SPRINGS RESTORATION IN THE MOJAVE NATIONAL PRESERVE

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Historically, any economic development in the Mojave Desert depended on the development of available water resources. The scarcity of surface water forced early European-Americans to seek out springs and underground sources to supply the water necessary to their activities, which included mining, ranching, transportation and farming. Most springs in Mojave Desert are not connected to a large carbonate aquifer region. Instead they are situated along mountain fronts fed by small perched aquifers. In order to access the limited water resources early users installed elaborate pipeline systems often moving water for many miles from its source (JRP and Caltrans 2000). While most diversions were installed for mineral processing and cattle watering, some were used for homesteading, railroad use and other obscure purposes. In either case, water development has led to the alteration of nearly half of all springs in MNP and in some instances even the depletion of smaller aquifers.

There is limited evidence that Native Americans manipulated some water resources in the Mojave Desert (Earle 2009), however, it is well documented and still evident today that early Euro-American inhabitants altered their environment in order to access more water. Hundreds of such sites were developed by Mojave miners and settlers (Koenig 2007). These developments may or may not have had surface water present initially but were named "springs" upon development and many retain those names today. Beginning in the late 1800s, mining claims were documented in county records and in the reports of the State Mineralogist. When water was used on site, the location of its source was always noted.

Regional newspapers reported updates on local mining operations and often noted whether water was piped a long distance, from how many miles away it was transferred, and the approximate volume used per day. Army posts were all sited near reliable water (e.g. Rock Springs, Piute Spring, Marl Spring, and Soda Springs) (U.S. Army 1859-1890). Early maps of the region focused on locating water sources for travelers (Thompson 1929).

Most springs in the 1.6 million-acre (647,500 ha) MNP are located in the Providence and New York Mountain ranges diagonally crossing the preserve (see Figure 1). The exact number of springs and seeps varies depending on climatic conditions. From 2002 to 2004 most springs were inventoried and GPSed. To date, over 250 sites associated with naturally occurring water have been identified but more are occasionally still found. In wet years, such as 2005, water is found seeping from places that normally are not associated with water. Late-summer monsoons in the preserve provide patchy rainfall coverage at best, but are most dependable along the spine of mountain chains from the Castle Peaks in the northeast to the Granites in the southwest. Of the spring and seep locations in MNP, all but probably two (MC Spring and Piute Spring) are mountain-front type springs discharging from perched aquifers that receive most of their recharge during the winter season. Thus they are unlikely to be affected by groundwater pumping from local basin aquifers. They are, however, sensitive to variable precipitation and like to go dry in a multiyear drought. These springs are the only natural water sources in a 1.6 million acre preserve for 321 bird and 50 mammal species.

Status of the Springs Inventory in Mojave National Preserve

The assessment of the springs and seeps in Mojave National Preserve (MNP) is an ongoing and dynamic process, with new spring and seep locations still being added to the Preserve's database, 15 years after its creation. All of the "large volume springs" in MNP have been developed. Of the approx. 250 springs and seeps surveyed, 118 (47%) are developed and 128 (51%) remain undeveloped. Of the developed springs 33 had water transferred off site, 27 had the horizontally excavated tunnel-type, known as qanats, 33 have drinkers (which include springboxes, troughs, tanks), 17 have vertically excavated shafts (wells), 6 are dammed and 5 are scrape-excavated springs (see Figure 2). These developments are not mutually exclusive. Often water is piped from a qanat into a drinker. However, to avoid double counting only the development with the highest impact is listed for each spring. A diversion is counted when the water is piped a considerable distance away from the source, where the destination may be a mining site, cattle trough or residence. Nearly 13% of all surveyed springs have been dry every time the location has been surveyed

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since 2002. Dry springs and seep split evenly between developed and undeveloped sites.

