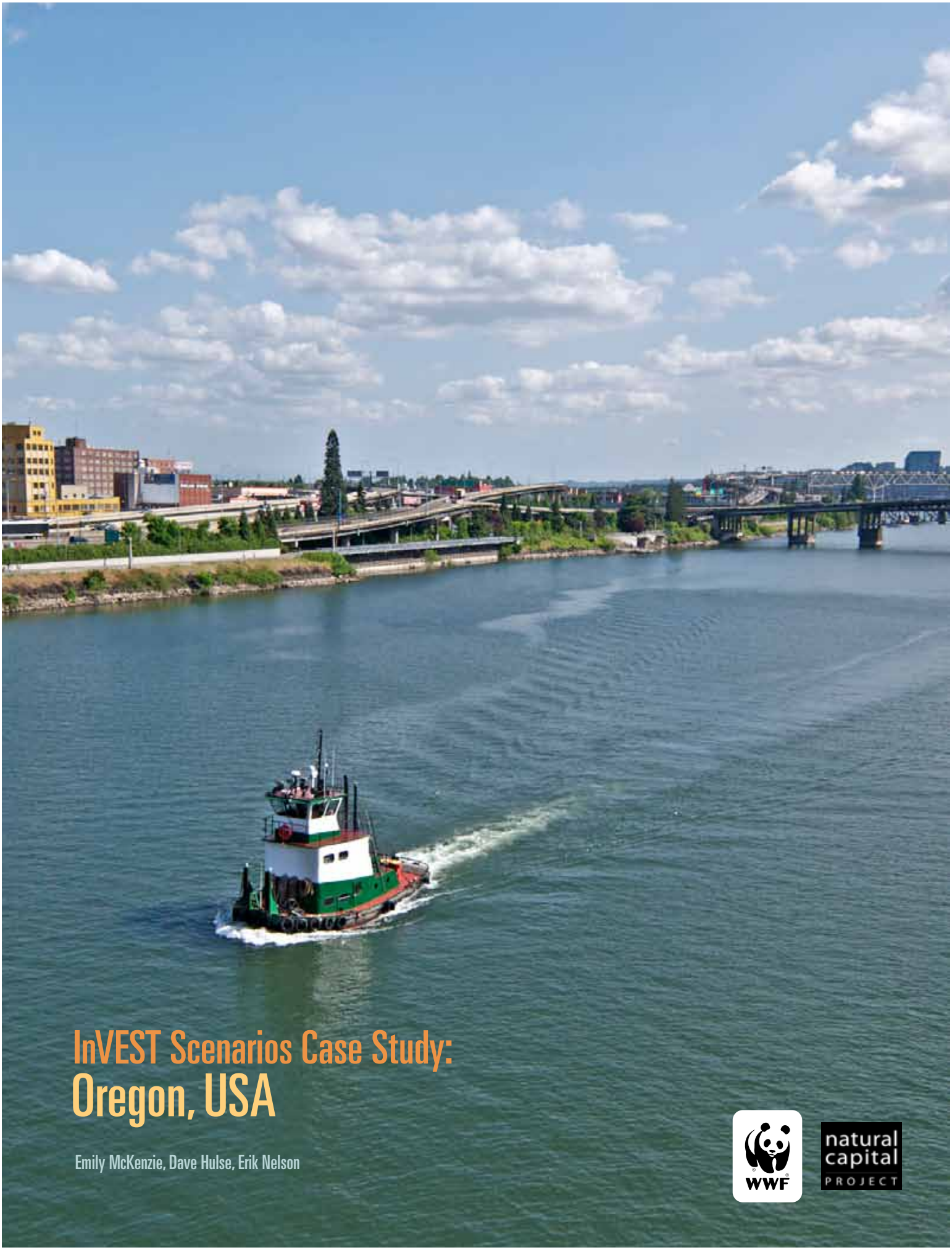


InVEST Scenarios Case Study: Oregon, USA

Emily McKenzie, Dave Hulse, Erik Nelson

WWF

natural capital PROJECT

excerpted from

Developing Scenarios to Assess Ecosystem Service Tradeoffs

This case study highlights a real-world example of using InVEST scenarios to inform decisions about land use. In this example, scenarios were developed, ecosystem service impacts were assessed, and the results were used to make sound policy decisions. The case study offers background on the policy context and goals, and then delves deeply into the experience with scenarios and draws out lessons.

