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ALTERNATIVE FUTURES FOR THE WILLAMETTE RIVER BASIN, OREGON

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Abstract. Alternative futures analysis can inform community decisions regarding land and water use. We conducted an alternative futures analysis in the Willamette River Basin in western Oregon. Based on detailed input from local stakeholders, three alternative future landscapes for the year 2050 were created and compared to present-day (circa 1990) and historical (pre-EuroAmerican settlement) landscapes. We evaluated the likely effects of these landscape changes on four endpoints: water availability, Willamette River, stream condition, and terrestrial wildlife. All three futures assume a doubling of the 1990 human population by 2050. The Plan Trend 2050 scenario assumes current policies and trends continue. Because Oregon has several conservation-oriented policies in place, landscape changes and projected environmental effects associated with this scenario were surprisingly small (most ≤10% change relative to 1990). The scenario did, however, engender a debate among stakeholders about the reasonableness of assuming that existing policies would be implemented exactly as written if no further policy actions were taken. The Development 2050 scenario reflects a loosening of current policies, more market-oriented approach, as proposed by some stakeholders. Estimated effects of this scenario include loss of 24% of prime farmland; 39% more wildlife species would lose habitat than gain habitat relative to the 1990 landscape. Projected effects on aquatic biota were less severe, primarily because many of the land use changes involved conversion of agricultural lands into urban or rural development, both of which adversely impact streams. Finally, Conservation 2050 assumes that ecosystem protection and restoration are given higher priority, although still within the bounds of what stakeholders considered plausible. In response, most ecological indicators (both terrestrial and aquatic) recovered 20–70% of the losses sustained since EuroAmerican settlement. The one exception is water availability. Water consumed for out-of-stream uses increased under all three future scenarios (by 40–60%), with accompanying decreases in stream flow. Although the conservation measures incorporated into Conservation 2050 moderated the increase in consumption, they were not sufficient to reverse the trend. Results from these analyses have been actively discussed by stakeholder groups charged with developing a vision for the basin's future and a basin-wide restoration strategy.

Key words: alternative futures; environmental assessment; impact analysis; landscape change; land use; scenario analysis; water use; Willamette River.

INTRODUCTION

The number of people in the United States grew 13% between 1990 and 2000 (Perry and Mackun 2001), and is expected to increase another 50% by 2050 (Hollmann et al. 2000). These percentages are even higher for many rapidly urbanizing areas in the western United States. To accommodate this growth, human use of land and water continues to expand. Postel et al. (1996) estimate that humans already appropriate 50% of global freshwater runoff and the percentage could climb to 70% by 2025. One-third to one-half of the earth's land surface has been altered directly and substantially by human activity (Vitousek et al. 1997). Both the amount of land used and intensity of land use are increasing (Richards 1990). These changes are considered by many to represent one of the most profound threats to ecosystem sustainability and biodiversity (Vitousek et al. 1997, Naiman and Turner 2000, Dale et al. 2001).

Only by modifying the behavior of many people can these trends be altered. Individuals and local communities make decisions every day about the manner and degree to which they use land and water that impact

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the nature and magnitude of environmental effects. Efforts to influence the behavior of individual users cut to the heart of several deeply held public values regarding individual rights, property rights, and the opportunity for wealth production (Hulse and Ribe 2000). The traditional command-and-control approach to environmental protection, while it has an important role, is not sufficient (Holling and Meffe 1996). To be effective, those with a stake in the problem (stakeholders) need to be actively engaged in the assessment, planning, and design of the solution (Yankelovitch 1991, Lee 1993, Gunderson et al. 1995). A feeling of community cooperation is also essential for successful implementation of these solutions (Kirch 1997, Daily 1999). Watershed councils and the U.S. Environmental Protection Agency's (EPA) Community-Based Environmental Protection program[7] are examples of attempts to implement such a participatory, collaborative form of governance. While these efforts also have their limitations and detractors, they represent a valuable component of a multipronged strategy for environmental protection.

Given the importance of the decisions being made, it is essential that watershed councils and community forums be well informed and their decisions based on sound science. The Pacific Northwest Ecosystem Research Consortium (PNW-ERC) was created to conduct research supporting community-based decision making in western Oregon and Washington (Baker et al. 1995). Consisting of 34 scientists from 10 different institutions, the PNW-ERC undertook as the centerpiece of its activities an alternative futures analysis for the Willamette River Basin, Oregon, described in this *Invited Feature.* Our approach builds on a rich history of alternative futures analysis arising largely out of the disciplines of landscape architecture and environmental planning (McHarg 1969, Murray et al. 1971, Steinitz 1990, Harms et al. 1993, Schoonenboom 1995, Steinitz et al. 1996, Hulse et al. 2000, Ahern 2001, Santlemann et al. 2001, Steinitz and McDowell 2001).

