow freer rein to market forces across all components of the landscape, but still within the range of what stakeholders considered plausible. Conservation 2050 placed greater emphasis on ecosystem protection and restoration although, as with Development 2050, still reflecting a plausible balance among ecological, social, and economic considerations as defined by stakeholders. All three futures assumed the same population increase, from 2.0 to 3.9 million people by 2050.

The historical, present-day, and future landscapes were represented as maps using a consistent classification scheme and resolution (Figure 3), and associated written assumptions about management practices and water use. Computer simulations, as in Figure 4, also help stakeholders visualize the future.

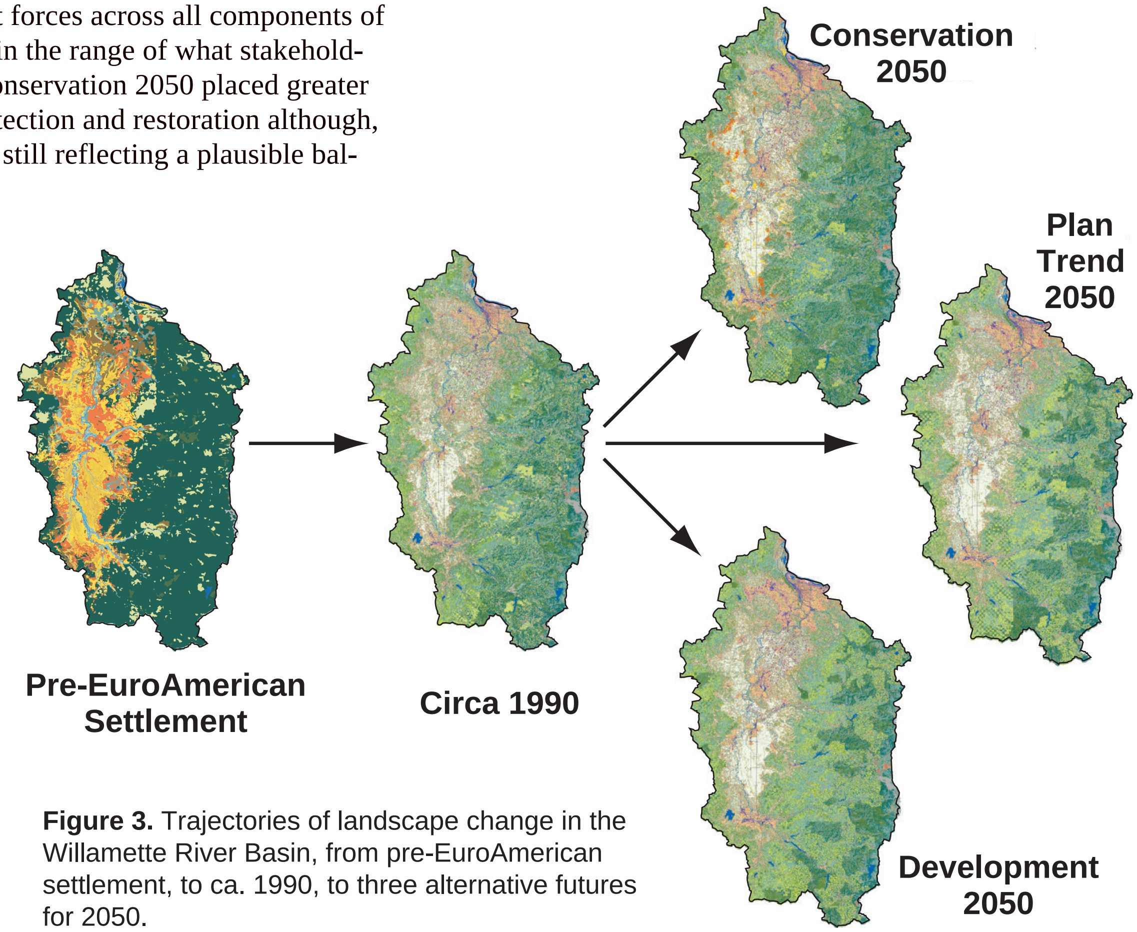


Figure 3. Trajectories of landscape change in the Willamette River Basin, from pre-EuroAmerican settlement, to ca. 1990, to three alternative futures for 2050.