Acknowledgment: This case study describes scenario development undertaken by the Pacific Northwest Ecosystem Research consortium, including the U.S. Environmental Protection Agency, Oregon State University and the University of Oregon. The scenario maps were later used by researchers at the Natural Capital Project who applied InVEST to assess ecosystem services under each scenario. The Natural Capital Project was not involved in the scenario development process described here.

Background

The Willamette River drains an area of nearly 30,000 km² between the Cascade and Coast Range mountains in western Oregon in the United States. It contains a rich variety of native fish and fauna and several threatened or endangered species, such as the northern spotted owl. Sixty-eight percent of Oregon's population lives in the Willamette River Basin. By 2050, this population is expected to double, creating challenges for land- and water-use planning.

In the mid-1990s, the governor of Oregon initiated several planning efforts to create an integrated strategy for development and conservation in the basin. First, the Willamette Valley Livability Forum was set up to develop and promote a shared vision for enhancing the livability of the river basin. Second, the Willamette Restoration Initiative was established to develop a strategy to protect and restore fish and wildlife habitat, increase populations of declining species, enhance water quality, and properly manage flood-plain areas.

Oregon has strong land-use planning and a history of conservation policies. However, at the time of this project, stakeholders had divergent views on the best approach to policy and planning. Some believed that greater natural resource protection and restoration was warranted to counteract loss of biodiversity. Other stakeholders felt that current land- and water-use policies were too restrictive, infringing unnecessarily on individual property rights.

What policy questions did the analysis set out to address?

The aim of the scenarios was to inform the vision and restoration strategy being developed by the community for land and water use in the Willamette River Basin. The scenario team aimed to draw out different views and priorities among

stakeholders, capture the essential elements in a few alternative future scenarios, help stakeholders find a common understanding about the best path forward, and help resolve conflicts. A principal goal was to develop capacity for community-based land- and water-use planning, rather than to achieve agreement on a specific plan.

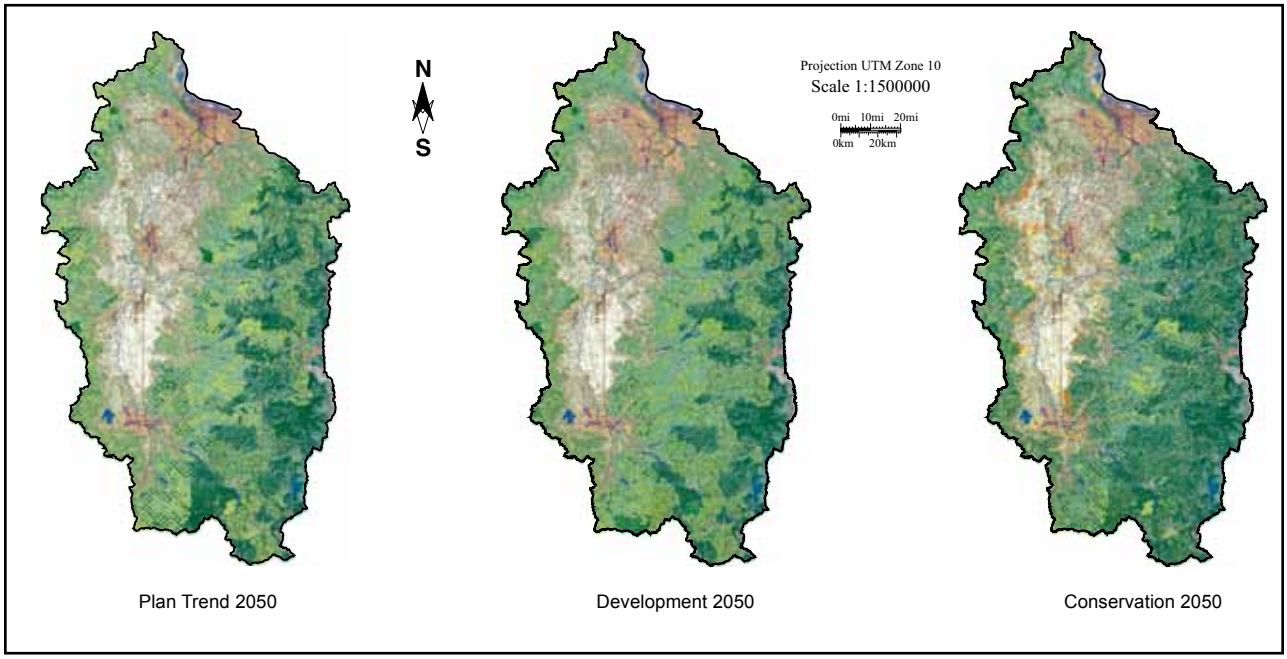
What scenarios were selected?