Community decision making typically involves stakeholders with widely divergent viewpoints and values. The most important end product of this process is development of consensus, or compromise, about desired goals and priorities, that is a shared vision for the future. The purpose of an alternative futures analysis is to facilitate this consensus-building process. It does so in four ways: (1) helping to clarify differences of opinion by forcing stakeholders to be very explicit about their individual goals and priorities, expressed as written assumptions for a specific future scenario; (2) presenting the system-level implications of stakeholder assumptions, goals, and proposed policies, in the form of the future landscape scenarios; (3) illustrating the types, magnitude, and locations of changes in land and water use that would be required to achieve a given future scenario; and (4) assessing the broader implications of each scenario, by evaluating the likely overall effects of these changes on a suite of ecological and socio-economic endpoints. Understanding the consequences of choices is an essential step in the process of moving public groups from dialogue to resolution and action, and one of the most effective ways to move forward is to present complex issues in the form of a relatively small number of ''visions'' (Yankelovich 1991, Costanza 2000).

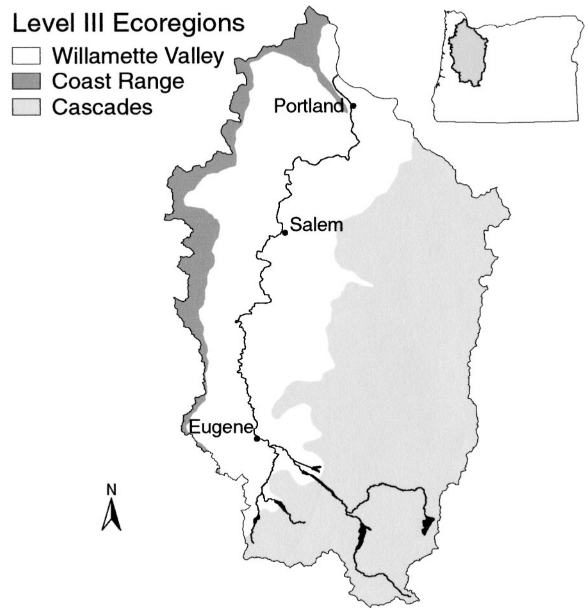

FIG. 1. Willamette River Basin, with major cities and the Willamette River shown. Upland areas are represented by the Coast Range and Cascades Level III Ecoregions as defined by Pater et al. (1998); the valley comprises the Willamette Valley Ecoregion.

In this paper, we summarize results and lessons learned from the Willamette River Basin alternative futures analysis. Further details on specific components of the analysis are provided in the accompanying papers of the *Invited Feature.* Results from this study were also presented in atlas format, designed for a more general audience, in Hulse et al. (2002).

METHODS

Study area

The Willamette River Basin (WRB) encompasses 29 728 km² between the crests of the Cascades and Coast Range in western Oregon (Fig. 1). Two-thirds of the basin is forested, predominately in upland areas (Cascades and Coast Range ecoregions). Major portions of the valley ecoregion have been converted to agricultural use (43% of the land area) and built structures (11%). Although the WRB accounts for only 12% of the land area in Oregon, it produces 31% of the

[7] URL: ⟨http://www.epa.gov/ecocommunity⟩

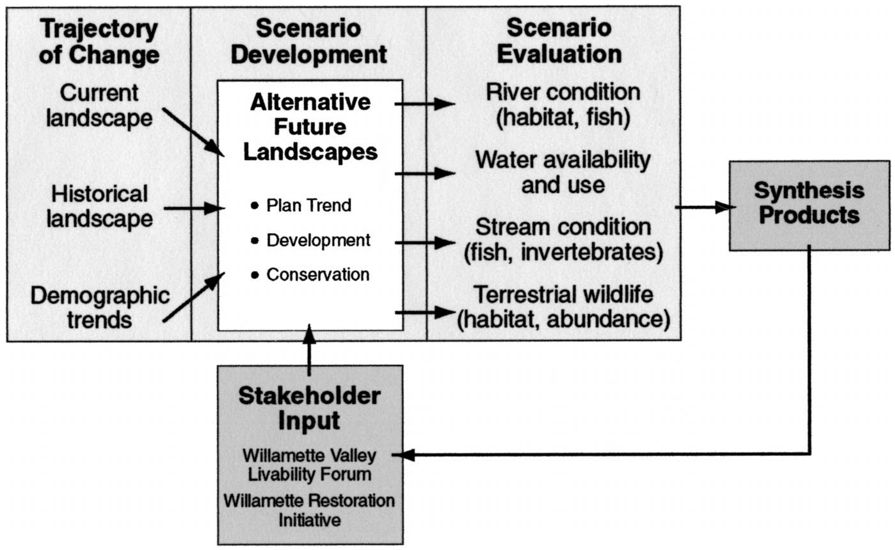

FIG. 2. Diagram of alternative futures analysis process, as applied in the Willamette River Basin.

state's timber harvests and 45% of the market value of agricultural products, and is home to 68% of Oregon's population. Oregon's three largest cities—Portland, Salem, and Eugene-Springfield—are located in the Willamette valley, adjacent to the Willamette River. About two million people lived in the WRB in 1990. By 2050, the WRB population is expected to nearly double to almost four million, placing tremendous demands on limited land and water resources and creating major challenges for land and water use planning (Hulse et al. 2002).

