Synthesizing Environmental Flow Needs Data in Water Scarce Regions

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Background

A paucity of readily available information on the flow needs of riparian and aquatic species can hamper efforts to include these needs in water management and planning. In 2011-2014 the WRRC completed a gap analysis of data on flow needs and responses in Arizona and built a geospatial database to house this information. In 2015 we are using the same database framework to expand the scope of the data to the deserts of the United States and Mexico with funding from the Desert Landscape Conservation Cooperative (DLCC) (Figure 1). The goals of the DLCC flows database are: 1) to develop a one-stop shop for information on riparian and aquatic species and ecosystem flow needs and responses for the deserts of the U.S. and Mexico and 2) aid managers in identifying areas and species where more data are needed and additional studies and research should be conducted.

Figure 1: Project study area. The Desert Landscape Conservation Cooperative (DLCC) spans the deserts of the U.S. and Mexico.

Methods

Gathering material for the database requires a multi-step, dynamic process that includes an advisory committee. This committee consists of federal, state, and local land/water managers and other riparian and aquatic ecosystem experts. The advisory committee provides direction for database content and structure. To determine how practitioners would use an environmental flows database, a survey was administered to 80 land and water managers in the study area (See Figure 2 for sample results). The structure and content of the expanded flows database will be based on these survey results and ongoing input from the advisory committee.

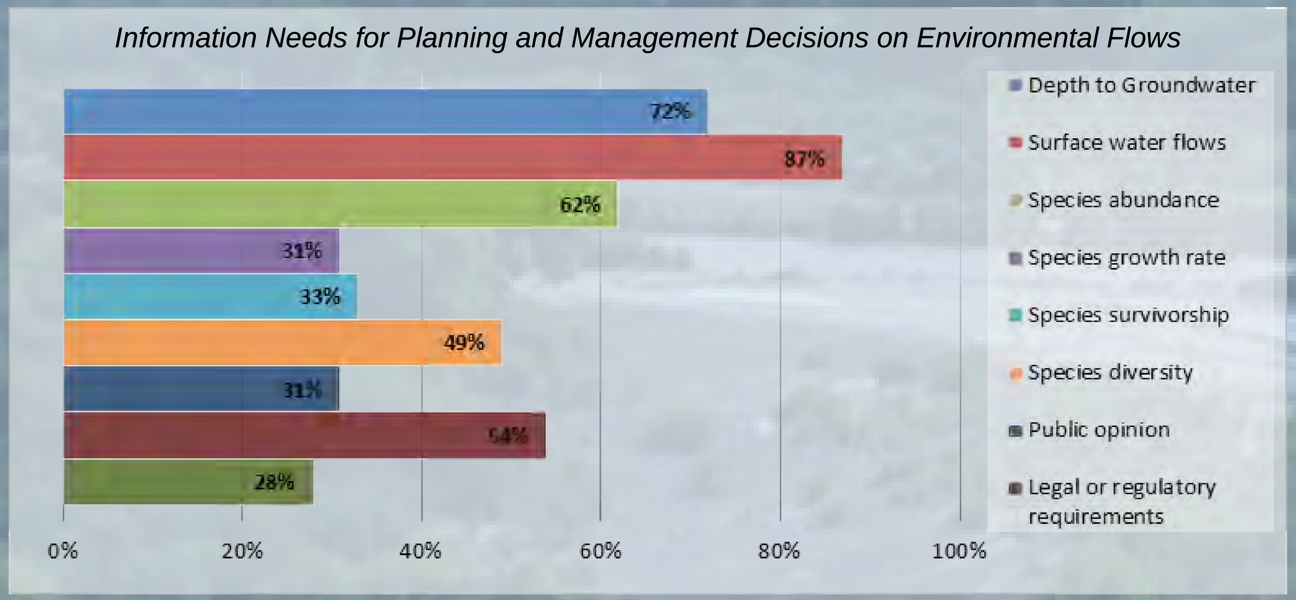


Figure 2: Survey responses for the question - What information do you want or need to help you make management and planning decisions regarding riparian and aquatic ecosystems? (n=43)