Three future scenarios were developed to illustrate major strategic choices for the Willamette Basin and represent the divergent views of stakeholders. Each scenario was projected at 10-year intervals through to the year 2050.

- **Plan Trend 2050:** This was a future projection scenario that represented the expected future landscape if current policies were implemented and current trends continued.
- **Development 2050**: This scenario reflected a plausible loosening of current policies, with less regulation of market forces.
- **Conservation 2050:** This scenario represented a future where greater priority would be given to ecosystem protection and restoration, but still with a plausible balance among social, environmental and economic objectives.

These scenarios were compared to the current situation (circa 1990) and historical landscapes from before Euro-American settlement.

FIGURE 1 Spatial scenarios in Willamette, Oregon



Land use/land cover of alternative futures for the year 2050. *Figure 2 in Hulse et al. (2004) Ecological Applications.*

How were scenarios developed?

The scenario development process involved a number of steps (see Figure 2):

1. Assess current situation and historical trends
2. Determine future scenario assumptions with stakeholder input
3. Depict scenarios spatially using land and water allocation models and parameters derived from scenario assumptions
4. Evaluate the impacts of the scenarios on natural resources (and subsequently also on ecosystem services)
5. Synthesize the scenarios in ways that are easy to assess and compare

We describe each of these steps here. For more details see Baker, Hulse et al. (2004), Hulse, Branscomb et al. (2004), US EPA (2002) and Hulse, Gregory et al. (2002).