We selected the WRB because of efforts, initiated by Oregon Governor John Kitzhaber, to produce an integrated strategy for development, conservation, and restoration in the basin. Kitzhaber created the Willamette Valley Livability Forum (WVLF) in 1996 to develop and promote a shared vision for enhancing the livability of the WRB (WVLF 1999). The Willamette Restoration Initiative (WRI) was established in 1998 to design 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 continuing basin growth (WRI 2001). Both groups consist of stakeholders selected by the Governor to be representative of the cross section of interests in the basin, including private citizens, industry and business, nonprofit organizations, and local, state, federal, and tribal governments. The Forum and WRI served as the primary clients for the WRB alternative futures analysis.

Overview of the process

Alternative futures analysis involves three basic components (Fig. 2): (1) characterize the current and historical landscapes in a geographic area, and trajectory of landscape change to date; (2) develop 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) evaluate the likely effects of these landscape changes and alternative futures on things people care about, i.e., valued endpoints. The future landscapes are designed with stakeholder input to illustrate major strategic choices. They are intended not as predictions, but rather to bracket the range of plausible policy options. The historical, present-day, and future landscapes are represented as maps of land use/land cover, using a consistent classification scheme and spatial resolution, and associated written assumptions about management practices and water use. The alternative futures are then compared based on their effects on a diverse array of endpoints, selected to represent the range of stakeholder interests as well as important ecological attributes. The overall process may be iterative. As stakeholders see results for the initial set of alternative futures, it may lead to new ideas or compromise positions that warrant design of additional future scenarios or analysis of additional endpoints.

Current (circa 1990) landscape.—The Circa 1990 representation of land use/land cover (see Fig. 1b in Hulse et al. 2004) was based on classified Landsat Thematic Mapper (TM) scenes (Oetter et al. 2000, Cohen et al. 2001) augmented in two ways: (1) using soils data on crop suitability, irrigation records, county-level crop statistics, and three additional, but less extensive land cover maps, to improve the accuracy of agricultural classes (Berger and Bolte 2004) and (2) with data from the 1990 U.S. Census, land ownership and tax assessor parcel records, county and metropolitan zoning classifications, and Oregon Department of Transportation and U.S. Geological Survey topographic quadrangle maps to enhance the representation of important rural and urban built features (Enright et al. 2002). The final map distinguishes 64 classes of land use/land cover by 30-m pixels. The same spatial resolution and classes, with one addition (oak savanna, a common vegetation class historically but rare today), were used for the historical and future landscapes to provide consistent input for the evaluation models.

Historical (~1850) landscape.—The map of historical land cover (called pre-EuroAmerican settlement; see Fig. 1c in Hulse et al. 2004) was derived from three sources: (1) a map of presettlement vegetation in the valley prepared by The Nature Conservancy's Oregon Chapter based on interpretation of General Land Office survey notes recorded between 1851 and 1909; (2) H. J. Andrews' 1936 Oregon Forest Types map (most higher elevation, public forest lands had not been harvested by 1936); and (3) the Oregon Actual Vegetation map developed by the Oregon Natural Heritage Program (Gregory et al. 2002*b*). The vegetation classifications used in these three mapping efforts were cross-referenced to the 65 PNW-ERC land use/land cover classes.

Future scenarios.—Three alternative futures were designed with detailed input from stakeholders. Oregon has a strong statewide program for land use planning, passed in 1973, which requires each city and county to develop a comprehensive plan and associated land use regulations consistent with 19 statewide planning goals. Three of these goals call for the conservation of agricultural lands, forest lands, and natural resources. Some stakeholders believe even greater emphasis on natural resource protection and restoration is warranted, to counter the continued loss of natural habitats and decline in native species as human populations in the basin expand. Other stakeholders, however, feel that current land and water use policies are too restrictive, unnecessary, and an infringement on individual property rights. This basic dichotomy in stakeholder viewpoints, between a desire for greater environmental conservation vs. the desire for more personal freedom, set the stage for scenario development. The Plan Trend 2050 scenario represents the expected future landscape in 2050 if current policies are implemented exactly as written and recent trends continue. Development 2050 reflects a loosening of current policies, 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 places 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 the stakeholders. All three scenarios assume the same population increase, from 2.0 million people in 1990 to 3.9 million by 2050. Additional details regarding the scenario development process and the three alternative futures are provided in Hulse et al. (2004) and Berger and Bolte (2004).

Scenario evaluations.—We evaluated the likely effects of the WRB landscape changes, over the 200-yr period from 1850 to 1990 to 2050 on four resource endpoints of concern (Fig. 2):

1) Water availability—demands for surface 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 water supply in the basin (Dole and Niemi 2004).
2) Willamette River—channel structure, streamside vegetation, and fish community richness in the mainstem of the Willamette River (Gregory et al. 2002*a, c*).
3) Ecological condition of streams—habitat and biological communities (fish and benthic invertebrates) in all second to fourth-order streams in the basin (Baker et al. 2002, Van Sickle et al. 2004).
4) Terrestrial wildlife—habitat for amphibians, reptiles, birds, and mammals in the basin, and the abundance and distribution of selected birds and mammals (Schumaker et al. 2004).