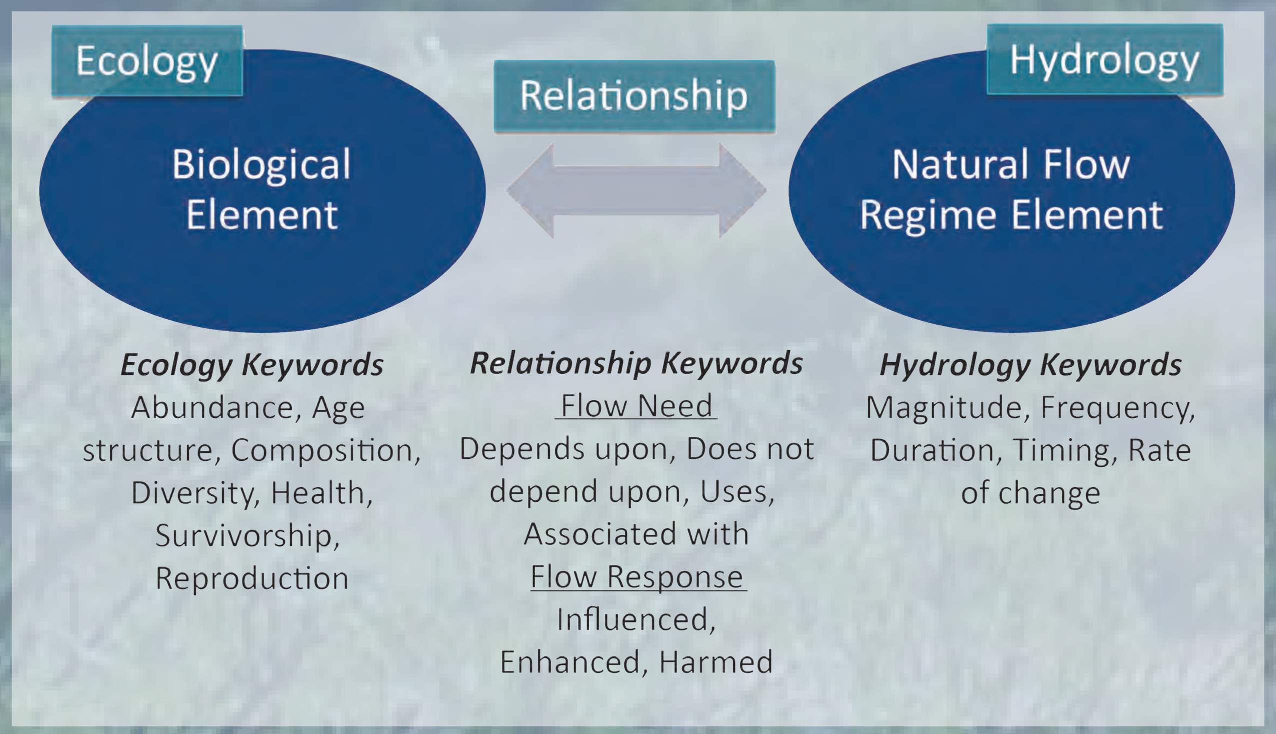


Figure 3: Method for standardizing environmental flow needs and response data using key biological elements and the five aspects of the natural flow regime.

As with the Arizona flows database, information from peer-reviewed literature and agency reports will be assessed to determine: 1) basic information; 2) type(s) of data collected; 3) environmental flow method used; and 4) quantified or described data on the relationship between the ecology and surface flows or groundwater levels. Study locations will be digitized in ArcGIS and linked to study data within a Microsoft Access geospatial database.

A key component of the existing Arizona database and the expanded DLCC database is a table that catalogs environmental flow needs and response data by ecosystem, functional group, or species. This information will be standardized via ecology and hydrology meta-categories that are linked to each other using keywords to describe the relationship between them (Figure 3). For example of table content and format see Table 2.