FIGURE 2 Scenarios process applied in the Willamette River Basin, Oregon

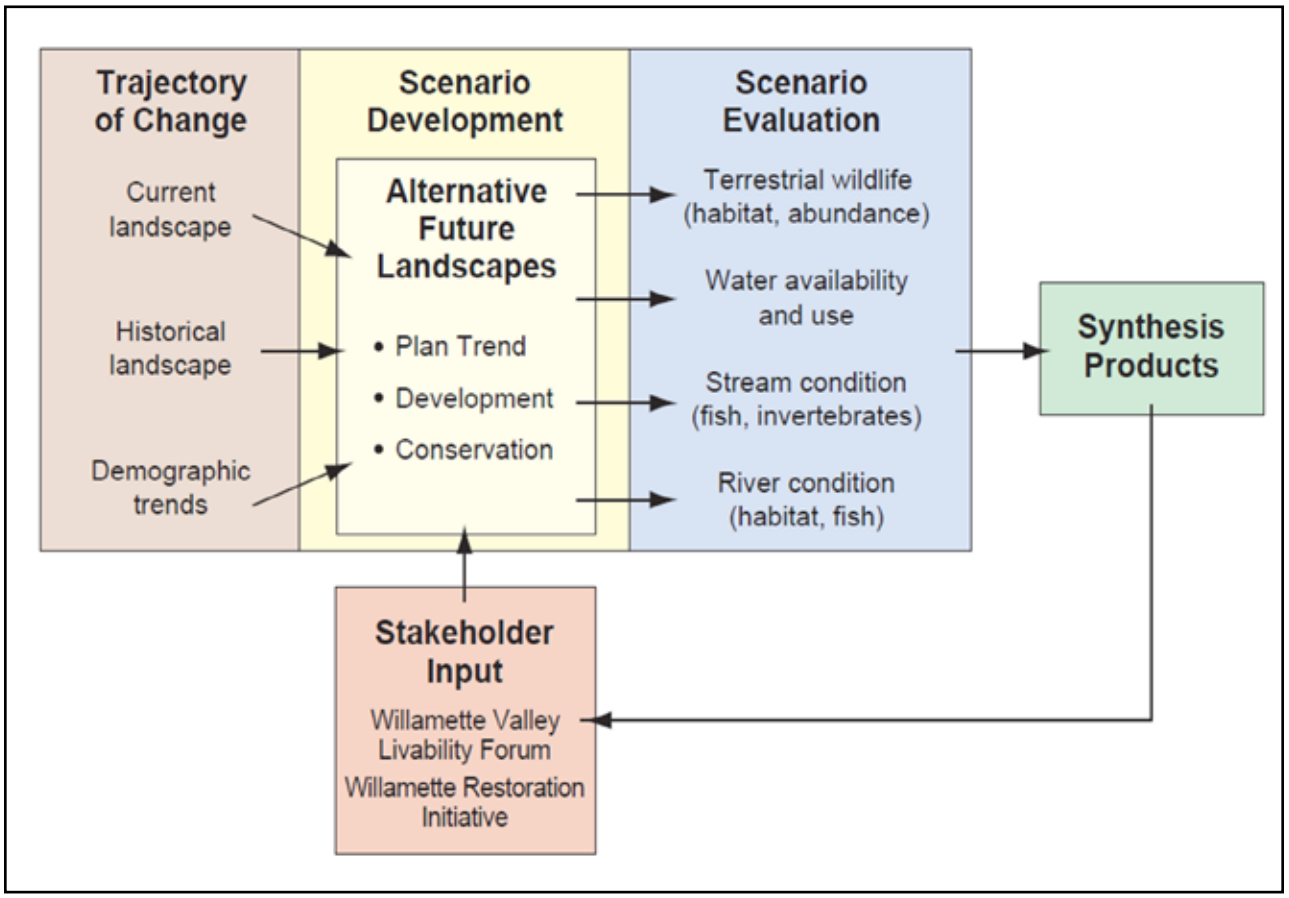


Figure 2 in Baker, Hulse et al. (2004) Ecological Applications

The study team characterized and compared the current and historical landscapes in the area. This enabled stakeholders to see the process of change over the previous century, which helped to stimulate thinking about the future. The team also reviewed projections for population growth in the Willamette River Basin. Based on these projections, they assumed 1.9 million additional people by 2050 under all three scenarios.

The study team began by developing assumptions that would underpin the scenarios. They engaged extensively with stakeholders in order to develop plausible assumptions given local knowledge and politics. Table 1 summarizes how stakeholders were engaged. The study team met monthly for two and a half years with the Possible Futures Working Group to develop value-based assumptions and rules about future land and water use in each scenario. The working group was supported by technical experts in sectors such as agriculture, forestry and biodiversity.

TABLE 1 Stakeholder engagement approaches used in Willamette Basin scenarios

Group	Outreach and feedback strategy
Entire population of Willamette River Basin	One-time, 8-page newspaper insert to 465,000 households
Willamette Livability Forum (100 community leaders appointed by governor to develop future vision for the basin)	Quarterly forums over three-year period with presentations and breakout sessions; electronic voting to review and refine scenario assumptions
Willamette Restoration Initiative (27 public- and private-sector citizens appointed by governor to develop recovery plan for threatened salmon in the basin)	Quarterly presentations over two-year period, discussed critiques of Conservation 2050 scenario assumptions
Possible Futures Working Group (20 citizens chosen on basis of expertise, constituency affiliation and representation, charged with defining plausible scenarios for 2050)	Monthly meetings over two-and-a-half-year period, presentations by researchers and others, received advice from technical expert groups
Technical expert groups (groups of 2–30 sector specialists)	Sporadic meetings, conference calls and emails with specific questions; provided specific quantities for scenario assumptions and judgments on habitat area requirements and future land and water use practices