The specific modeling approach varied among endpoints, reflecting differences in the underlying processes and types of data available. Water availability was assessed using a computer model (''The Watermaster'') simulating the allocation of water among competing uses. An individual-based, spatially explicit, population model (PATCH) simulated changes in wildlife abundance and distribution. Regression models, based on extensive survey data, were used to estimate biotic changes in streams and the river. Habitat suitability indices for both streams and wildlife were derived from expert-defined rules. Willamette River channel complexity and streamside vegetation, although listed above, were more closely aligned with scenario development than evaluation. Detailed reconstructions of the river channel and adjacent vegetation were created for 1850, 1895, 1932, and 1990 based on available data. These maps, together with stakeholder-defined targets and constraints, were used to identify areas of the river most likely to lose (Development 2050) or recover (Conservation 2050) channel complexity in the future.

Our objective was not to predict the future, but rather to assess the sensitivity of valued endpoints to the alternative land and water use policies incorporated in the future scenarios. Other factors that could significantly influence endpoint response, such as global climate change and additional invasions of exotic species, were not considered.

Percent change relative to 1990 for selected indicators from each of these analyses are presented in Figs. 3 and 4. Present-day condition (Circa 1990) was selected as the primary reference for among-scenario

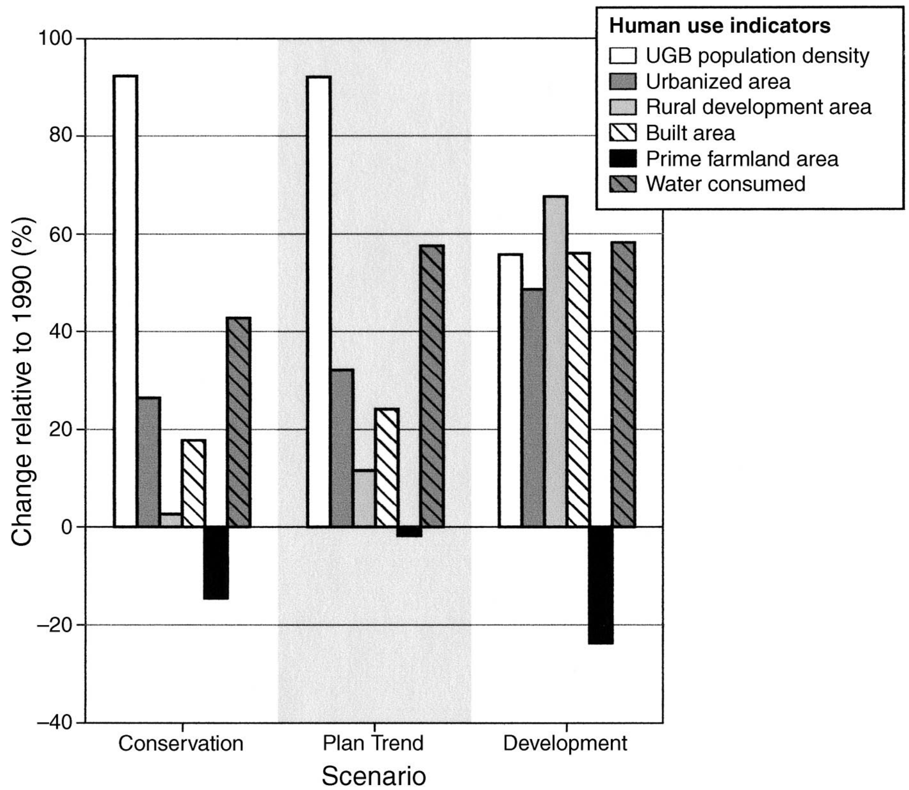

FIG. 3. Percentage change in selected indicators of human use in the WRB, in the three future scenarios relative to Circa 1990. Indicators are mean human population density within urban growth boundaries (UGBs), total area affected by urban development, by rural development, and by urban and rural development combined (built area; Hulse et al. 2004), area of prime farmland (Berger and Bolte 2004), and quantity of water consumed for out-of-stream uses (Dole and Niemi 2004).

comparisons for two reasons: (1) stakeholders are most familiar with and can best relate to conditions in the present and (2) our estimates for 1990 are more reliable than those for historical or future scenarios.

RESULTS

Changes in the WRB have been substantial since EuroAmerican settlement, particularly in the Willamette valley. Historically, a diverse bottomland forest of black cottonwood, Oregon ash, alder, and other riparian species extended 2–10 km wide along the length of the Willamette River. Only 20% of that area is forested today (Gregory et al. 2002*a*). Elsewhere in the valley, fires set regularly by Native Americans maintained open grasslands and oak savanna (Boyd 1986). 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 presettlement fire regime. It is questionable whether any true oak savanna remains. An estimated 97% of the wet and dry prairie and 95% of wetlands have been lost. Upland portions of the WRB still are predominately forested, although forest age structure has shifted due principally to forest harvesting. The extent of older conifers (>80 yr) in the WRB 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. As a result of efforts to straighten and control the river, the total river length has declined by ~25% and area of off-channel alcoves and islands by >50%. Irrigation, municipal, industrial, and other out-of-stream water uses currently consume an estimated 1060 m^3/d of surface water, causing an estimated 130 km of second- to fourth-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 are estimated to have been 15% and 90% higher historically than today, depending on the specific endpoint (Fig. 4).