Sample Results - Arizona Environmental Flow Needs Assessment

Figure 4: Of the 121 studies of Arizona streams that examine environmental flow needs and responses 84 were included in the gap analysis. These 84 studies span 34 Arizona streams and represent 22% of perennial or intermittent river-miles in Arizona. Most frequently studied were the San Pedro, Colorado, Verde, and Bill Williams Rivers.

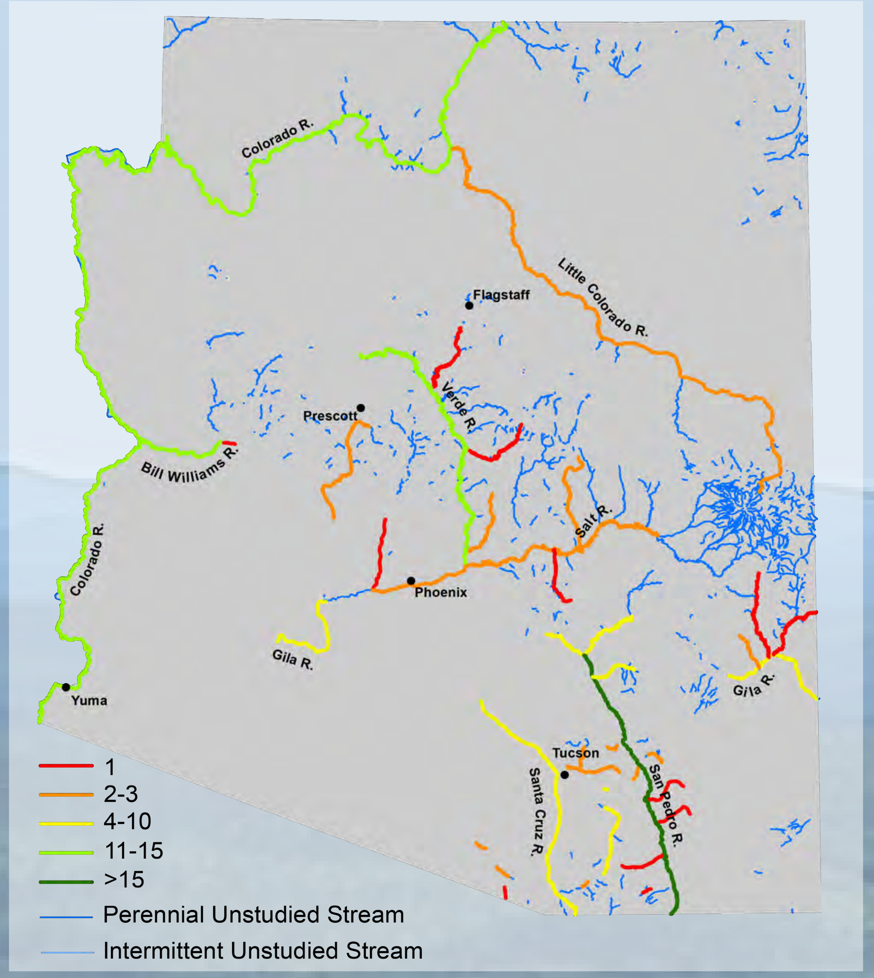
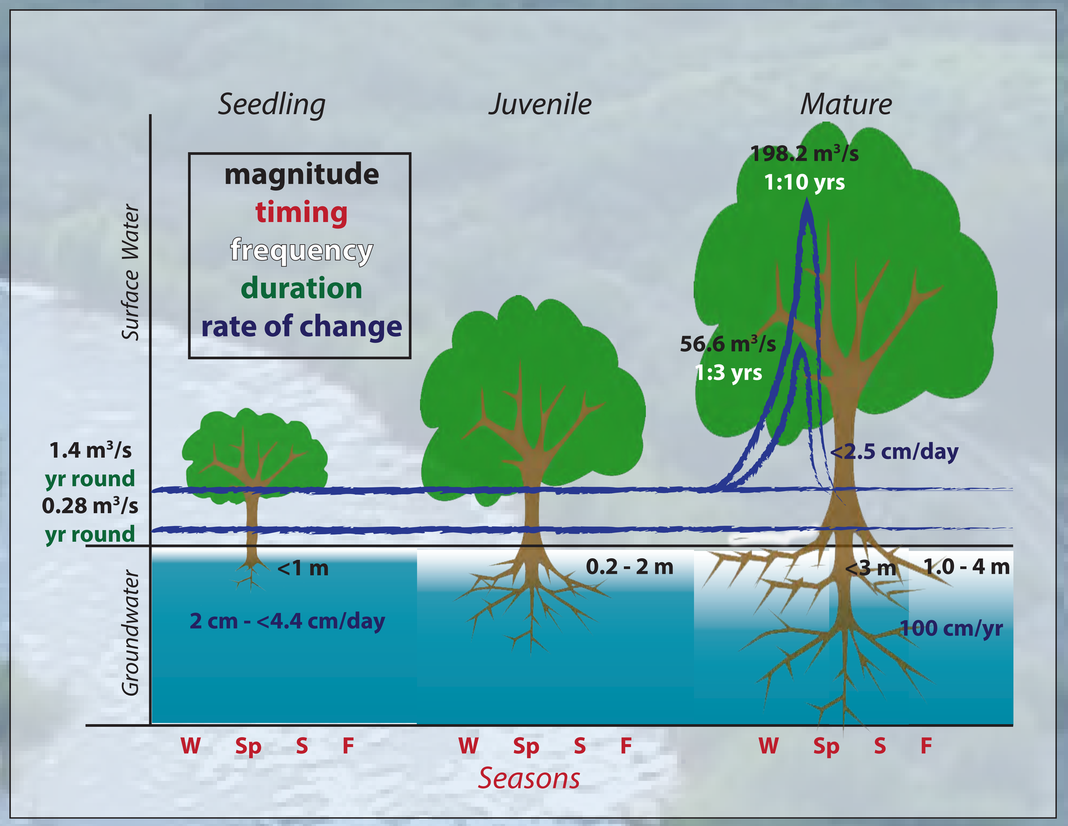


