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Environmental flows in the desert rivers of the United States and Mexico: Synthesis of available data and gap analysis

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ABSTRACT

Although riparian and aquatic ecosystems make up a small fraction of the area in arid and semi-arid lands, they are critical for the survival of desert life. There are, however, few compendia of efforts to define the quantity of water needed to maintain these ecosystems and understand the risks and stressors to them. Through our analysis we found that 62% of the rivers examined in the deserts of the U.S. and Mexico have had just one study over the past four decades and 67% of studies used qualitative methods. Furthermore, only one-third of the 312 species catalogued in our work have been studied more than once and only 5% have been considered five or more times. The most common risks or stressors to riparian and aquatic species were engineered structures, invasive species, and altered flows; and while 10% of studies included climate stressor, climate change impacts were infrequently examined. Ultimately, we found that although research has been conducted across the desert watersheds of the U.S. and Mexico, there are significant gaps in our knowledge of basic data such as the location and extent of perennial and intermittent streams, let alone studies of environmental flow needs.

1. Introduction

1.1. Understanding environmental flows

Environmental flows are defined as “the quantity, quality, and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems” (Acreman, 2016 p. 622, Brisbane Declaration). Riparian and aquatic ecosystems, including the species they contain, depend on dynamic surface water flows, groundwater levels, and groundwater discharge to streams via springs. The importance of water via streams and springs for riparian and aquatic ecosystems has led to increased interest in understanding the connections between hydrology and ecology of these systems. Of the 280 papers published in the peer-reviewed literature in 2014 and 2015 with the key words “environmental flows,” only 7% remain when refined to include the keywords “desert” or “arid”. This paucity of easily accessible information on environmental flows in arid systems is of particular concern because of the important role streams and springs play in providing water and habitat in the desert landscape. Furthermore, this lack of understanding of how much water riparian and aquatic ecosystems need to survive is problematic because it creates barriers to incorporating environmental flow needs into policy and law (Pahl-Wostl et al., 2013).

The authors created the Desert Flows Database (wrrc.arizona.edu/desertflowsdata) through funding by the Desert Landscape Conservation Cooperative (DLCC) as a first step to providing access to timely information for the management of riparian and aquatic species and ecosystems in the desert watersheds of the United States and Mexico. This database, which is the basis for the synthesis and gap analysis presented in this paper, was created as a one-stop-shop for managers looking for published data on the water requirements of riparian and aquatic species and ecosystems and the methods used to determine these water needs.

Using the information contained within the Desert Flows Database, the Water Resources Research Center at the University of Arizona and the Watershed Ecohydrology Program at Northern

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Arizona University, sought to answer the following questions for the desert watersheds of the United States and Mexico: 1) what is the extent and distribution of environmental flow data in the region? 2) what are the most frequently studied species? 3) what methods are researchers and managers using to determine environmental flow needs and 4) what are the most common risks and stressors to riparian and aquatic species and ecosystems in the region? Based on our previous work in Arizona (Mott Lacroix, Xiu, & Nadeau, and Megdal, 2016) our hypotheses included: 1) data on environmental flows would be concentrated on the largest perennial streams in the region; 2) the most frequently studied species would be those that are endangered species (e.g., silvery minnow and southwestern willow flycatcher) or provide habitat for endangered species (e.g., cottonwood-willow forests); 3) most methods would be qualitative; and 4) risks and stressors would vary by ecoregion.

1.2. Study area

The DLCC is regional partnership formed and directed by resource management entities, and public and private agencies interested in the Mojave, Sonoran, and Chihuahuan Desert regions in the United States and Mexico. The DLCC is one of 22 landscape cooperatives across North America. The mission of the DLCC is to contribute with scientific and technical information through collaborative partnerships that seek to develop, deliver and communicate scientific knowledge, monitor and evaluate climate change impacts, and educate resource managers and the general public on the effects of climate change and environmental threats (https://desertlcc.org).

