Challenges and Strategies for Spring Ecosystem Restoration in the Arid Southwest

CHALLENGES AND STRATEGIES FOR SPRING ECOSYSTEM RESTORATION IN THE ARID SOUTHWEST

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Spring ecosystems are unique and important resources in arid regions. They are integral parts of greater watersheds as they are hotspots for biodiversity, they harbor endemic and sometimes endangered species, as well as provide a wealth of information on groundwater quality and quantity (Sada et al. 2001; Stevens and Meretsky 2008). Although springs are proportionally small in comparison to other types of water sources (e.g. rivers, lakes), they face a unique predicament because they are subject to the same demands placed upon all water resources in the Southwest; however, they are not afforded the same consideration in management plans and practices (Stevens and Meretsky 2008; Nelson 2008).

A historical lack of effective management practices to conserve and protect these important ecosystems has also contributed to the threatened status of springs ecosystems in the arid Southwest. Springs are often diverted or developed for human use and livestock often graze near springs in arid regions causing a multitude of negative effects. Furthermore, springs are being affected by recent trends of high rates of groundwater pumpage for municipal uses (Sada et al. 2001; Unmack and Minckley 2008).

With the high rate of degradation, spring ecosystems would greatly benefit from thorough and effective restoration practices. This paper addresses the challenges faced and looks into the strategies developed for effective spring ecosystem restoration. This is done by outlining the current status of springs in aridlands and reviewing an example of a restoration project conducted specifically on springs in the Southwest. In reviewing the current challenges and strategies for spring ecosystem restoration, this paper aims to create greater awareness on the need for developing and implementing sound ecosystem management practices that are based upon effective restoration principles.

SPRING ECOSYSTEMS IN ARIDLANDS

Springs can be defined as the point in which groundwater reaches the earth's surface (Springer and Stevens 2009). In aridlands, spring ecosystems offer vital contributions to the surrounding physical, ecological, and cultural landscape (Sada et al. 2001; Barquin and Scarsbrook 2008; Stevens and Meretsky 2008). In regions with severe water scarcity, springs support critical habitat for the local biota, some of which are endemic to certain springs due to their isolated locations. Springs serve as crucial water sources to local wildlife and migratory species (Sada et al. 2001). Springs can serve as indicators of groundwater quality and quantity, which can otherwise be difficult to ascertain in some areas (Sada et al. 2001; Kreamer and Springer 2008; Springer and Stevens 2009). Springs also serve as hotspots for biodiversity in arid and semi-arid landscapes and are culturally significant to tribes and communities all over the world (Stevens and Meretsky 2008).

Since springs are often primarily utilized as water resources for both wildlife and human development, the integrity of these vulnerable ecosystems has been increasingly compromised by many factors that threaten to eradicate spring ecosystems. Excessive groundwater extraction to satiate the increasing needs of populations and development lowers the water table thus decreasing spring discharge and, in worse case scenarios, completely dewaters springs at their source (Glennon 2002; Kreamer and Springer 2008). Grazing and trampling by livestock or large ungulates can destroy the aquatic biota and introduce invasive species, thus reducing native populations and biodiversity. Grazing can also lead to stream bank instability because of vegetation removal and trampling, which can potentially seal the source of smaller springs or lead to severe geomorphologic changes, and contribute to water quality degradation through excessive nutrient loading (Allen-Diaz et al. 2004; Unmack and Minckley 2008). Diversion and unregulated use of spring water can deprive an ecosystem of its main resource, as a result degrading the ecosystem (Grand Canyon Wildlands Council

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2002; Stevens and Springer 2004).

SPRINGS MANAGEMENT

Historically, springs have been scientifically understudied and legally overlooked for their unique attributes which has led to inadequate management practices that have done little to address the various threats to spring ecosystem health (Barquin and Scarsbrook 2008; Nelson 2008). As with any water source in an arid region, springs have primarily been used for anthropocentric reasons with little regard to sustaining ecological integrity and springs have suffered degradation as a result (Unmack and Minckley 2008). As the integral role of springs in the greater ecological system becomes progressively acknowledged, effective management practices have become central to spring ecosystem sustainability. Given the current benefits that springs offer arid regions coupled with the threats these ecosystems face, there is a surprisingly limited amount of literature on spring management. Most of the literature recognizing springs as important and critical ecosystems have emerged in the last decade. Aside from springs being mentioned as types of water sources, relatively little scientific understanding, comprehensive classification, or legislation regarding springs existed as little as twenty years ago (Springer and Stevens 2009).