Historical Spring Development

The documentation that exists about spring development is sparse at best. However, records do exists of spring developments for various springs at various locations at various points in time. Based on this documentation and the remains found at present time suggests a following likely historical spring development: (1) A location was initially selected based on vegetation. Willow trees (Salix spp.) and what was known by local ranchers as "water weed" (Baccharis sergiloides) are usually a good indication of water close to the surface and/or a perched aquifer. Topography, such as canyon and washes in combination with vegetation may also be a good indicator of a water source. In wet years these location are more common and were referred to by locals as "wet weather seeps" (Overton 2008). (2) Phreatophytic vegetation was cleared to reduce evapotranspiration. A form of excavation took place to encourage the formation of a surface storage pool. (3) Excavations include qanat (horizontal well), adits (horizontal mine shaft), hand-dug wells, spring boxes and open excavations. (4) Drainage systems were usually set-up to be gravity-fed and were mostly piped to limit water loss due to evaporation. However, a few drainage systems resembled miniature canals (Koenig 2007). Some excavation, such as qanats were progressively excavate into the hillside, chasing the water as its perched storage became depleted. In these cases the progressive excavation eventually produced a tunnel in the hillside where an interior storage pool fed water to a pipe; (5) When these horizontal excavation could no longer support a gravity-fed system or the tunnel excavation became too hazardous, the tunnel was abandoned and a well and or windmill would be set-up to continue to extract water for piped translocation. (6) Wells could either be deepened or ultimately abandoned if it collapsed and/or efforts to develop it further produced diminishing results and/or the water was no longer required because of depleted/abandoned mines, and consequentially abandoned settlements or discontinued ranching activity.

The majority of the hillside tunnels have collapsed by now. Weathering and vegetation growth may even conceal evidence of the site's history. Current spring conditions of developed sites may appear from mildly to significantly impacted, based upon visual

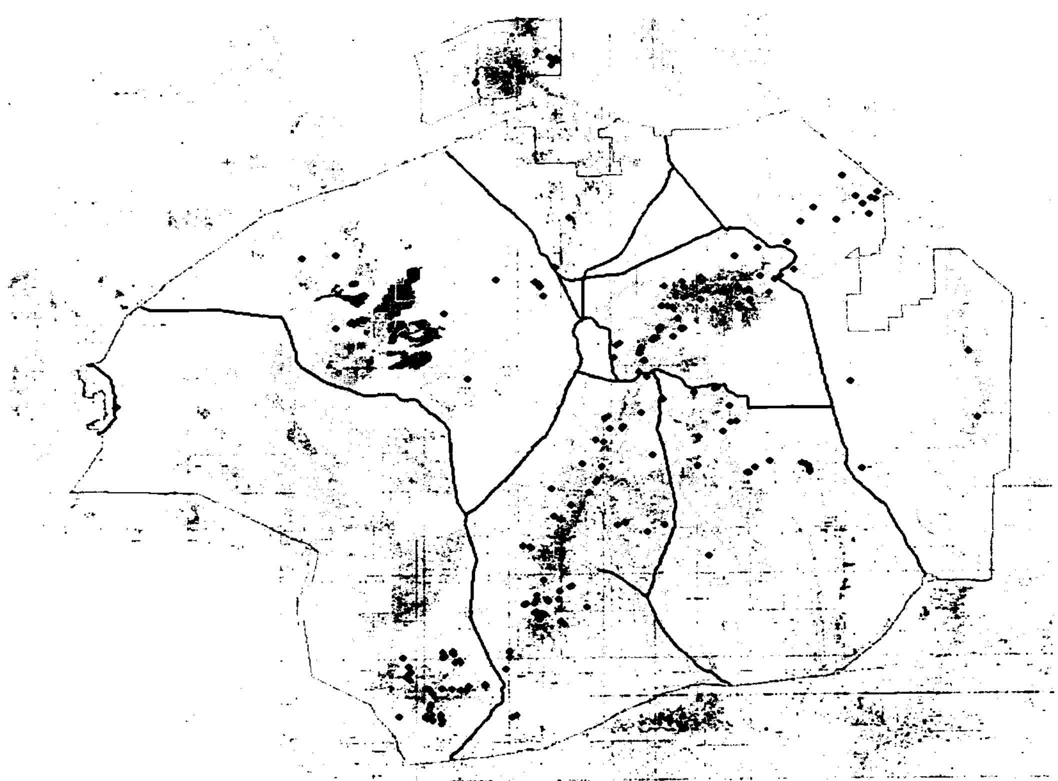

Figure 1. Location of Mojave National Preserve and location of springs in the preserve (diamonds). Dark lines represent major roads in the Preserve; the lighter lines demarcate wilderness boundaries.

observations, but this is only a guess since the original conditions were not properly documented, if at all. Several sites still support growth of familiar phreatophytic plants, but the ground is dry. A typical abandoned spring development has a dry soil surface, collapsed excavation structure or well shaft cover, and is overgrown with Baccharis sergiloides. Sometimes the excavation appears to be collapsed, yet the diversion still functions. Eventually, though, the pipe intake will accumulate sediment, become clogged, and cease to function. Overgrown vegetation makes it difficult to recognize a "spring" from just another heavily vegetated spot in the drainage.

