Trajectories of Change and the Challenges of Future Conservation and Restoration of Major Rivers

Trajectoires des grands fleuves et défis pour leur conservation et leur restauration

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RÉSUMÉ

La conservation et la restauration des rivières exigent une stratégie cohérente afin de 1) développer une ligne directrice, 2) anticiper les changements à venir, 3) créer un cadre spatialement explicite, et 4) maintenir une collaboration entre scientifiques, praticiens, et citoyens. Les actions pour conserver ou restaurer la rivière doivent permettre de 1) maintenir ou rétablir la dynamique de la rivière dans la mesure du possible, 2) identifier et protéger l'écosystème, 3) lier les modèles sociaux avec les modèles écologiques, et 4) développer des alternatives de gestion robustes face aux incertitudes à venir. Les efforts déployés dans la rivière Willamette (Oregon, USA) seront utilisés pour illustrer ces principes. L'analyse spatialement explicite des trajectoires de changement de l'environnement de 1850 à 2050 pour l'ensemble du bassin fournit une ligne directrice. La mise en place d'une démarche partenariale (la Willamette River Initiative) constitue le cœur de cette dynamique ayant pour but de créer une vision commune à tous les acteurs, des indicateurs de suivi des changements, des recherches scientifiques, et d'identifier les financements supports. Un cadre général ("Slices" framework) fournit un point de vue spatial commun pour la surveillance, la planification et la mise n place de priorités. Les résultats du suivi écologique du chenal principal de la rivière Willamette seront présentés. Les cartes des zones fréquemment inondables fournissent une base commune pour la planification des actions de conservation et l'évaluation de la qualité des habitats aquatiques. La visualisation efficace de l'information environnementale complexe est essentielle pour la communication, et plusieurs exemples illustreront la puissance de cet outil de collaboration.

ABSTRACT

Conservation and restoration of rivers require a strategy that 1) develops guiding vision, 2) anticipates future change, 3) creates a spatially explicit framework, and 4) maintains collaboration of scientists, practitioners, and citizens. Actions to conserve or restore the river must 1) maintain or restore the dynamics of the river to the greatest extent possible, 2) identify and protect healthy parts of the ecosystem, 3) link social patterns with ecological patterns, and 4) develop management alternatives that are robust in the face of future uncertainty. Efforts in the Willamette River in Oregon, USA will be used to illustrate these principles. Spatially explicit analysis of trajectories of environmental change from 1850 to 2050 for the entire basin provided a guiding vision. A collaborative partnership (the Willamette River Initiative) serves as a virtual "backbone" organization to create a common vision, shared metrics for tracking progress, scientific research, regular convening and funding. The "Slices" framework provides a common spatial perspective for monitoring, planning, and prioritization. Results of ecological monitoring of the mainstem Willamette River will be illustrated. Maps of areas inundated under frequent floods provide a common basis for planning conservation actions and assessing aquatic habitat quality. Effective visualization of complex environmental information is essential for communication, and several examples will illustrate the power of this tool for collaboration.

KEYWORDS

Floodplain, land use, future scenarios, restoration, river.

1 INTRODUCTION

Rivers and their floodplains play central roles in the historical development of cities, their populations, and economies. As communities and regions grow and flourish, the environmental and aesthetic values of rivers are soon challenged by the social processes and populations that benefitted from the inherent dynamics and diversity of rivers (Hulse and Gregory 2004). Geomorphic processes that built floodplains are soon viewed as dangerous and damaging for communities that have moved into the floodplains and placed homers and property close to the dynamic river. Floodplain forests are converted to industrial areas, urban and residential buildings, and open farmlands. Channels are hardened and straightened, inadvertently increasing the power of the river and causing unintended damage. Floods that shaped the river, built floodplains, created diverse aquatic habitat, and exchanged nutrients are controlled and dampened, leading to loss of aquatic productivity and biodiversity. Water quality and quantity become increasingly limited as water is withdrawn from the rivers and municipal and industrial wastes are added. Fisheries and wildlife that once supported human communities decline and become imperilled. Non-native species are introduced, frequently altering the abundance and distribution of native species. Global and regional climate trends create uncertainties about future environmental conditions and the viability of aquatic species. In the face of changing land use, human populations, and regional climate, river managers face a complex morass of seemingly contradictory demands, land use practices, and community values (Gregory 2009).

Conservation and restoration of rivers require the integration of scientific understanding of river processes and ecology, social values and processes, and local and national politics and governance. This formidable challenge requires a strategy that 1) develops and shares a guiding vision of the future landscape and riverscape, 2) anticipates future change, 3) creates a spatially explicit framework for assessment and monitoring of the river and its floodplains, and 4) maintains on-going collaboration of scientists, practitioners, land owners, and citizens. Actions to conserve or restore the river ecosystem must 1) maintain or restore the dynamics of the river to the greatest extent possible, 2) identify and protect intact, healthy, functioning parts of the river ecosystem, 3) link social patterns and trends with ecological patterns and trends, and 4) develop management alternatives that are robust in the face of multiple alternative future scenarios of climate and land use.

2 WILLAMETTE RIVER PARTNERSHIP

Recent efforts in the Willamette River in Oregon, USA will be used to illustrate these principles of collaborative conservation and restoration of a floodplain river. The Willamette Basin encompasses 29,785 square kilometres. Five of Oregon's ten largest cities are located along the river and its basin supports 75% of the population of Oregon. The Willamette Valley population is expected to grow from 2.5 million people to more than 4.4 million by 2050. Efforts to improve water quality and reduce land use impacts have improved environmental conditions over the last 60 years, but many reaches of the river and tributaries do not meet current water quality standards. The river has been straightened and simplified with a loss of more than 20% of the mainstem habitat. More than 80% of the area of floodplain forests has been lost since 1850 and has been replaced by agricultural and urban development. Flood control efforts have dramatically reduced winter floods and more than doubled summer low flows. The river network supports 34 native fish species, but 32 non-native fish species have been introduced.