Reference: Hulse, Branscomb et al. (2004)

Scenario creation proceeded by answering, in a spatially explicit way, the question of where and when to accommodate the additional 1.9 million people anticipated by 2050, while maintaining the agricultural- and forestry-based rural life. The land-use and land-cover patterns of the three alternative scenarios were then developed to explore the baseline and two divergent trends in public opinion: (1) less regulation of market forces with subsequent development, and (2) greater government regulation for conservation priorities. The scenarios differed mostly in the assumed spatial distribution of urban and rural residential areas. The projection (Plan Trend 2050) scenario was developed first to allow stakeholders to become familiar with the data and to understand spatial assumptions.

Each assumption developed from a general concept, to a parameter value, to detailed spatial allocations. For example, rural residential areas were assumed to expand in different spatial patterns for each scenario. The total number of rural structures was estimated for each scenario to provide parameter values for the modeling. The team then determined spatial patterns for rural residential expansion. In the Conservation 2050 scenario, expansion clustered near existing rural residential zones. In the Plan Trend 2050 scenario, expansion occurred only in existing rural residential areas. In the Development 2050 scenario, the location of rural residential expansion was determined by the suitability for rural residences (see Table 2 in Hulse, Branscomb et al. (2004) for the full list of assumptions).

The Conservation scenario was substantially based on expert opinion: experts estimated the area of key habitats required to sustain, in perpetuity, the array of dependent species. Spatially explicit analyses identified locations biophysically suited to meet the area targets. These locations were mapped and then reviewed by a series of groups to assess the political plausibility of conserving or restoring those areas.

How were scenarios translated into land-cover maps?

The scenario assumptions were translated into mapped spatial scenarios using computerized allocation models. Future landscape patterns were assumed to result from interactions among six landscape change processes: agriculture, forestry, urbanization, rural residential development, natural habitats and water use. Each was implemented through a computerized allocation model. Each model consisted of GIS algorithms that distributed land-use/land-cover (LULC) transitions across the landscape based on transition probabilities, which were derived directly from the assumptions defined by stakeholders, plus a stochastic element. Further details on how each model operated can be found in Hulse, Branscomb et al. (2004).

The stakeholder assumptions were refined iteratively to create plausible scenarios. As each scenario neared completion, the maps were presented to stakeholders for review. The study team also used computer simulations to help stakeholders visualize and compare the possible future landscapes. If the models produced maps that stakeholders felt did not match their assumptions, the models and maps were revised accordingly. Considerable effort was made to define 65 LULC categories that were meaningful both to stakeholders who had to interpret them, and to modelers developing and evaluating the scenarios.

How did the scenarios shape the final results for policy makers?

The scenarios research team evaluated the likely effects of each scenario on four resources: water availability, the Willamette River (the structure, vegetation and fish community), the ecological condition of streams, and terrestrial wildlife (Baker et al. 2004).

Results from these analyses were actively discussed by stakeholder groups charged with developing a vision for the basin's future and basin-wide restoration strategy. The restoration opportunities map, created as an interim step toward Conservation 2050, became part of the restoration strategy proposed by the Willamette Restoration Initiative.

InVEST was later used to assess how scenarios would affect a number of ecosystem services: water quality, storm peak mitigation, soil retention, carbon sequestration, biodiversity, and market returns to landowners (from agricultural crop production, timber harvest, and housing values) (Nelson et al. 2009). The research found no significant tradeoffs among ecosystem services and biodiversity, but a tradeoff between market values and all other ecosystem services and biodiversity. The economic value of the conservation scenario was higher than the other two scenarios when reasonable values for ecosystem services were added to market value estimates.

Key assumption

- Assumed same population growth for all scenarios (from current 2 million to about 3.9 million people by 2050).

