Methods to determine flow and habitat needs for stream-dependent species are often inconsistent and variably applied. Most of this wide variability is due to the temporal and spatial scales selected and whether the requirements are for a single species, assemblages of species, or a habitat type. Additionally, scientific advancement and resource protection require robust experimentation and the ability to adaptively incorporate findings as they are discovered. The Endangered Species Act, on the other hand, often takes a conservative approach in laying out what actions are acceptable when species might be impacted. Therefore, determining the water needs of wildlife requires an effective linking of ecosystem science with policies aimed at protecting threatened and endangered (T&E) species.

The approaches used to estimate wildlife water needs range widely from examining the requirements of a single species at a fine scale to characterizing system conditions at a river-reach scale, to making broad regional assessments. With increasing frequency, approaches are based on recognizing that wildlife needs are shaped by the natural conditions in which each species evolved. In the water arena, reservoir operators who consider ecosystem concerns are using aspects of the river’s natural hydrograph (high flow timing, magnitudes, and durations) to inform release decisions. These adjustments tend to be made within the context of the operating purposes of the reservoir (such as conservation storage, flood damage reduction, or hydropower), and often take the form of planned releases designed to benefit targeted species and provide an opportunity to study ecosystem responses.

Research on the Bill Williams River, a tributary to the Colorado River in west-central Arizona (see map on previous page), is examining the impacts on stream-dependent biota of releases from Alamo Dam, a multipurpose facility operated by the Corps. A multi-agency stakeholder group is funding research to characterize the system’s biology and hydrology. Following the framework espoused by the Sustainable Rivers Project, a workshop of 60 regional experts met in March 2005 to develop initial estimates of ecological flow needs of the river’s flora and fauna. The workshop produced a set of nine ecological flows that are now being evaluated (Shafroth and Beauchamp, 2006).

No Species? Look at Processes
A major challenge to determining the water needs of T&E species is that they are frequently too scarce to study directly.

Sustainable Rivers
One program that supports this type of work is the Sustainable Rivers Project, an ongoing partnership between the U.S. Army Corps of Engineers (Corps) and The Nature Conservancy to improve the health and life of rivers by changing the operations of Corps reservoirs. Currently, eight rivers are enrolled in the project nationwide, including the Bill Williams and Willamette rivers in the West. Estimating the flows necessary for river ecosystems to be sustainable is a milestone for project sites. Four of the sites have completed initial estimates using an expert panel approach and an exhaustive review of scientific literature on the river of interest.

A major challenge to determining the water needs of T&E species is that they are frequently too scarce to study directly.
habitat, such as vegetation and water quality, can be used to determine flow requirements for wildlife.

In the Bill Williams River area, the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) and yellow-billed cuckoo (*Coccyzus americanus*) nest in the cottonwoods (*Populus fremontii*), willows (*Salix gooddingii*), and salt cedar (*Tamarix ramosissima*) that dominate the riparian zone. In the absence of sufficient bird populations to study directly, the researchers instead are investigating the water needs of their habitat, focusing on vegetation.

**Modeling Habitat**

A critical piece of the Bill Williams evaluation has been characterizing the physical environment using a suite of hydrologic models: MODFLOW, HEC-RAS, and HEC-ResSim. The models can be connected with various ecological investigations using the Ecosystem Functions Model (HEC-EFM). Applications of HEC-EFM use a combination of statistical analyses, hydraulic modeling, and geographic information systems to predict biological outcomes of different river flows and stages. For example, research has shown that propagation of cottonwoods is dependent upon the timing and the rate of recession of river stage (Mahoney and Rood, 1998). If the stage recedes too quickly, seedling root growth cannot keep pace with the withdrawing water, resulting in root desiccation and seedling death.

An equally crucial component of the flow-ecology work on the Bill Williams River has been use of planned releases from Alamo Dam. These releases, made annually since 2005, aim to recreate some of the physical processes that existed prior to impoundment.

