PERSPECTIVES FROM THE FIELD

Watershed Planning and Climate Change Adaptation in the Intermountain Western United States: Linking Global Trends to Local Management

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Observed and projected events associated with climate change indicate the need for a paradigm shift from reactive, small-scale, and short-term water resources management to proactive, large-scale, and long-term ecosystem adaptation that enhances ecosystem resilience to climate variability. *Adaptation* is defined here as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007). Adaptation and resilience to climate change will require new approaches and thoughtful, preventive actions at a broad scale to reduce the vulnerability of watersheds in the Intermountain West United States (US) (US Interagency Climate Change Adaptation Task Force, 2010). The need for a paradigm shift in watershed planning, linking local responses to climate changes across the Intermountain West, is supported by recent observed drought conditions and more intense rainfall and flood events. This article discusses challenges and opportunities associated with linking observed and projected climate changes with local watershed planning and management at one of the most highly visible recreational areas in the Western US—the Arkansas Headwaters Recreation Area in Colorado.

Climate Change and Watershed Ecosystems

The Intergovernmental Panel on Climate Change and the US Climate Change Science Program have concluded that climate change will affect water resources in the Intermountain West. While total annual precipitation is increasing in the northern latitudes and average precipitation over the continental US has increased, the western and southwestern US are trending towards reduced precipitation. In the context of higher temperatures, this reduction in precipitation results in lower soil moisture and a substantial effect of runoff in rivers (IPCC, 2007; USCCSP, 2008a,b). Scientific consensus further suggests that more intense precipitation events are likely to increase in frequency in the region, thereby increasing flood risk with a high level of statistical confidence (>90%).

Natural vegetation cover that is integral to healthy watersheds can be affected by the stresses of aforementioned climate changes. Direct effects can include die-off during drought and blowdown of trees during storm events. In addition, ecological systems such as fisheries, wetlands, and riparian areas may be impacted. Indirect climate-sensitive disturbances can include invasive-species infestations and wildfire (USCCSP, 2008). Such effects increase vulnerability of watershed ecosystems to long-term stressors. Studies have further concluded that changes to runoff and stream flow would have considerable regional-scale consequences for economies as well as natural ecosystems (Milly, Dunne, and Vecchia, 2005). The intensity of extreme weather events—droughts, heat waves, floods, and violent storms—could adversely impact regional economic systems such as ranching, farming, and recreation.

Watershed Based Planning in the Intermountain West

In the Intermountain West, observed climate-related trends in temperature, snowfall, and stream flow suggest that changes in watershed management practices will be necessary to adapt to the altered hydrologic regime (Udall and Bates, 2007). The watershed approach to wetland mitigation (see USACE and USEPA, 2008) provides a firm foundation for broadening the analytical lens to include climate-driven variability factors at the watershed scale and allow for such adaptation. Entire river systems, including upland areas and tributaries throughout the Intermountain West, are becoming dryer and flooding with increased intensity (Udall and Bates, 2007). Increased drought, coupled with more intense rainfall and flood events, can cause downstream environmental impacts such as increased sedimentation.

Local flood mitigation activities and river monitoring in the Intermountain West should include consideration of climate change impacts. Observed climate changes are also creating new opportunities to take a broader view of watershed planning and management activities, including diverting excess flows to downstream reservoirs and groundwater recharge projects in areas like the Arkansas River Basin. Additionally, managers may explore opportunities to enlarge existing infrastructure to capture flows produced during intense rainfall events.

Case Study: The Arkansas Headwaters Recreation Area

The Arkansas Headwaters Recreation Area in Colorado encompasses 152 stream miles and more than 4,500 square miles surrounding the Arkansas River from its headwaters in the town of Leadville, downstream to the city of Pueblo. The upper Arkansas River is a regional jewel that provides numerous ecosystem services, including important fisheries and wildlife habitat, water supply, water quality, flood control, and recreation. There are numerous competing demands on river basin resources. Diverse land ownership, past and present mining with associated superfund sites, coupled with agriculture, ranching, and forestry activities, make it a complex system to manage.

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Over the last decade, the Arkansas Headwaters Recreation Area has experienced trends indicative of climate-related variability throughout the Intermountain West: drought, erosive forces from intense rainfall events, loss of upland vegetative cover, and higher sedimentation rates. However, a lack of baseline data and analysis suggests that additional work is needed to understand the causes and sources of sediment loading and susceptibility to climate-driven variability. Most recently, due to recurring localized flash floods, the Colorado Division of Parks and Outdoor Recreation (Colorado State Parks) initiated a collaborative partnership to lead a pilot stream restoration project at Hecla Junction in the Arkansas Headwaters Recreation Area. The goals of this pilot project are to apply stream restoration and sediment reduction approaches; monitor physical, chemical, and biological parameters of success; and relate lessons learned to other at-risk tributaries in the Arkansas Headwaters Recreation Area. Preliminary results of the restoration project will be compiled after project construction in 2011, thus providing an opportunity to expand the future watershed planning framework to link climate change to local management.

Future Directions

Though impacts of climate change are now being felt across the Intermountain West, a disconnect remains between observed long-term, large-scale trends and watershed management activities at the local level. The case study at the Arkansas Headwaters Recreation Area provides a foundation for integrating macrolevel concepts of ecosystem adaptation and resilience to climate change variability into local watershed planning and management activities USCCSP (2008b). Key areas of future focus adapted include the following:

- Protecting key ecosystem services that underpin the system
- Reducing susceptibility to climate-related variability
- Reducing human-induced changes that erode resilience
- Increasing representation of different species and communities under protection
- Restoring ecosystems that have been compromised or lost
- Identifying potential habitat refuges

A critical next step is the initiation of a holistic watershed planning process that includes these approaches to climate adaptation and resilience for the Arkansas Headwaters Recreation Area.

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