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Potential effects of climate change on riparian areas, wetlands, and groundwater-dependent ecosystems in the Blue Mountains, Oregon, USA

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ABSTRACT

Riparian areas, wetlands, and groundwater-dependent ecosystems, which are found at all elevations throughout the Blue Mountains, comprise a small portion of the landscape but have high conservation value because they provide habitat for diverse flora and fauna. The effects of climate change on these special habitats may be especially profound, due to altered snowpack and hydrologic regimes predicted to occur in the near future. The functionality of many riparian areas is currently compromised by water diversions and livestock grazing, which reduces their resilience to additional stresses that a warmer climate may bring. Areas associated with springs and small streams will probably experience near-term changes, and some riparian areas and wetlands may decrease in size over time. A warmer climate and reduced soil moisture could lead to a transition from riparian hardwood species to more drought tolerant conifers and shrubs. Increased frequency and spatial extent of wildfire spreading from upland forests could also affect riparian species composition. The specific effects of climate change will vary, depending on local hydrology (especially groundwater), topography, streamside microclimates, and current conditions and land use.

Practical Implications

Riparian areas, wetlands, and groundwater-dependent ecosystems have enormous conservation value throughout western North America. These special habitats are typically biodiversity hotspots for both plants and animals. They also play a significant role in maintaining functional hydrologic regimes in watersheds and providing cool water for spawning and rearing of salmonid fish species.

Resource managers at national forests in the Blue Mountains (northeast Oregon and southeast Washington, USA) are mandated to protect riparian areas and retain their functionality. Riparian areas have been degraded by livestock grazing, water diversions, and other land uses over many decades. Although restoration of riparian areas is a priority for federal managers, competition among different users creates a complex social and political environment.

The added stress of climate change makes riparian and wetland restoration and conservation even more challenging. Some smaller habitats (e.g., near springs and streams) could disappear, whereas larger habitats, especially those with a good groundwater supply, may be more resilient to a warmer climate. Most riparian and wetland ecosystems will experience some degree of increased stress in a warmer climate, including the indirect effects of increasing wildfire and nonnative species. Some changes may occur gradually and others may occur episodically (e.g., following wildfire). Long-term monitoring is needed to detect where, when, and how climate change effects occur.

Riparian areas, wetlands, and groundwater-dependent ecosystems have been classified and mapped throughout the Blue Mountains, an important first step for conservation and restoration. Impacts from land-use practices have been quantified in some locations, providing a benchmark for systems that are currently compromised. Our assessment of climate change impact and vulnerability can be used to develop restoration priorities and to identify those aquatic ecosystems that could experience the most stress from a warmer climate and altered hydrologic regimes. Maintaining a reasonable degree of hydrologic functionality and minimizing impacts from land use will contribute to building and sustaining resilience.

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1. Introduction

In the Blue Mountains, climate change will likely have significant, long-term implications for freshwater resources and associated vegetation. Climate change is expected to cause a transition from snow to rain, resulting in diminished snowpack and shifts in streamflow to earlier in the season (Leibowitz et al., 2014). Additional effects include more extreme high streamflows, more extreme low streamflows, reduced groundwater recharge, and altered nutrient dynamics and other ecosystem functions (Johnson et al., 2012; Raymondi et al., 2013). Increasing air temperatures contribute to shifts in precipitation and stream runoff patterns, and also influence fire frequency and severity (Schoennagel et al. 2017), and the duration of the fire season. Another consequence of warming temperatures is the higher frequency and severity of droughts, which have increased the susceptibility of plant species to pathogens and insect pests, leading to regional tree die-offs (Breshears et al., 2005) and changes in the distribution of vegetation.

Here, we describe the potential effects of climate change on riparian areas, wetlands, and groundwater-dependent ecosystems (GDEs) in the Malheur, Umatilla, and Wallowa-Whitman National Forests. We define riparian areas, wetlands, and GDEs, highlighting the considerable overlap among these ecosystems, then briefly describe the current condition, land use impacts, and range of plant communities that occur in these habitats. We describe potential climate-influenced changes for different vegetation assemblages, and emphasize that there is considerable uncertainty about rates and direction of change, depending on physical and biological conditions and land use effects.

2. Definitions

Riparian areas are zones of direct physical and biotic interactions between terrestrial and aquatic ecosystems (Gregory et al., 1991), and include the continuum from headwaters to the mouths of streams and rivers, the vertical dimension that extends upward into the vegetation canopy and downward into subsurface interactions, and the lateral dimension that extends to the limits of flooding on either side of a stream (Stanford and Ward, 1993).