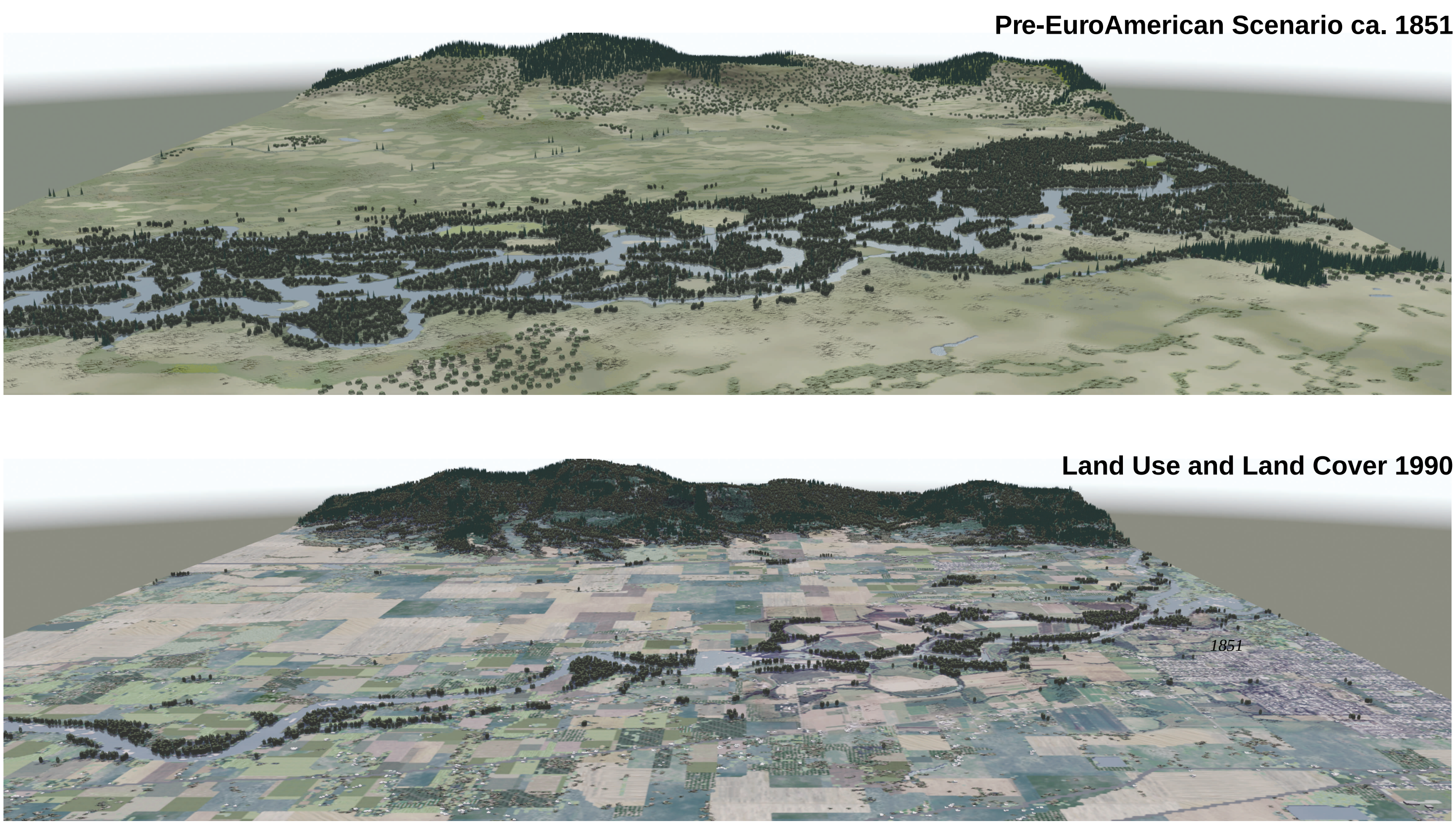


Figure 4. Computer simulation of the upper Willamette River and floodplain between Harrisburg and Eugene-Springfield, ca. 1850 and ca. 1990.

The alternative futures were then compared based on their expected effects on four major endpoints, using quantitative models developed specifically for this purpose by project scientists:

1. Terrestrial Wildlife - habitat for amphibians, reptiles, birds, and mammals in the Basin and the abundance and distribution of selected wildlife species.

2. Water Availability - demands for water for irrigation, municipal and industrial supplies, fish protection, and other uses, and the degree to which these demands can be satisfied by the finite supply of surface water in the Basin.

3. Ecological Condition of Streams - habitat and biological communities (fish and benthic invertebrates) in all 2nd to 4th order (small to medium size) streams in the Basin.

4. Willamette River - channel structure, streamside vegetation, and fish community richness in the Willamette River.

Results are reported as projected changes in condition relative to ca. 1990 (Figures 5 and 6) because we have greater confidence in our estimates of differences between scenarios (changes over time) than in estimated absolute values for any given scenario. Present-day conditions (ca. 1990) were selected as the primary reference for among-scenario comparisons for two reasons: (1) stakeholders were most familiar with and best related to current conditions and (2) the estimates for ca. 1990 were more reliable than those for historical or future conditions.

Summary of Results

Changes since 1850. Changes in the Willamette River Basin have been substantial since EuroAmerican settlement, particularly in the Valley. One hundred and fifty years ago, a diverse bottomland forest of black cottonwood, Oregon ash, alder, and other riparian species extended 2-10 kilometer wide along the length of the Willamette River between what is now Eugene and the mouth (Figure 4). Only 20% of that area is forested today. Elsewhere in the Valley, fires set regularly by Native Americans maintained open grasslands and oak savanna. Since about 1850, extensive land conversion for human use, together with invasion of shrubs and trees following fire suppression, have lead to nearly 100% loss of some of the unique habitats that evolved under the pre-settlement fire regime, in particular wet and dry prairie and oak savanna.