Over the next 50–60 years, the number of people living in the WRB is expected to nearly double. Even so, more landscape change, and thus more environmental effects, occurred between 1850 and 1990 than stakeholders considered plausible from 1990 to 2050, regardless of the future scenario (Fig. 4). In all three scenarios, future landscape changes reflect mostly a shifting from past resource uses to new uses, rather than a substantial expansion of human use of land and

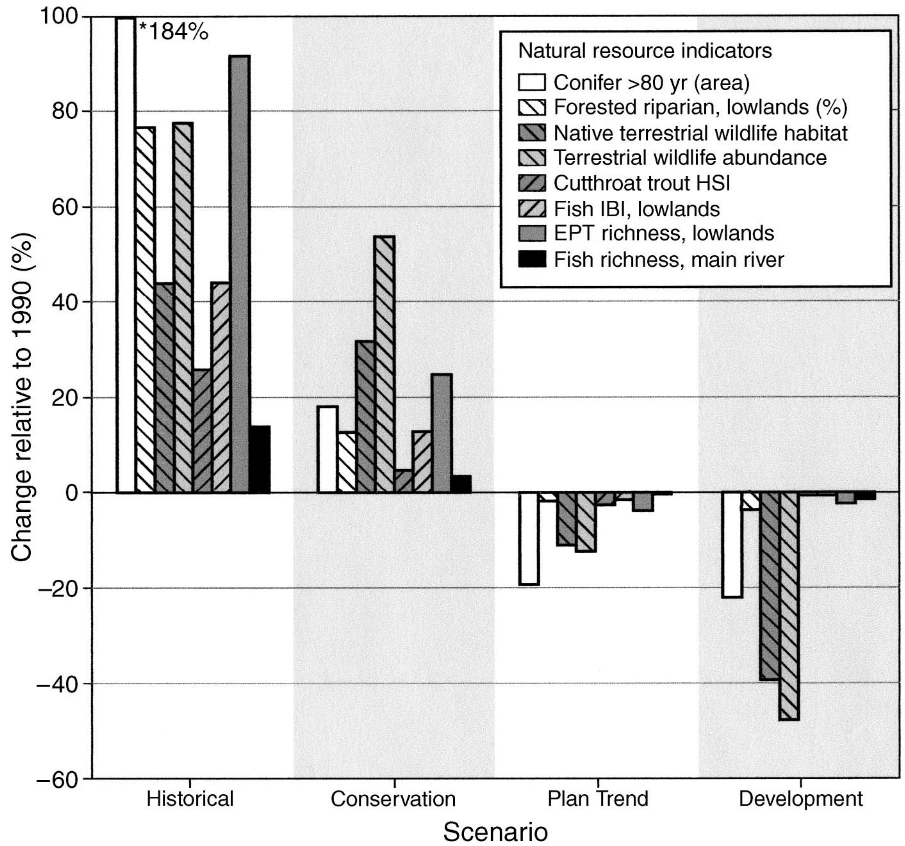

FIG. 4. Percentage change in selected indicators of natural resource condition in the WRB, in the three futures and pre-EuroAmerican settlement scenarios, relative to Circa 1990. Vegetation indicators are the estimated area of conifer forests >80 yr old and percentage of 120-m wide riparian buffer along all streams in the Valley Ecoregion with forest vegetation (Hulse et al. 2002). The indicator for native terrestrial wildlife habitat is percentage of 256 native non-fish vertebrate species projected to gain habitat minus percentage projected to lose habitat. The indicator of terrestrial wildlife abundance is the percentage of 17 species modeled projected to increase more than 10% in abundance minus percentage projected to decline >10% (Schumaker et al. 2004). Stream condition indicators are percentage change in median cutthroat trout habitat suitability index (HSI) for all second- to fourth-order streams in the basin and percentage change in median fish index of biotic integrity (IBI) and Ephemeroptera, Plecoptera, and Trichoptera (EPT) richness in second- to fourth-order streams with watersheds predominately in the Valley Ecoregion (Baker et al. 2002, Van Sickle et al. 2004). The Willamette River indicator is percentage change in median fish richness (Gregory et al. 2002*c*).

water into relatively intact, natural ecosystems. For example, new areas of rural and urban development occur predominately on lands currently used for agriculture. Our results indicate that the difference between agriculture and development, in terms of their effects on aquatic and terrestrial wildlife, is much smaller than the effect associated with the original conversion of natural systems into either agriculture or development. Even in Development 2050, substantial portions of the landscape, particularly in the uplands, retain 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 are, however, significant differences in environmental quality among scenarios and important local variations within each future.