The emerging awareness of the need to manage spring ecosystems in order to restore or preserve their ecological integrity has been exemplified by recent efforts in various parts of the world. Barquin and Scarsbrook (2008) summarize the major advances in spring ecosystem management by highlighting the main areas of the world in which spring ecosystem management has become active. In Australia, spring ecosystems are facing similar threats as those in the western United States. The condition of springs in the Great Artesian Basin in the northwestern part of Australia has become such an issue that researchers make a point to address problems and solutions every year in a focus group. The federal government of Australia has formulated strategies at a national level to address the vitality of groundwater-dependent ecosystems (Barquin and Scarsbrook 2008). In the United States, the Edwards aquifer in Texas has received attention due to the negative impact that groundwater development has had on the local springs (Glennon 2002). Isolated spring ecosystems in Ash Meadows, Nevada have also gained recognition and subsequent improved management strategies as the springs harbor pupfish, an endemic and endangered species (Glennon 2002). This example is discussed in further detail later in this paper.

The management of a vital resource, such as water, in a region that is defined by its scarcity is highly complex. Unless a spring has significant historical importance or harbors an endemic or endangered species, springs generally get grouped under larger categories of water and are prescribed general management strategies that might not address the specific needs of spring ecosystems (Nelson 2008). An instance of springs being underrepresented in water conservation and protection efforts is best exemplified by the national attention given to the loss of wetlands and the orchestrated attempt to restore these systems. Section 404 of the Clean Water Act of 1977 initiated the continuing effort to conserve and restore North America's precious and highly degraded wetlands (Cowardin et al. 1979; Environmental Laboratory 1987). A large amount of literature has since been published on wetland delineation and restoration strategies to guide wetland restoration. A search of official wetland definition and delineation under the Environmental Protection Agency revealed the word spring occurred one time in the entire 142 page document and it was merely to mention that springs should be grouped into the larger Riverine System (Cowardin et al. 1979). A later publication by the U.S. Army Corps of Engineers in 1987 to classify wetlands for federal protection failed to mention springs even once (Environmental Laboratory 1987).

The lack of attention to springs in water management literature and other documents developed to guide agencies charged with the management of these unique waters is a major obstacle for developing sound restoration goals and plans. As more awareness is gained for the need to specifically address springs, restoration strategies for spring ecosystems can be fully developed based on sound science and comprehensive management strategies.

RIPARIAN RESTORATION

Riparian areas are of high value to both the natural and developed world. Riparian areas offer critical habitat for a plethora of species both aquatic and terrestrial; they are crucial to maintaining the physical and geomorphic characteristics of greater watersheds and they are culturally important as well as offer high esthetic and recreational values (Williams et al. 1997). Unfortunately these highly valued riparian areas are also under great threat from anthropogenic changes imposed on the landscape. Hirsch and Segelquist (1978) claim that anywhere from 70% to 90% of all natural riparian areas in the United States were found to be degraded at the time of their study. Because populations and development have increased since 1978, potentially, this estimate has increased. Due to this high percentage of degraded riparian areas, riparian restoration is critical.

The arena of riparian restoration has a very substantial amount of literature discussing the best and most effective practices to achieve restoration goals and objectives. Riparian restoration is highly important in arid regions in which water sources are heavily relied upon to supply resources for expanding populations. Riparian restoration can be defined in a multitude of ways. The basic tenets of riparian restoration include returning a riparian system to its pre-disturbed biological, physical, and chemical conditions by actively repairing anthropogenic disturbances and/or allowing a riparian system to recover naturally (Kauffman et al. 1997; Williams et al. 1997). While the goals and objectives of restoration projects will differ depending on location and specific needs of a degraded riparian system, ecological linkages and relationships within a watershed as well as watershed-scale perspective are key to successful restoration projects (Williams et al. 1997; Angermeier 1997). As spring ecosystems are important within greater watersheds and also contain key ecological linkages to the greater ecological system, riparian restoration is both applicable and relevant to spring ecosystems.

CHALLENGES TO SPRING ECOSYSTEM RESTORATION

One of the most prominent challenges to restoring spring ecosystems in the arid Southwest originates from the lack of effective management practices being applied to springs. A fundamental aspect of effective management for spring ecosystems is conducting and maintaining an accurate and thorough inventory and assessment of springs under a management agency's given jurisdiction (Stevens and Meretsky 2008). Unfortunately, this basic level of inventory has not yet been completed by many land management agencies in the Southwest (Sada et al. 2001; Springer et al. 2008). For those spring inventories that have been completed, critical data such as rate of discharge, water chemistry, and aquatic fauna have yet to be documented leaving most inventories incomplete and sometimes inaccurate (Grand Canyon Wildlands Council 2002). Without extensive knowledge of a spring's ecology, the species it supports, and the level of degradation (if any), land managers do not have enough appropriate information to make sound management decisions on which springs are in dire need of restoration as well as the specific restoration needs of these degraded springs. Without that basic knowledge, developing a plan for restoration is difficult.