Upland portions of the Basin still are predominately forested, although forest age structure has shifted due principally to forest harvesting. The extent of older conifers (> 80 years) in the Basin has been reduced by about two-thirds.

In 1850, the Willamette River was physically more complex than it is today, particularly in the upstream reaches between Eugene and Corvallis. As a result of efforts to straighten and control the river, the total river length has declined by about 25% and the area of off-channel alcoves and islands by over 50%.

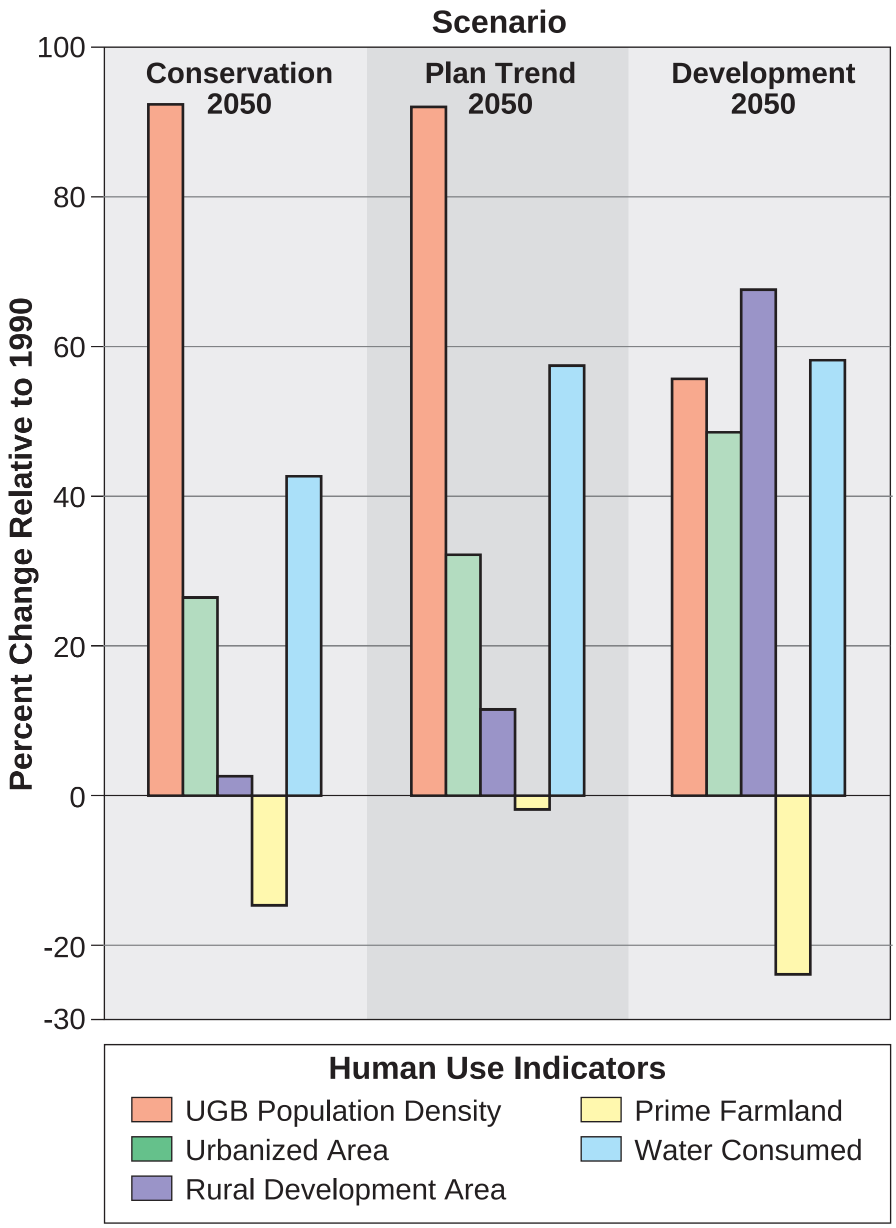
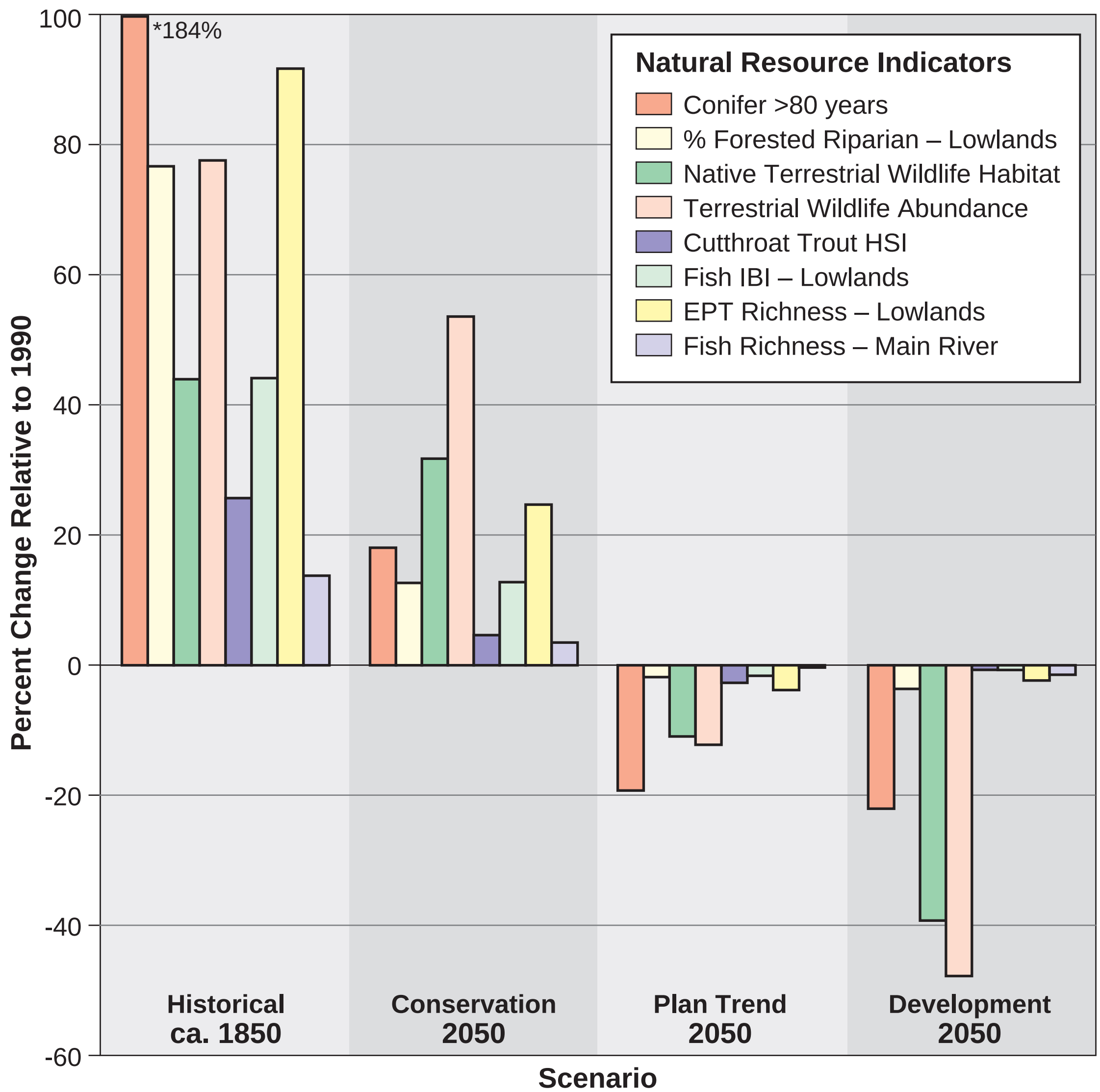