Plan Trend 2050

The Plan Trend 2050 scenario assumes that existing policies and plans are implemented exactly as written. Where no specific plans or policies exist, recent trends are assumed to continue. Three existing policies with major impacts on the WRB are (1) the federal 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) starting in 1995 in order to protect the northern spotted owl and other threatened and endangered species; (2) the Oregon Forest Practices Act, which is less restrictive than the Northwest Forest Plan but still requires riparian buffers and other practices to limit the impacts of forest harvests on aquatic and terrestrial wildlife on state and privately owned forest lands; (3) the Oregon Land Use Planning Program, which requires each city and county to develop a comprehensive land use plan and associated regulations with a particular focus on preventing the loss of agricultural and forestry resource lands. Each of these policies and plans was developed independently. Plan Trend 2050 provided a unique opportunity to examine their joint implications 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 occurs only within designated urban growth boundaries (UGBs) and existing rural residential zones. As a result, population density within UGBs almost doubles relative to 1990 (from 9.4 residents/ha in 1990 to 18.0 residents/ha in 2050), while the amount of urbanized land plus land influenced by rural development increases by <25% (by 48 800 ha) (Fig. 3). Consistent with current policies, little (<2%) prime farmland or forestry resource land is lost. However, the extent of older conifer forest (aged >80 yr) declines by 19% (114 000 ha) relative to 1990, and what remains is concentrated on federally owned lands protected by the Northwest Forest Plan. Except for the shift in forest age and densification of urban development, changes in land use and land cover under Plan Trend 2050 are fairly minor. As a result, projected effects on aquatic and terrestrial wildlife are small basin-wide (≤10% change relative to 1990; Fig. 4), although significant declines occur in some locations and for some species. In contrast, projected changes in water use and availability are substantial. Surface water consumption increases 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 would be met in most areas. However, stream flows would decline. The length of second- to fourth-order streams expected to go dry during a moderately dry summer would double, from ~130 km in 1990 to 270 km in Plan Trend 2050. Seventeen of the 178 discrete sub-basins defined by Oregon's Water Resources Department in the WRB, representing an area of 2400 km^2, would likewise experience near zero stream flow at their outfall, compared to zero sub-basins with no flow ~1990. Unfortunately, our models were not adequate to assess the degree to which these changes in stream flow would adversely affect aquatic and terrestrial wildlife.

Development 2050

In Development 2050, current land use policies are relaxed and new development occurs at lower densities over a larger area. Even so, population densities within UGBs still increase by 55% (to 14.6 residents/ha) relative to 1990. Urbanized areas expand by almost 50% (62 000 ha), and the area influenced by rural structures by 68% (49 000 ha) (Fig. 3). Jointly, urbanized areas and areas influenced by rural structures account for 10.4% of the total basin area, compared to 6.7% of the basin area in 1990 and 8.3% in Plan Trend 2050. Most of this new development occurs on agricultural lands. Furthermore, the location of UGBs, a consequence of historical settlement patterns, predisposes urban expansion to occupying higher quality soils and particularly valuable agricultural resource lands. Twenty-four percent (60 700 ha) of 1990 prime farmland is lost. Forestry practices include somewhat greater emphasis on clear-cutting and less stream protection in Development 2050 compared to Plan Trend 2050, but stakeholders did not consider it plausible that current policies controlling forest harvest practices would be drastically curtailed. As a result, under Development 2050, the area of conifer forest >80 yr in age is reduced by 22% relative to 1990, compared to the 19% reduction for Plan Trend 2050. The changes in land use/land cover in Development 2050 would have negative effects on terrestrial wildlife overall. Thirty-nine percent more species would lose habitat than gain habitat relative to the 1990 landscape (Fig. 4). Of the 17 terrestrial wildlife species modeled for changes in population abundance, nine would experience a 10% or greater decline in abundance relative to 1990; only one species (the coyote) is 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. Streams already degraded due to agricultural land uses in 1990 would not be significantly further degraded by the conversion of agricultural land to residential development that occurs in Development 2050. As for Plan Trend 2050, water consumption for out-of-stream uses would increase markedly, by 58% in Development 2050 relative to 1990. However, the extent of streams with near zero flow in a dry summer would be 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 second- to fourth-order streams (75% more km than in 1990) and 11 sub-basins (encompassing 1580 km^2) would have near zero flow in a dry summer. Demands for water for municipal, industrial, and domestic use would again be met in most areas.

Conservation 2050

Conservation 2050 places greater priority on ecosystem protection and restoration, although still within the range of what stakeholders considered plausible. Like Plan Trend 2050, Conservation 2050 emphasizes high-density development. Both the spatial extent of UGBs and human population density within UGBs are very similar in the two scenarios (Fig. 3). However, the use of clustered rural housing in Conservation 2050, leaving the remainder of the affected parcels in natural vegetation, further constrains the land area impacted by rural residential development. The near doubling of the human population in the basin from 1990 to 2050 is accommodated with only an 18% increase in the amount of land urbanized or influenced by rural structures (35 000 ha). As a result, there is relatively little (<2%) conversion of agricultural lands to urban or rural development. Yet, 15% of 1990 prime farmland is still lost, converted in this scenario mostly to natural vegetation. Conservation strategies on agricultural lands include 30-m or wider riparian buffers along all streams (first order and higher as represented on a 1:100 000 scale stream coverage), 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 include 30 m or wider riparian buffers on all streams, a gradual decrease in the average timber harvest clear-cut size, and retention of small patches of legacy trees. The result is a 17% increase in the area with conifer forests aged 80 yr and older, relative to 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 (41%) of what occurred prior to EuroAmerican settlement (see Fig. 4).