One of the first steps in development of a shared guiding vision was development of a spatially explicit analysis of trajectories of environmental change from 1850 to 2050 for the entire basin (Baker et al. 2004). Land cover and land use were mapped for scenarios of the past and present. Scientists invited a stakeholder group of practitioners and citizens to define the assumptions for spatial representation of three alterative future scenarios for 2050—Plan Trend (the future landscape if we continue to implement our current policies and practices), Development (relaxed environmental policies regulations to provide greater flexibility for market forces), and Conservation (greater application of conservation and restoration actions to insure long-term ecological function). Teams of scientists modelled changes in aquatic ecosystems, wildlife, land cover, and water resources for these scenarios of past, present, and alternative future scenarios. Aquatic and terrestrial resources had declined greatly from 1850 to the present and continued to decline in the future under our current practices and policies. Resource loss was even greater for the Development scenario, especially for wildlife resources. The plausible conservation and restoration actions projected for the Conservation scenario resulted in a reversal of the patterns of resource decline and recovered 20 – 40% of the aquatic and terrestrial resources that have been lost over the previous 150 years (Van Sickle et al. 2004).

As in most rivers and regions, the planning, regulation, and management of activities that affect the river involve a large number of agencies, institutions, citizen groups, and private industries and land owners. In this large, complex system, river stakeholders need to work from a common agenda, engage in complementary restoration activities over many years, and evaluate results according to a shared set of metrics. A collaborative partnership between the state of Oregon and the Meyer Memorial Trust has created the Willamette River Initiative (WRI) to serve as a virtual "backbone" organization to provide these critical functions. The WRI includes four core partners—University of Oregon, Oregon State University, Oregon Watershed Enhancement Board, Bonneville Environmental Foundation—which then extends their actions through a network of watershed councils, land trusts, local governments, and citizen groups.

The analysis of alternative future scenarios created a guiding vision for the WRI and provided a spatially explicit framework for identifying anchor habitats for conservation and setting goals and priorities for conservation actions. One of the key elements of the planning, assessment, and monitoring of the mainstem Willamette River was the development of a common spatial representation of the river and floodplain that was consistent with a dynamic and ever changing river. We developed a "Slices" framework in which the floodplain was represented as 100-m slices or bands perpendicular to the floodplain axis (http://ise.uoregon.edu/slices/Main.html). The Slices approach was first suggested to our group by Dr. Herve Piegay and provides a representation of the floodplain in which the river channel can change without altering the spatial framework. In addition, the "slices" provide a consistent view of the river that inherently includes both banks and the full extent of the aquatic habitat. It provides the spatial link to data on ecological conditions, aquatic communities, river geomorphology, and human infrastructure. The Slices framework now provides a common spatial perspective for scientific monitoring, conservation planning, and prioritization of alternative actions.

Collaborative efforts between state agencies and university scientists have used the slices floodplain framework to assess aquatic resources in the mainstem Willamette River. Fish communities exhibit an overall decrease in abundance and species richness along the 230-km length of the mainstem. Mainstem habitats are dominated by native fish, but sloughs exhibit increasing proportions of non-native species from the upper reaches to the mouth. Cold-water species, such as cutthroat and rainbow trout and Chinook salmon, are most abundant in the upstream reach. Cold water refuges are created by subsurface flow from the river through the floodplain, providing water in sloughs that is as much as 9°C colder than the mainstem. Studies have shown that the majority of trout use these cold water refuges during the warmest period of the summer and maintain body temperatures several degree lower than water temperatures in the mainstem. These cold water refuges provide future conservation opportunities in the face of municipal thermal pollution and future climate uncertainty.

LIDAR analysis and topographic modelling has provided a depiction of the area of the floodplain inundated under frequent floods. The Slices maps now provide these inundation boundaries for 2-yr recurrence interval floods, which have frequent effects on aquatic communities and can be easily altered by bank engineering. We are developing additional maps for both larger and smaller flood discharges. These maps then provide a common basis for planning conservation and restoration actions as well as assessment of flood habitat quality for critical aquatic species.

Effective visualization of complex environmental information is essential for communication among the public, conservation groups, agencies, and scientists. We created a digital library website to provide technical information to the public (http://www.willametteexplorer.info). We developed animations of past, present, and future conditions along the river based on technical maps from the alternative futures analysis (http://www.fsl.orst.edu/pnwerc/wrb/access.html under Related Data, visualizations). Recently, the WRI has started the production of a film about the collaborations involved in the conservation actions by the network of partners (http://www.youtube.com/watch?v=4bcISkQyjEs). The Willamette River Initiative established a biennial meeting of partners—Within Our Reach Conference—to share information and progress and explore new directions.

In the Willamette basin, an array of organizations—each with its own mission, geographic focus, and funding sources—is working to restore critical habitat and water quality, acquire key conservation properties, re-envision cities' relationship to the river, re-think dam operations, and engage the agricultural and gravel industries. The partnership formed through the Willamette River Initiative provides critical backbone support that collectively creates a common vision, shared metrics for tracking progress, scientific research, regular convening and funding. Working together with the network of partners and local communities, conservation and restoration of the Willamette River and its tributaries have been dramatically accelerated and strengthened.

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