Figure 5. Percent change in selected indicators of human use in the Willamette River Basin, in the three future scenarios relative to ca. 1990. Indicators are average human population density within urban growth boundaries (UGBs), land area affected by urban and rural development, area of prime farmland, and quantity of water consumed by out-of-stream uses.

Figure 6. Percent change in selected indicators of natural resource condition in the Willamette River Basin, in the three futures and pre-EuroAmerican settlement scenarios, relative to ca. 1990. Vegetation indicators are the estimated area of conifer forest > 80 years old and % of 120-meter wide riparian buffer along all streams in the Valley Ecoregion with forest vegetation. Indicator for native terrestrial wildlife habitat is % of all 256 species projected to gain habitat minus % projected to lose habitat. Indicator of terrestrial wildlife abundance is % of 17 species modeled projected to increase more than 10% in abundance minus % projected to decline > 10%. Stream condition indicators are % change in median cutthroat trout habitat suitability index (HSI) for all 2nd to 4th order streams in the Basin and % change in median fish Index of Biotic Integrity (IBI) and Ephemeroptera, Plecoptera, and Trichoptera (EPT) richness in 2nd to 4th order streams with watersheds predominately in the Valley Ecoregion. Willamette River indicator is % change in median fish richness.



Irrigation, municipal, industrial, and other out-of-stream water uses currently consume an estimated 1060 m^3/day of surface water, causing an estimated 130 kilometers of 2nd to 4th order streams to go dry in a moderately dry summer. In the absence of these withdrawals, no streams would be expected to go dry.

As a result of these major habitat changes, biological endpoints (wildlife habitat and abundance, stream and river biota) are estimated to have been 15 to 90% higher historically than today, depending on the specific endpoint (Figure 6).

Changes through 2050. The number of people living in the Willamette River Basin is expected to nearly double between now and 2050. Even so, more landscape change, and thus more environmental effects, is estimated to have occurred from 1850 to 1990 than stakeholders considered plausible from 1990 to 2050, regardless of the future scenario (Figure 6). In all three futures, landscape changes reflected for the most part a shifting from past human uses to new uses, rather than a substantial expansion of human use of land and water into unimpacted, natural ecosystems. For example, new areas of rural and urban development were projected to occur predominately on lands currently used for agriculture. In terms of effects on ecosystems, our results indicated that the difference between agriculture and development is much smaller than the difference between natural systems and either agriculture or development. Even in Development 2050, substantial portions of the landscape, particularly in the uplands, retained their natural vegetation cover and some level of environmental protection. The stakeholder advisory group, which oversaw design of the future scenarios, did not consider more drastic landscape alterations plausible, given Oregon's history of resource protection, social behaviors, and land ownership patterns. There were, however, significant differences in environmental quality among scenarios and important local variations within each future.