Predicted cottonwood recruitment generated by an experimental flow release (lower left) from Alamo Dam to the Bill Williams River. Three recession rates (1, 2, and 3 inches per day) were tested as suitable for recruitment. Statistical results (top) were translated to water surface profiles and spatial layers (lower right) using the hydraulic modeling tools HEC-RAS and GeoRAS.
and to reduce uncertainties about the connections between water management and ecology so as to improve future reservoir release decisions. HEC-EFM was utilized on the river to simulate cottonwood establishment for the releases in 2005 and 2006, both of which successfully established large numbers of new native trees. Results of the 2006 analyses are shown on the previous page.

Applying predictive tools like HEC-EFM allows reservoir releases and alternative water management policies to be tested before implementation to see potential impacts to the habitats of T&E species. Coupling these predictive tools with ongoing field studies in turn improves the models, which can then be used with more confidence to simulate connections between river flows and ecosystem dynamics.

**Changing the Man vs. Nature Paradigm**

Research on tributaries to the Colorado River is especially important given the amount of disturbance on the mainstream. The Colorado River Basin once had the greatest number of endemic fishes of any drainage in the United States. Today, 85 percent of endemic fish species in Arizona are threatened or endangered with extinction (Warren and Burr, 1994). Their decline stems from the fact that ecosystem conditions that shaped the evolution of these fishes—flashy, warm, silt-laden rivers—to a large degree no longer exist. Flows within the lower Colorado River are now dictated by daily hydropower peaks and an elevated baseflow to provide agricultural water deliveries. These changes in flow regimes have made repatriation efforts difficult. There are, however, efforts to mimic, as closely as possible, those native ecosystem components while still having the river provide the anthropocentric services we depend upon. Examples range from releases of water from mainstream impoundments that more closely approximate natural flows, to research of individual backwaters, both natural and human-created, as refugia for these endemic species.

We ask much of rivers. We rely on them for a multitude of human needs yet understand that we are not the only species that rely on them for well-being. Determining how much water—at what frequencies, intervals, and magnitudes—is necessary, especially for T&E species, is a daunting task given increasing pressure for rivers to provide human services. These determinations are based upon equal parts physical, biological, and social science. Only through improved understanding of the ecosystem processes that define a river, and the species dependent upon it, can the water needs for wildlife be determined.

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**References**


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**Summary**

The ESA’s “take,” “jeopardy,” and “adverse modification of critical habitat” standards can be costly for water projects, and implementing the avoidance or conservation measures necessary to comply is often time- and effort-intensive. As water scarcity in the West continues, achieving the ESA’s goals will increasingly require creative solutions and alternatives, taking into account the importance of water as a resource for all living things.

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**References**

Code of Federal Regulations, Chapter 50, Parts 17 and 402.


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for individuals or entities other than the federal government. One such exception is Section 10(a)(1)(B) of the ESA, under which FWS or NMFS may permit the taking of listed species otherwise prohibited “if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.”

If the construction or operation of a water project has incidental effects on listed species or their habitat that rise to the level of take, the project proponent must obtain an incidental take permit (ITP) from FWS or NMFS (or take coverage under Section 7, discussed above) in order to avoid liability under Section 9. Because water projects are often operated over extended periods, it is not uncommon for ITPs to be issued for 50 years or more. Obtaining the permit can take several years for a large project, during which time the applicant may not construct or operate the project if take of listed species would result.

To obtain an ITP, the applicant must prepare a habitat conservation plan that specifies: 1) the likely impact of the take; 2) how the applicant intends to “minimize and mitigate” such impacts and what funding is available to do so; 3) alternative actions to the take that were considered and rejected by the applicant and the reasons they were rejected; and 4) any additional measures that may be required by the Secretary “as being necessary or appropriate for purposes of the plan.”

Habitat conservation plans also can require millions of dollars to complete. For example, the cost of implementing conservation measures in the Roosevelt Dam and Lake Habitat Conservation Plan in central Arizona (FWS, 2002), which concerned reservoir operations and benefited four bird species, was estimated by the applicant to be between $14.6 million and $29.4 million.

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