Strengths

- Involvement of stakeholders led to a greater understanding and sense of ownership of the scenarios.
- The multilevel stakeholder group structure created an effective process where a sufficiently small group of stakeholders could define assumptions in quantitative detail, while also getting review from larger stakeholder groups that were broadly representative of the whole constituency.
- Local knowledge from stakeholders was used to create future scenarios that were considered to be both plausible and relevant.
- The projection scenario—Plan Trend 2050—was developed first, which enabled stakeholders to become familiar with the data and how to develop spatial assumptions.
- Scenario maps were presented to stakeholders iteratively, with stakeholders resolving ever narrower questions about the scenario assumptions and then reviewing the scenario maps. This enabled the effects of parameters to be perceived and reviewed, and led to stakeholders being less overwhelmed by the complexity of the process.

Challenges and areas for future improvement

- Extensive stakeholder engagement was time and resource intensive. The project took five years, and two-and-a-half years were devoted to defining the scenario assumptions. This process would therefore not be replicable in most circumstances.
- The scenarios did not combine climate change, changes in technology, or changes in market prices into scenarios of land-use/land-cover change.
- Tying scenarios tightly to what stakeholders considered plausible meant there was little variation among alternative futures.
- The stakeholders did not have much input in selecting the final endpoints (ecosystem services or natural resource impacts) that would be assessed for each scenario.
- The InVEST analysis was undertaken later, outside of the stakeholder engagement process.

SNAPSHOT | Willamette, Oregon

POLICY CONTEXT

Policy level

Multi-stakeholder forum with interests in management of Willamette River Basin

Policy questions

- What are the different views and priorities for the future among stakeholders?
- Can stakeholders find a common understanding about the best path forward and resolve conflicts?

Ecosystem services included

- Water quality, storm peak mitigation, soil retention, carbon sequestration. Also modeled biodiversity and market returns to landowners (from agricultural crop production, timber harvest and housing values).
- Original analysis also evaluated impacts of scenarios on water availability; the Willamette River (structure, vegetation and fish community), the ecological condition of streams, and terrestrial wildlife.

SCENARIO PRODUCT AND PROCESS

Scenario format

Quantitative, spatial scenario assumptions that were used in computerized allocation models to produce land-use and land-cover maps for each scenario. Computer simulations were also used to visualize each scenario.

Number of scenarios

3 (plus current and historical landscapes)

Time frame for scenarios

Projected at 10-year intervals through year 2050 (baseline in 1990, study published in 2002)

Spatial extent of scenarios

30,000 km^2 in Willamette River Basin

Spatial extent of policy recommendations

Willamette River Basin

Stakeholder participation in scenarios

High

Consideration of exogenous drivers

High

Consideration of endogenous drivers

High

Capacity and time required

High

Case Study References

Baker, Joan P., David W. Hulse, Stanley V. Gregory, Denis White, John Van Sickle, Patricia A. Berger, David Dole, and Nathan H. Schumaker. 2004. "Alternative futures for the Willamette River Basin, Oregon." *Ecological Applications* no. 14 (2):313–324. doi:10.1890/02-5011.

Hulse, D., S. V. Gregory, and J. Baker. 2002. *Willamette River Basin Planning Atlas: Trajectories of environmental and ecological change*. Corvallis, Oregon: Oregon State University Press.

Hulse, David W., Allan Branscomb, and Susan G. Payne. 2004. "Envisioning alternatives: Using citizen guidance to map future land and water use." *Ecological Applications* no. 14 (2):325–341.

THE NATURAL CAPITAL PROJECT IS A PARTNERSHIP AMONG

Developing Scenarios to Assess Ecosystem Service Tradeoffs: Guidance and Case Studies for InVEST Users is a resource for practitioners who want to assess the provision of ecosystem services under alternative future scenarios. The guide draws on case experiences where InVEST was used to compare ecosystem service tradeoffs under different scenarios. It can help InVEST users choose appropriate types of scenarios and methods, engage stakeholders, and create scenario maps. The guide highlights key issues and questions for reflection, along with tools, case studies, references and resources for those who want to learn more.

InVEST is a suite of ecosystem service models, developed by the Natural Capital Project, for mapping, quantifying and valuing ecosystem services under different scenarios. InVEST helps decision makers incorporate ecosystem services into policy and planning at different scales in terrestrial, freshwater and marine environments.

Further materials are available on the scenarios page at naturalcapitalproject.org