Plan Trend 2050 (Figure 7) assumed that existing policies and plans were implemented as written. Where no specific plans or policies existed, recent trends were assumed to continue. Three existing policies with major impacts on the Basin are (1) the Northwest Forest Plan, which eliminated timber harvesting on an extensive network of riparian buffers and reserve areas on federal lands (60% of the forestry lands in the Basin); (2) the Oregon Forest Practices Act, which is less restrictive than the Northwest Forest Plan but also requires riparian buffers on state and privately owned forest lands; and (3) the Oregon Land Use Planning Program, which requires each city and county to develop a comprehensive land use plan with a particular focus on preventing the loss of agricultural and forestry resource lands. Plan Trend 2050 provided a unique opportunity to examine the implications of these policies, in combination, for future landscape change. The result was something of a surprise to stakeholders as well as technical experts involved in the project.

Under Plan Trend 2050, new development occurred only within designated urban growth boundaries and existing rural residential zones. As a result, population density within urban areas almost doubled relative to ca. 1990 (from 9.4 residents/ha in ca .1990 to 18.0 in 2050), while the amount of urbanized land plus land influenced by rural development increased by less than 25% (Figure 5).

Consistent with current policies, little (<2%) prime farmland or forestry resource land was lost. However, because recent trends in forest harvesting on private lands were assumed to continue, the extent of older conifer forest (aged > 80 years) declined by 19% relative to 1990 and what remained was concentrated on federally owned lands protected by the Northwest Forest Plan. Except for the shift in forest age and increased density of urban development, changes in land use and land cover under Plan Trend 2050 were relatively minor.

Projected effects on aquatic and terrestrial wildlife were fairly small basin-wide (≤ 10% change relative to ca. 1990; Figure 6), although significant declines occurred in some locations and for some species. In contrast, projected changes in water use and availability were substantial.

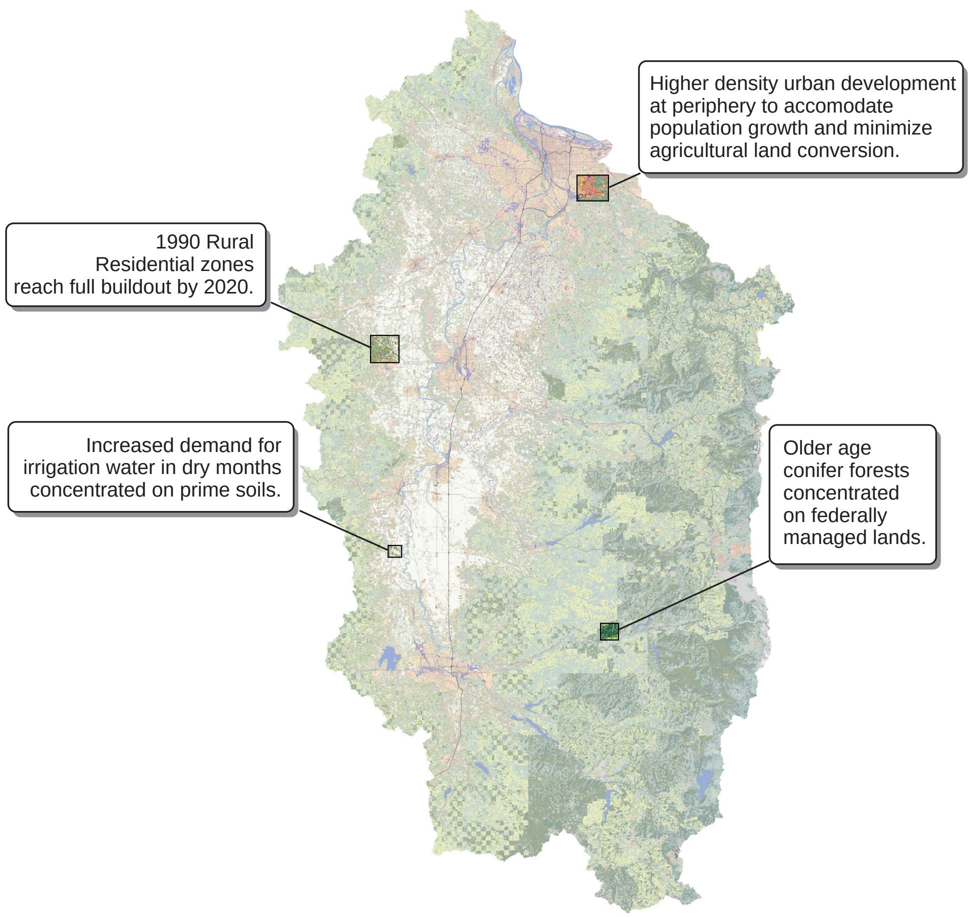


Figure 7. A diagram of the Plan Trend 2050 alternative, highlighting some key features.