The study area consists of 41 watersheds at the 6 digit hydrologic unit code level that touch the geography of the DLCC (See Fig. 1). This geography represents a 2,173,000 km2 area that contains some of the most imperiled and iconic rivers and springs in the U.S. and Mexico. This region includes the Mojave, Sonoran, and Chihuahuan deserts, semi-arid grasslands and valley bottoms, and isolated "sky-island" mountain ranges, with elevations ranging from near sea level to more than 3050 m. The DLCC also contains several large river systems: the middle and lower Rio Grande, the lower Colorado River, Gila River, San Pedro River, Rio Sonora, Rio

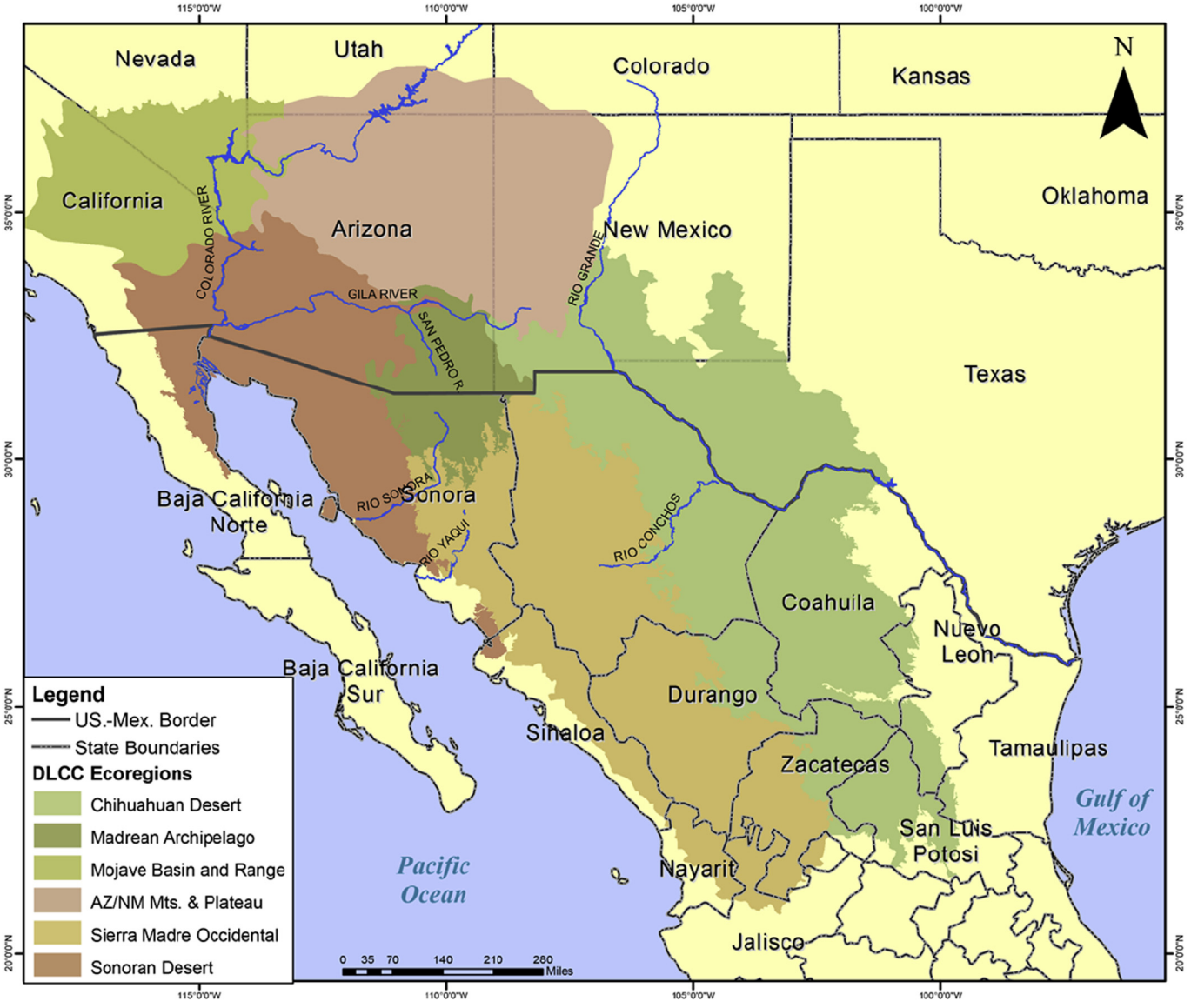

Fig. 1. Desert Landscape Conservation Cooperative (DLCC) geography.