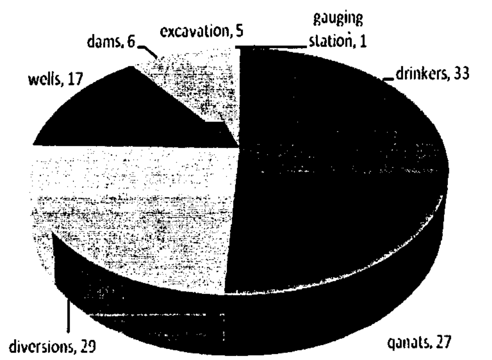

Figure 2. A breakdown of how springs in the Mojave National Preserve have been developed. Only the most disturbing development at each spring has been listed here to avoid double counting.

Restoration Questions

When it comes to restoring water features/resources in the National Park System there are a number of questions that need to be addressed, even before any plans should be made. What does spring restoration mean in the Mojave Desert? What type of restoration is sought: Ecological and cultural? Unlike an ecological restoration, a cultural restoration of a water feature to its historic condition would add great cultural value to MNP, which is also a mission of the Park System. When considering an ecological restoration, the main question is whether a developed spring will be able to recover to its pre-Euro-American condition, especially under changing climatic factors? What will be restored: function or process? If a "restored" site is one that is self-sustaining, we may have to concede that many springs will be destroyed as a result of the restoration effort. They may fill with phreatic vegetation, eliminating the presence of surface water in most years. Such active management of these springs include removal of access vegetation? How did the native population of the Mojave "manage" these springs? How can we restore something if we don't know the original conditions, especially without knowing if these springs were managed by people at all over the past 9000 years? If we let nature take its course, what will the springs look like in 10 years, 50 years, or 100 years? Should the National Park Service attempt to manage the recovery of desert springs? What management goals should be identified? A caveat to restoration is that some desirable target conditions (e.g. flowing surface water) imply frequent and intensive management (e.g. periodic removal of phreatophytes). How much disturbance is acceptable when performing management activities? How much can be done on a shoestring budget?

Passive Restoration at Arrowweed Spring

Around 1956 a rancher used a backhoe to excavate and expose the seepy hillside at Arrowweed Spring. He dug a 4' deep, V-shaped trench into the water-exuding sediments in front of the exposed hillside, vertically installed a stilling well (a 4' long section of slitted culvert) at the hinge-point, and filled the rest of the trench with cinder gravel. He connected a pipeline at the base of the stilling well to drain the accumulating water. The pipeline ran for over 8 miles and conveyed about 15 gallons per minute. By 2000 the surface of the site was mostly dry and heavily vegetated with Baccharis. Surface water was limited to a 10' reach.

In March 2001 the system was perturbed by plugging the drainage pipe and removing some Baccharis to speed the re-hydration process. Good winter precipitation in spring 2003 helped the site recover to a lush appearance with a stream of surface water running 300' down the slope. By 2008 the spring had become a little oasis in the desert featuring a plethora of plant and bird species, providing open water access even during the driest time of the year.

What Management Options Exist?

Potential management efforts at springs could take several forms, ranging from passive monitoring to active restoration. Active efforts could include plugging and/or removal of a drainage system, removal of phreatophytic plants, or slope reconstruction. Should production of surface flow be encouraged by installing a French drain at the excavated tunnels? Is it important to know which springs still have pipe systems in place, even if no remnants remain on the surface? What if nothing is n done? Would plants merely usurp all available near-surface water; thereby prohibiting wildlife use?

What research questions should we be asking? What monitoring questions would be most useful? Should we try to manage for surface flow? What if we remove phreatophytes on an experimental basis? What other actions might encourage surface flow? How best to prioritize springs for restoration? Should we seek money for active restoration at any springs? Are there any strategies we can adopt to help protect the springs from a projected long-term drought? What effects on aquatic resources and environments might we expect at springs in different current conditions?

Stay tuned as many of these question are being addressed and will continue to be pondered as the assessment of the springs and seeps in the Mojave National Preserve continues and various restoration projects are being carried out.

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