Table 1: Of the 135 species in the database only 25% have been studied more than once and only 11% more than twice. Only three reaches or rivers—Upper Colorado, Upper Verde and Bill Williams Rivers—have been examined for the flow needs or responses of the entire ecosystem within the context of a single study.

Study Subject	Number of Studies	Taxa
Fremont Cottonwood *(Populus fremontii)*	22	Veg.
Salt Cedar *(Tamarix ramossisima)*	14	
Gooding Willow *(Salix gooddingii)*	12	
Velvet Mesquite *(Prosopis velutina)*	12	
Cottonwood/Willow Forest	10	
Chinese Tamarisk *(Tamarix chinensis)*	5	
Seep Willow *(Baccharis salicifolia)*	5	
Speckled Dace *(Rhinichthys osculus)*	5	Fish
Roundtail Chub *(Gila robusta)*	5	
Big Sacaton *(Sporobolus wrightii)*	5	Veg.
Cattail *(Typha)*	4	

Figure 5 and Table 2: Cottonwoods were the most frequently studied species in the Arizona flows database. A graphic representation of cottonwood flow needs data and associated tabular information demonstrate the methodology for standardizing study data and provide an example of database content.



Age	Ecology	Relationship	Hydrology: Water	Magnitude	Timing	Frequency	Duration	Rate of Change	Study Types	Citations
Cottonwood (Populous fremontii)										
Flow or Level Needs										
seed	A	assoc. with	GW	<0.82 ± 0.16 - <1.58 ± 0.14				<4.4 ± 0.8 cm/day	O	Shafroth et al 1998
seed	S	assoc. with	GW	<1 m/bls				~2 cm/ day	O	Stromberg et al. 1996
juv.	A, S	assoc. with	GW	0.2 to 2 m/bls					O	Pima County 2009; Stromberg et al 1996
	A, C	assoc. with	GW	1 to 3 m/bls			Year Round	<1 m yr flux	O	Leenhouts et al. 2005; NPS 2008; Pima County 2009; Stromberg et al. 2009
	A, S, H	assoc. with	GW	0.1 to 5.1 m/bls			Year Round		O	Horton et al. 2001; Stromberg et al. 1996
	H	depends upon	SW	0.28 to 2.8 m3/s		baseflow			R	Hautzinger et al. 2006
	R	assoc. with	SW	0.06 -0.15 m above low flow	March-April			max 2.5 cm/day	R	Shafroth & Beauchamp 2006
	R	depends upon	SW	198.2 m3/s	winter-spring, wet yr	1:10 yrs			R	Hautzinger et al. 2006
	R	depends upon	SW	56.6 m3/s	winter-spring, dry yr	every 2-3 yrs			R	Hautzinger et al. 2006
Flow or Level Responses										
seed	S, H	enhanced by	GW	0.5 to <2.6 m/bls			during first yr	<2 to 3 cm/day, <0.5 m/yr	O, R	Lite & Stromberg 2005; Turner & Haney 2008
	A	enhanced by	GW	<1.5 m/bls					M	Merritt and Bateman 2012
	A	enhanced by	GW	<2.6 to <2.8 m/bls				<0.46 m/yr	O	Lite and Stromberg 2005; Busch and Smith 1995
	H	enhanced by	GW	0.5 - 2.25 m/bls					R	Turner and Haney 2008
	S, H	harmed by	GW	>2-3 m/bls				abrupt >1m	O, R	Horton et al 2001; Stromberg 2008; Turner and Haney
	S	harmed by	SW	>1,000 cfs	March-Oct. or Nov.-Feb.		>50 to >80 days		R	BWRC Technical Committee 1994
	A, C	harmed by	SW	5 m3/s	May-June			3.1 +- 0.2 cm/day	O	Beauchamp and Stromberg 2007

Ecology: A = Abundance, C = Composition, H = Health, R = Reproduction, S = Survivorship
Water: GW = Groundwater, SW = Surface Water
Study Types: O = Observational, R = Recommended, M = Modeled

For additional information on the Arizona study see Mott Lacroix et al. (2014) Synthesizing environmental flow needs data for water management in a water-scarce state: The Arizona environmental water demands database. *River Research and Applications*. Early View (26 Dec 2014) DOI: 10.1002/rra.2858.

Initial Conclusions and Next Steps

In Arizona, few studies examine the entire riparian or aquatic ecosystem. This may be due to a lack of flow methodologies that fully capture the natural flow regime and a limited number of studies that were designed to provide flow prescriptions for water management. There is a disconnect between what is studied and the data needs of water and natural resource managers. By using the DLCC network, this database will help natural resource managers connect to available science on environmental flow needs and responses. The expanded database will be complete in 2015. In 2016 the DLCC will create a guidebook that can be used by managers to evaluate and implement environmental flow methodologies based on management concerns, constraints, and likely impacts of climate change.

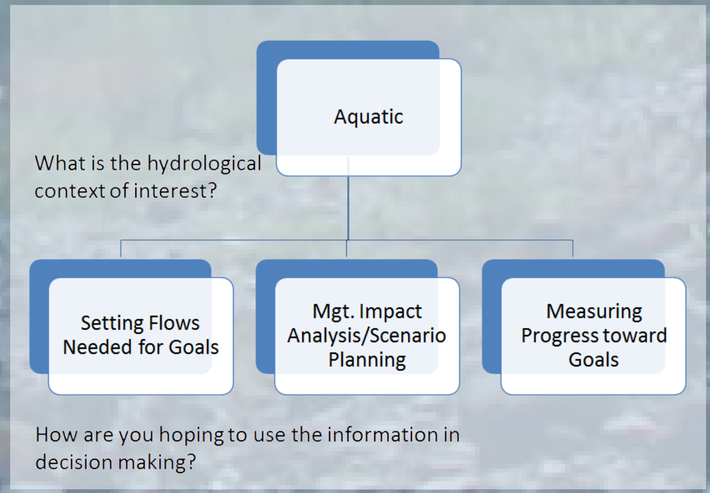


Figure 6: Sample of a decision tree for environmental flow methodologies