Surface water consumption increased by 57%, reflecting a 20% increase in diversions for municipal and industrial uses and 65-120% increase in diversions for irrigated agriculture. Demands for water for municipal, industrial, and domestic uses were met in most areas; however, stream flows declined. The length of 2nd to 4th order streams expected to go dry during a moderately dry summer doubled, from about 130 km ca. 1990 to 270 in Plan Trend 2050. Likewise, 17 of Oregon's Water Resources Department's planning areas, covering 8% of the Basin area, were projected to have near zero stream flow at their outfall, compared to no such areas in ca. 1990. Unfortunately, our models were not adequate to assess the degree to which these changes in stream flow would adversely impact aquatic and terrestrial wildlife.

In ***Development 2050*** (Figure 8), current land use policies were relaxed and new development was allocated at lower densities over a larger area. Even so, population densities within urban growth boundaries still increased by 55% (to 14.6 residents/ha) relative to 1990. Urbanized areas expanded by almost 50% and the area influenced by rural structures by 68% (Figure 5). Urbanized areas and areas influenced by rural structures together accounted for 10.4% of the total Basin area, compared to 6.7% of the Basin area ca. 1990 and 8.3% in Plan Trend 2050. Most of this new development occurred on agricultural lands. Furthermore, the location of urban growth boundaries, a consequence of historical settlement patterns, predisposes urban expansion to occupying higher quality soils and particularly valuable agricultural resource lands. Twenty-four percent of 1990 prime farmland was lost.

Forestry practices included a greater amount of clear-cutting and less stream protection in Development 2050 than in Plan Trend 2050, but stakeholders did not consider it plausible that current policies controlling forest harvest practices would be drastically curtailed. Under Development 2050, the area of conifer forest > 80 years in age declined by 22% relative to 1990, compared to the 19% reduction for Plan Trend 2050.

The changes in land use and land cover in Development 2050 would have negative effects on terrestrial wildlife overall. Thirty-nine percent more species lost habitat than gained habitat relative to the ca. 1990 landscape (Figure 6). Of the 17 terrestrial wildlife species modeled for changes in population abundance, nine experienced a 10% or greater decline in abundance relative to 1990; only one species (the coyote) was projected to increase in abundance by at least 10%.

Projected effects on aquatic life, on the other hand, were relatively small (<5% decline relative to 1990). Both agriculture and residential development have similar adverse effects on aquatic life. Thus, streams already degraded due to agricultural land uses in 1990 did not decline further with the conversion of agricultural land to residential development that occurred in Development 2050.

As for Plan Trend 2050, water consumption for out-of-stream uses increased markedly, by 58% in Development 2050 relative to ca. 1990. However, the extent of streams with near zero flow in a dry summer was slightly less in Development 2050 than for Plan Trend 2050, because of a shift in the spatial distribution of withdrawals. An estimated 230 km of 2nd to 4th order streams (75% more km than in 1990) and 11 water planning areas (5% of the Basin area) would have near zero flow in a dry summer. Demands for water for municipal, industrial, and domestic use again were met in most areas.