Another challenge is the high variability of types of springs on the landscape. Resource managers might have a highly variable topographic landscape in which there are several different types of springs. A strategy that is effective in restoring one type of spring might not be relevant to a different type of spring. The need for individualized restoration strategies depending on spring type is a time-intensive and resource-intensive undertaking that poses a challenge for any resource manager.

STRATEGIES FOR SPRING ECOSYSTEM RESTORATION

Classification systems are a widely suggested approach to initiate the process of spring management and restoration (Sada and Pohlmann 2002; Springer et al. 2008; Thompson et al. 2008; Stevens and Meretsky 2008; Springer and Stevens 2009). Classification systems provide a common lexicon for researchers, scientists, and resource managers for which to discuss spring ecosystems in their many variations (Springer et al. 2008; Springer and Stevens 2009).

Springer et al. (2008) developed a classification system which takes components of previous attempts at classifying springs and adds aspects in order to get a more thorough understanding of all interactions within a spring ecosystem. The classification system proposed by Springer et al. (2008) includes location, geomorphic characteristics, spring channel dynamics, flow or spring discharge, water quality, climatic variables, biota, management, and cultural influences. This extensive classification system was developed with the intent to be used and adapted as necessary. In 2009, Springer and Stevens (2009) published a paper that presents twelve 'spheres of discharge' based upon the Springer et al. (2008) classification system. This system is in use by many efforts to inventory springs in Northern Arizona and has been effective as a concise way in which to describe the various springs found in this region.

In the effort to approach springs restoration in a systematic way, Thompson et al. (2008) developed and applied a classification system to prioritize springs for conservation in New Mexico, USA. The classification system was developed in order to provide a way in which to conduct a rapid assessment of the location, extent of riparian habitat, and current condition of any given spring (Thompson et al. 2008). Resource managers can then use this rapid assessment to prioritize which springs are heavily degraded and in need of immediate restoration practices.

Instituting classifications for springs, conducting thorough inventory and monitoring on springs, and developing specific restoration goals and objectives are all examples of some of the strategies in implementing effective spring ecosystem restoration.

A Case Study: Ash Meadows National Wildlife Refuge

There has been an effort to restore and conserve riparian areas in the hopes of mitigating loss of these critical resources. While the extent of riparian restoration programs is too large to review in detail here, a relevant example of a springs restoration project is the efforts in Ash Meadows, Nevada.

The Ash Meadows National Wildlife Refuge (referred to as The Refuge) spring restoration project in the Mojave Desert, Nevada is an ongoing effort since 1998 to restore habitat for the endemic and federally listed endangered Ash Meadows speckled dace (Rhinichthys osculus nevadensis), the Devil's Hole pupfish (Cyprinodon diabolis), the Warm Springs pupfish (Cyprinodon nevadensis pectoralis), and the Ash Meadows Amargosa pupfish (Cyprinodon nevadensis mionectes) that depend on thermal springs in The Refuge (Keith 2007). Restoration activities in that area that helped mitigate degradation and loss of endangered species include: Flow management, grade control structures, grazing management, habitat enhancement, riparian revegetation, and streambank recontouring. Through follow-up monitoring of these restoration projects, the effects of the ongoing program are closely measured. In a 2007 report, native fish species were recovering to 'favorable levels' while native vegetation efforts were not meeting such success (Keith 2007). The restoration at The Refuge is a great example of a spring restoration project that has experiences both success and continued challenges.

It is important to note that the extensive restoration project developed for the springs within The Refuge were initiated due to the threat of federally listed species. While countless other springs in the arid Southwest face the same threats and levels of degradation, restoration action has not taken place due to the lack of mandate and attention.

CONCLUSION

Restoration of spring ecosystems is crucial to maintaining the integrity of greater watersheds and is temporally critical in the arid Southwest. As many spring ecosystems suffer various scales of degradation across the landscape, there is great potential for restoring and conserving these unique water sources. An important enabling step in the process to develop and implement adequate and effective restoration strategies is improving upon the overall status of spring ecosystem management in arid regions. Recognizing the importance of spring ecosystems in arid landscapes and mandating proper management approaches to these unique ecosystems is important for land management agencies and other managing entities. As land managers begin to conduct or complete comprehensive inventories and assessments of springs under their jurisdictions, necessary data will be collected that can be used to instigate a restoration program based on sound and current science.

The challenge to conserving and restoring degraded spring ecosystems in the arid Southwest is a surmountable problem. The strategies for effectively restoring spring ecosystems can be realized once adequate attention and drive is brought to land managers and water resource managers alike. It is hoped that examples such as the Ash Meadows National Wildlife Refuge can be realized without the dire threat of losing an entire species but rather the recognition of the critical attributes that spring ecosystems offer the greater watershed in general. A proactive approach is needed to ensure the sustainability and ecological integrity of springs in the arid Southwest.

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