In the Blue Mountains, riparian ecosystems occur across a broad range of climatic conditions, and geomorphic and physical features at all elevations (Crowe and Clausnitzer, 1997; Johnson, 2004; Wells, 2006). Stream sizes, landforms, valley widths, and hydrologic regimes determine the biotic communities that occur along streams. Riparian areas, wetlands, and intermittent streams are included within Riparian Habitat Conservation Areas (RHCAs), which specify minimum buffers from each side of the stream channel edge: intermittent streams (15 m), wetlands and non-fish-bearing perennial streams (46 m), and fish-bearing streams (91 m). Active management within buffers must comply with riparian management objectives designed to improve habitat conditions for fish species.

Wetlands are ecosystems inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil (FICWD, 1989). Wetlands can be diverse physically and biologically, varying in duration, seasonality, and depth of inundation and soil saturation. In the Blue Mountains, the dominant wetland types are palustrine, lacustrine, and riverine (Cowardin et al., 1979; Figs.1–3). Palustrine wetlands are freshwater ecosystems that include marshes, wet meadows, and forested wetlands. Lacustrine wetlands border lake shores. Riverine wetlands occur along stream channels. Most riparian areas are categorized as riverine wetlands, and all wetland and riparian areas in national forests in the Blue Mountains are managed as RHCAs.

Groundwater-dependent ecosystems (GDEs) are biotic communities whose extent and life processes depend on access to or discharge of groundwater (Springer and Stevens, 2009; USFS, 2012a,b). Many wetlands, lakes, streams, and rivers receive inflow from groundwater, which can contribute substantially to maintenance of water levels, as well as water temperature and chemistry required by native biota (Lawrence et al., 2014). In the Blue Mountains, GDEs include springs, high-elevation lakes, fens, streams, rivers (Brown et al., 2009, 2010), and riparian wetlands along gaining river reaches. Fens are peat-accumulating wetlands that are largely supported by groundwater (thus, GDEs). Groundwater is important to most watersheds in northeastern Oregon (Gannett, 1984; Brown et al., 2009).

3. Methods

To assess current condition of riparian areas and wetlands in the Blue Mountains, we reviewed the regional literature for documented impacts of past land use on seven broad riparian/wetland plant community types, and utilized information from theses, government reports and scientific journal articles. We also analyzed riparian vegetation data collected through the interagency program, PACFISH INFISH Biological Opinion Effectiveness Monitoring (PIBO; http://fsweb.r4.fs.fed.us/unit/nr/pibo/index.shtml), which monitors biological and physical components of aquatic and riparian habitats throughout the Columbia River Basin (Meredith et al., 2011; Archer et al., 2012). For 191 sites in the Blue Mountains, we assessed riparian vegetation changes in total plant cover, woody cover, and non-native species cover (2007–2011), and compared data from reference and managed sites (Coles-Ritchie et al., 2007). To evaluate current distribution of wetlands in the Blue Mountains, we summarized information from the Oregon Wetlands Geodatabase (http://oregonexplorer.info/wetlands/DataCollections/GeospatialData_Wetlands) (Figs. 1–3).

To assess the current condition of GDEs, we utilized data compiled by The Nature Conservancy (Brown et al., 2010), the National Hydrology Dataset (http://nhd.usgs.gov), and the Oregon Wetlands Geodatabase. In addition, we summarized existing inventory data; since 2008, 133 GDEs, mostly springs, have been characterized in Blue Mountains' national forests, using the GDE Inventory Field Guide (USFS, 2012a). As part of this protocol, information on management indicators is recorded to assist in identifying concerns and needs for management action. We assessed three indicators: aquifer functionality, soil integrity, and vegetation composition. In the Malheur and Wallowa-Whitman National Forests, GDE inventories targeted sites where proposals for water development could be damaging, whereas inventories in the Umatilla National Forest targeted portions of grazing allotments and watersheds with specific management concerns.

To describe the potential effects of climate change on riparian areas and wetlands in the Blue Mountains, we utilized published research that examined responses of riparian and wetland characteristics to drought and hydrologic alteration, primarily dams and diversions, focusing on studies conducted in the western USA. We also considered local knowledge from resource managers and stakeholders—summarized during a series of meetings on climate change adaptation—who have observed changes to specific resources, such as aspen and cottonwood stands over recent decades. For potential effects of climate change on GDEs, we summarized regional predictions of vulnerability (Brown et al., 2009, 2010) and relied on published, scientific literature. For these resources, there is considerable uncertainty in our projections, however, because empirical data are lacking on specific mechanisms through which climate change will influence riparian and wetland plant communities.