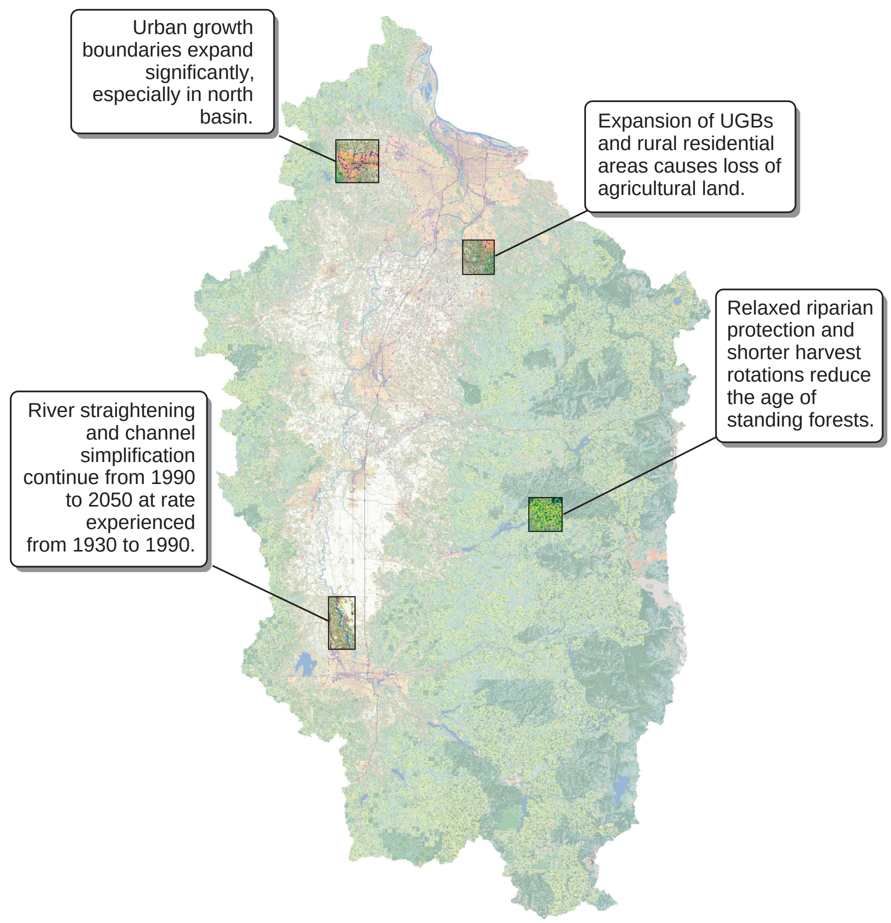


Figure 8. A diagram of the Development 2050 alternative, highlighting some key features.

Conservation 2050 placed a greater priority on ecosystem protection and restoration (Figure 9). As in Plan Trend 2050, Conservation 2050 emphasized high-density development. Both the areal extent and human population density within urban growth boundaries were very similar in the two scenarios (Figure 5). However, the use of clustered rural housing in Conservation 2050, leaving the remainder of parcels in natural vegetation, further constrained the land area affected by rural residential development. The near doubling of the human population in the Basin from 1990 to 2050 was accommodated with only an 18% increase in the amount of land urbanized or influenced by rural structures.

As a result, there was relatively little (<2%) conversion of agricultural lands to urban or rural development. Yet, 15% of ca. 1990 prime farmland was still lost, converted in this scenario mostly to natural vegetation. Conservation strategies on agricultural lands included 30-meter or wider riparian buffers along all streams, conversion of some cropland to native vegetation (in particular natural grasslands, wetlands, oak savannah, and bottomland forests) in high priority conservation zones, establishment of field borders and consideration of wildlife habitat as a factor in crop selection in environmentally sensitive areas, and a 10% increase in irrigation efficiency. Areas along the Willamette River that historically had complex, dynamic channels were targeted for restoration of river habitat complexity and bottomland forest.

Conservation measures implemented on private forestry lands included 30-meter or wider riparian buffers on all streams, a gradual decrease in the average clear-cut size, and retention of small patches of legacy trees. The result was a 17% increase in the area with conifer forests aged 80 years and older, relative to ca. 1990, as opposed to the 19% and 22% decrease in area for Plan Trend 2050 and Development 2050, respectively. Still, the extent of older age conifer forest would be less than half of what occurred prior to EuroAmerican settlement (see Figure 6).

Both aquatic and terrestrial wildlife responded to the sum of these conservation measures. In lowland streams, indicators of stream condition, such as the fish index of biotic integrity and EPT richness, were projected to increase by 9-24% relative to ca. 1990, representing an estimated recovery of 20-65% of the decline in these indicators since EuroAmerican settlement. For terrestrial wildlife, 31% more species gained habitat than lost habitat relative to ca. 1990. Of the 17 wildlife species modeled for population abundance, 10 were projected to increase in abundance by at least 10%, relative to ca. 1990, and only one (the mourning dove) would decrease by 10% or more, almost the opposite of the projected wildlife responses for Development 2050. Thus a substantial number of wildlife species would benefit from Conservation 2050, positively impacting biodiversity in the Basin. Wildlife abundances, however, would still be below historical estimates for most species.

Water consumption increased in Conservation 2050 relative to ca. 1990, but to a somewhat lesser degree than for Plan Trend 2050 and Development 2050. No water planning areas were projected to have near zero flow in a moderately dry summer, although an estimated 225 km of 2nd to 4th order streams would still go dry (70% more km than ca. 1990). Thus, the water conservation measures incorporated into Conservation 2050 were not sufficient to reverse recent trends of increasing water withdrawals for human use. Major changes in Oregon's water rights laws would likely be needed to substantially reduce water withdrawals, but such changes were not considered plausible by stakeholders during scenario design.