Both aquatic and terrestrial wildlife respond to the sum of these conservation measures. In lowland streams, indicators of stream condition, such as the fish index of biotic integrity and EPT invertebrate richness, are projected to increase by 9–24% relative to 1990, representing a recovery of 20–65% of the decline in these indicators estimated to have occurred since EuroAmerican settlement. For terrestrial wildlife, 31% more species gain habitat than lose habitat relative to 1990. Of the 17 wildlife species modeled for population abundance, 10 are projected to increase in abundance by at least 10%, relative to 1990, and only one (the mourning dove) would decrease by 10% or more, almost the reverse of projected wildlife responses in Development 2050. Thus, a substantial number of wildlife species would benefit from Conservation 2050 (~70% of the net number of species that would benefit from the pre-EuroAmerican settlement landscape compared to 1990), positively impacting biodiversity in the basin. Wildlife abundances, however, would still be below historical estimates for most species.

Water consumption increases in Conservation 2050 (by 43%) relative to 1990, but to a somewhat lesser degree than for Plan Trend 2050 and Development 2050 (57–58% increase relative to 1990). No sub-basins are projected to have near zero flow in a moderately dry summer, although an estimated 225 km of second- to fourth-order streams would still go dry (70% more km than ~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.

Discussion

Were we successful?

Did our analyses help shape the Forum's vision of the basin's future or the WRI'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. We would not expect any of the three scenarios we developed to be universally adopted as the vision for the future. They were only a first iteration, illustrating the spectrum of plausible options. Nor would we necessarily expect stakeholders ever to define their shared vision for an area as large as the WRB in such a detailed, spatially explicit manner as the scenarios presented in Hulse et al. (2004). The level of detail embodied in the alternative futures approach is intended to clarify points of view and demonstrate the implications of land and water use decisions being made, to assist in the consensus-building process. Final products from stakeholder deliberations are more likely to be a set of agreed upon goals, priorities, and targets, and broad strategic approaches. Both the Forum and WRI have produced such documents (WVLF 1999, WRI 2001) and are continuing to refine them.

Although more informed decisions are the ultimate measure of success, other indicators include: Did people listen? Were the tools or results used? Did stakeholders change their way of doing business? In each case, the answer is yes. We made several presentations to the Forum and WRI, at their request. 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 eight-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 eight pages were devoted to our results. Our results were also made available to the general public via the web and as a published atlas (Hulse et al. 2002).

A centerpiece of the WRI restoration strategy (WRI 2001) is the conservation and restoration opportunities map we created as an interim step toward Conservation 2050 (Hulse et al. 2004). Our analyses also produced two spin-off futures analyses, which relied in part on our scenarios and data but assessed different endpoints. The Forum and Oregon Department of Transportation evaluated alternative transportation futures and effects on traffic congestion. A project initiated by 1000 Friends of Oregon 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 in our project identified a shortage of commercially zoned land basin wide, providing a concrete example of the value of larger scale planning. The current land use program mandates comprehensive plans for each UGB but requires no regional evaluation of land supply or other issues, even in such a tightly economically coupled area as the WRB.

The Plan Trend 2050 scenario generated a heated debate regarding whether it accurately reflected the landscape that would result if no new policies were implemented. Most felt no, principally because current policies are not being implemented exactly as written, as assumed in Plan Trend 2050. For example, the Oregon land use legislation and statewide regulations allow for exceptions to the statewide goals and local comprehensive plans and regulations, and such exceptions are often granted. Thus, while major components of the WRB landscape already have 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. Natural resource protection 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 more balanced effort in both upland and lowland areas would be more effective. This and other recommendations derived from our analyses were included in the project atlas (Hulse et al. 2002) and in presentations to the Forum and WRI.

What might we have done differently?

As noted earlier, the WRB is not the only example of an alternative futures analysis. Others that involved a partnership between EPA and landscape planners include Monroe County, Pennsylvania (White et al. 1997, Steinitz and McDowell 2001); Camp Pendleton, California (Steinitz et al. 1996); two watersheds in Iowa (Santelmann et al. 2001); and Muddy Creek watershed within the WRB (Hulse et al. 2000). Each study has approached the task in slightly different ways, emphasizing different types of scenarios and endpoints. For example, in the WRB and Muddy Creek watershed, scenarios represent a gradient between conservation and development/market orientation, acting equally across all components of the landscape. In Monroe County and Camp Pendleton, in contrast, scenarios emphasized different land development patterns for dealing with increased population growth (e.g., low-density sprawl, concentrating growth within a new ''city,'' transportation-driven alternatives). In Iowa, scenarios were designed to protect one particular valued endpoint, e.g., biodiversity or water quality. Most of these projects assumed a constant population increase among scenarios. However, in Muddy Creek watershed, human population growth varied among the future scenarios in a manner consistent with the basic premise of each scenario; the most conservation-oriented future had the lowest population growth. None of these approaches is right or wrong, but instead the scenarios selected, as well as the endpoints evaluated, should reflect the types of questions being asked, major differences of opinion among stakeholders, and most pressing issues in the study area.