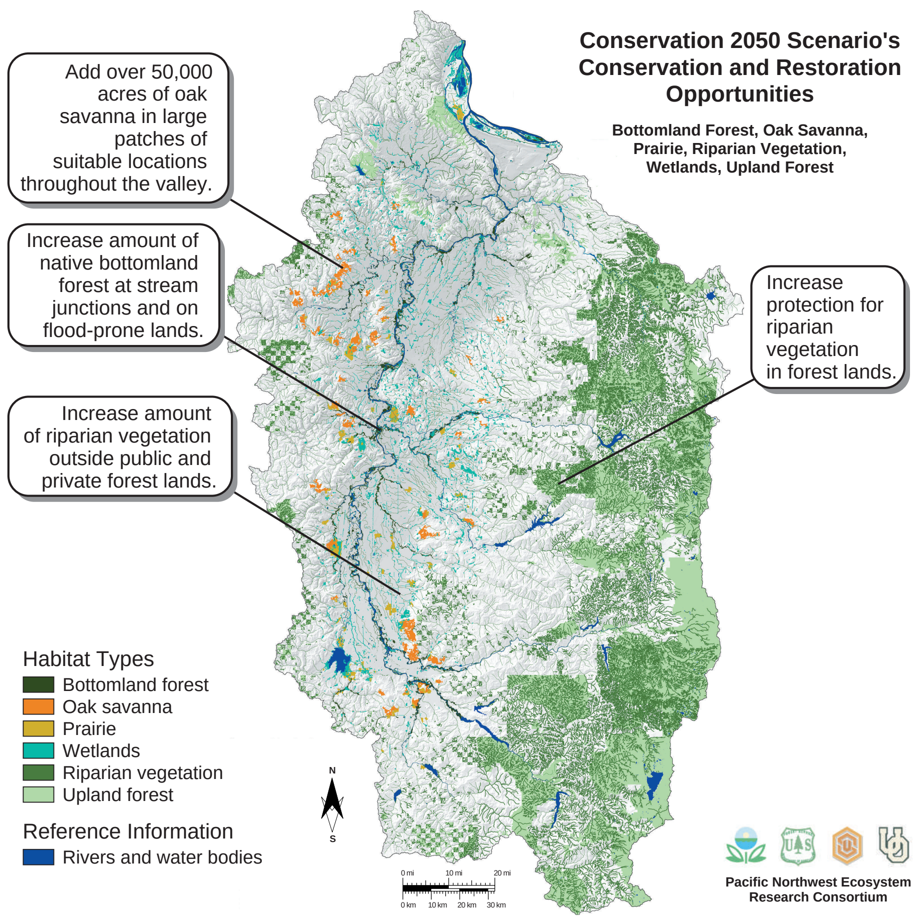


Figure 9. Conservation and restoration opportunities map, highlighting key conservation strategies incorporated into the Conservation 2050 scenario.

Were We Successful?

Did our analyses help shape the Willamette Valley Livability Forum's vision of the Basin's future or the Willamette Restoration Initiative's basin-wide restoration strategy, or lead to more informed decisions by local citizens and governments? Unfortunately, we have no direct measure of our influence on such deliberations. However, there is substantial evidence that people listened, and in some cases changed their way of doing business. Examples include the following:

- The Forum organized a basin-wide conference, open to all interested participants, in April 2001 at which our results were a featured component.
- The Forum also published an 8-page newspaper tabloid, entitled "The future is in our hands," distributed to more than 450,000 households in all major newspapers in the Basin. Two of those 8 pages were devoted to our results.
- A centerpiece of the Willamette Restoration Initiative restoration strategy is the restoration opportunities map (Figure 9) we created as an interim step toward Conservation 2050.
- Our analyses stimulated two related futures analyses, which relied in part on our scenarios and data but assessed different endpoints. The Forum evaluated alternative transportation futures and effects on traffic congestion. A project initiated by 1000 Friends of Oregon (http://www.friends.org/) assessed the implications of landscape futures for infrastructure costs (e.g., road, sewer, and water services) as well as losses of farm and forestry lands.
- Land allocation modeling during scenario development identified a shortage of commercially zoned land basin-wide, providing a concrete example of the value of large scale planning. The current land use program mandates comprehensive plans for each urban growth boundary but requires no evaluation of land supply across all urban areas combined, even in such a tightly-economically-coupled area as the Willamette River Basin.

The Plan Trend 2050 scenario generated a heated debate among stakeholders regarding whether it accurately reflected the landscape that would result if no new policies were implemented. Most felt not, principally because current policies are not being implemented exactly as written, as assumed in Plan Trend 2050. For example, Oregon Land Use Laws allow for exceptions to the goals and comprehensive plans, and such exceptions are often granted. Thus, while major components of the Basin landscape already have quite conservation-oriented policies, as reflected in Plan Trend 2050, not all these policies are having their full effect. Also evident is the imbalance in current policies among different parts of the landscape. Conservation policies to date have focused disproportionately on upland, forested systems. Because upland and lowland portions of the Basin support distinctly different types of habitats and species, a balanced effort in both upland and lowland areas would be more effective. This and other recommendations derived from our analyses were included in our final publication and presentations to the Willamette Valley Livability Forum and Willamette Restoration Initiative.

For more information, contact:

Joan P. Baker
U.S. Environmental Protection Agency
National Health and Environmental Effects Research Laboratory - Western Ecology Division
200 SW 35th Street
Corvallis, Oregon 97333

(541)754 - 4517
Baker.Joan@epa.gov

David Hulse
University of Oregon
Department of Landscape Architecture
Eugene, Oregon 97403

(541)346 - 3672
dhulse@darkwing.uoregon.edu

Stan Gregory
Oregon State University
Department of Fisheries and Wildlife
Corvallis, OR 97331

(541)737 - 1951
Stanley.Gregory@orst.edu

A more complete description of the project can be found in:

Willamette River Basin Planning Atlas: Trajectories of Environmental and Ecological Change (D. Hulse, S. Gregory, and J. Baker, editors), published by Oregon State University Press in 2002 (1-800-426-3797).

Selected data from the project can be downloaded from:
http://oregonstate.edu/dept/pnw-erc/.