In the WRB, stakeholder input dominated the scenario development process (Hulse et al. 2004). The project team met monthly with the stakeholder working group over a two-year period to develop very detailed assumptions and iteratively design each alternative future. Such in-depth involvement of stakeholders in the scenario development process leads to greater stakeholder understanding, a feeling of ownership in the final product, and increased likelihood that the results will be used. It also takes maximum advantage of local knowledge, helping to ensure that the future scenarios are plausible and reflective of stakeholder concerns at a high level of detail. On the other hand, the process is extremely time consuming, which was one of the reasons we were able to develop only three future scenarios. Furthermore, by tying scenario design so tightly to what stakeholders considered plausible, the range of variation among alternative futures was fairly constrained. Stakeholders were reticent to incorporate drastic shifts from current policies, and as a result less likely to develop innovative future visions. Yet human behavior is inherently unpredictable and major shifts in social norms are not uncommon. One example is the recent passage of Oregon Ballot Measure 7, requiring financial compensation of landowners adversely affected by any state or local governmental regulation including environmental and land use policies. Although the measure was later declared unconstitutional by the Oregon State Supreme Court on a technicality, if it had implemented, the focus on individual property rights in the ballot would have changed the landscape in ways the stakeholders considered only marginally plausible just a few years earlier. Clearly, the details of what will unfold in the future are nearly impossible to predict. Thus, the emphasis should be on capturing the fundamental policy and human sentiment differences that meaningfully distinguish one scenario from another in a way that captures public attention and imagination.

The essence of the alternative futures approach is that scenarios reflect stakeholder values, assumptions, and visions. However, there should also be room for creative design on the part of landscape planners, incorporation of important ecological principles, and other technical input. Such expert-based scenarios are more likely to be ''outside the box'' of current stakeholder experience and can play a critical role in broadening the debate and altering entrenched ways of thinking. One concern, however, is whether stakeholders will feel sufficiently represented to engage in an active discussion of options and future visions once such expert-designed scenarios are presented. Thus, the optimal approach may be to blend the two, introducing expert-based designs early on in the process, to stimulate stakeholder thinking about other options and hopefully lead to stakeholder-defined scenarios that incorporate many of the same principles and ideas.

One potential shortcoming of our analyses was the relatively small role stakeholders played in endpoint selection. Endpoint selection was heavily affected by the expertise of the project team, formed before discussions with stakeholders started, more than by stakeholder input and concerns. Active engagement of stakeholders in endpoint selection would have helped ensure their full spectrum of concerns was addressed in a balanced way, increased stakeholder buy-in to the results, and provided an educational opportunity for project team members to discuss potential consequences of landscape change that stakeholders may not have otherwise anticipated. The objective of scenario evaluations is to ensure that stakeholders understand the full implications of the range of decisions before them. While all of the endpoints evaluated in the WRB have been identified by the Forum and WRI as high priority issues, social and economic endpoints were under-represented. Economic concerns played a role in stakeholder decisions about scenario design, and projected high building densities in urban areas and other land use changes embodied in each future scenario generated substantial debate about the social acceptability of such changes. Yet, additional social and economic endpoints together with greater stakeholder involvement in endpoint selection may have increased the impact of our results on stakeholder deliberations.

The future of futures

The WRB, as well as the other example alternative futures analyses cited above, were principally research projects, conducted by landscape planners and scientists in academia and government. To make a real difference, alternative futures analyses need to move out of the realm of research and into routine application. Cities and counties frequently spend hundreds of thousands of dollars funding consultants to assist in transportation and land use planning. However, typically these analyses address only one or a few landscape components, and city and county jurisdictions are generally too small to assess the cumulative effects of multiple policies in multiple jurisdictions on entire ecosystems and landscapes. Regional leaders and local citizens increasingly are seeing the value of larger-scale, more comprehensive planning efforts. With training and appropriate tools, interdisciplinary teams of consultants could support such visioning efforts by conducting a collaborative alternative futures analysis. One of the key challenges for such widespread application will be to make the analyses affordable yet also sufficiently robust, comprehensive, and detailed to be of value.

Additional research is also warranted. In particular, the overall approach would benefit from more formal evaluation of its effectiveness at informing community decisions. Can we improve the manner in which we interact with and communicate to stakeholders? Are there approaches for scenario design and evaluation that would make the results more used and useful? Is the cost required to develop detailed, highly accurate, landscape characterizations or apply more complex evaluation models worth the return in improved decision making? Additional effort is needed on social and economic endpoints, including approaches that deal with the difficulties projecting parameters such as interest rates and discount rates 30–50 yr into the future. Even for environmental endpoints, the most readily available models (e.g., water quality models) often do not assess the endpoints of direct interest to stakeholders (e.g., changes in biological communities) (Reckhow 1999). To date, most analyses have dealt poorly with linkages among endpoints (e.g., water availability and stream biota), and feedback loops among policies, landscape patterns, and ecosystem policies. Finally, the visioning process would be aided by better approaches for combining stakeholder-driven and expert input into scenario design. Many of these research needs are not unique to alternative futures analyses, but would benefit environmental assessment approaches in general.

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