WETLANDS ACTION PLAN

ARID-LAND SPRING CIÉNEGAS OF NEW MEXICO

Prepared by Robert Sivinski
RCS Southwest
for
New Mexico Environment Department
Surface Water Quality Bureau

December 2018

Citation: Sivinski, R.C. 2018, Wetlands Action Plan, Arid-land Spring Ciénegas of New Mexico. New Mexico Environment Department, Surface Water Quality Bureau, Wetlands Program, Santa Fe, New Mexico.

Acknowledgements: This Wetlands Action Plan is the product of collaboration between many partners and stakeholders, especially our Steering Committee members: A.T. Cole (Pitchfork Ranch), Daniela Roth (New Mexico Energy, Minerals and Natural Resources Department (EMNRD)-Forestry Division), Malia Volke (New Mexico Department of Game and Fish), Maryann McGraw and Karen Menetrey (New Mexico Environment Department Surface Water Quality Bureau (SWQB), Wetlands Program), Melanie Gisler (Institute of Applied Ecology (IAE)), and Esteban Muldavin (Natural Heritage New Mexico, Museum of Southwestern Biology, University of New Mexico (UNM)). Carmen Austin (EMNRD-Forestry Division), Gwen Kolb (US Fish and Wildlife Service, Partners for Wildlife) and Athena Cholas and Santiago Misquez (Natural Resources Conservation Service (NRCS)) assisted with the public workshops.

Funding: This Wetlands Action Plan was prepared for and funded by the New Mexico Environment Department Surface Water Quality Bureau Wetlands Program to satisfy U.S. EPA CWA Section104(b)(3) Wetlands Grant (Assistance Agreement No. CD-01F109-01-0D (FY2016)), entitled "Wetlands Standards, Wetland Action Plans, and Improved Non-Regulatory Program Elements for New Mexico". The contents of this document do not necessarily reflect the views and policies of the EPA, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

Cover Photo: Eastern part of Lang Ciénega (31.3399 -108.8035) in Hidalgo Co., NM.

Photo Credits: All Photos are by the author unless otherwise indicated.

For more information, please contact:

Maryann McGraw, Wetlands Program Coordinator
New Mexico Environment Department
Surface Water Quality Bureau
Harold Runnels Building N2050
1190 St Francis Drive, PO Box 5469
Santa Fe, New Mexico 87502
Telephone: 505-827-0581
E-mail: maryann.mcgraw@state.nm.us

Table of Contents

SUMMARY OF FINDINGS AND PLAN OF ACTION

The purpose of this Wetlands Action Plan (WAP) is to identify the needs and define a strategy for protecting and restoring the arid-land spring ciénegas of New Mexico. These important wetlands provide habitats for unique plants and aquatic animals and are essential sources of water and pasture in arid regions throughout the state.

Ciénega is the Spanish word for "marsh", but it has also become an ecological term for a stable spring-fed wet meadow or marsh in an, otherwise, arid region – like an oasis in the desert. Arid-land spring ciénegas are very rare and some are critical habitats for several species of plants and animals that occur only in arid-land spring waters and ciénegas. Prehistoric and historic people of arid southwestern America have relied upon and exploited these uncommon sources of water and lush vegetation to the point that many arid-land spring ciénegas have been destroyed or severely altered. Those that retain their ecosystem functions need immediate attention to their protection and/or restoration.

Several arid-land spring ciénegas were already known to occur in New Mexico prior to the preparation of this WAP, but additional ciénegas were located during the WAP effort with a survey of publicly available aerial imagery and literature. A total of 169 arid-land spring ciénegas are documented for New Mexico. Only 114 are considered to be still functional or restorable. Numerous land use and climate change impacts are endangering these rare wetlands. The most pernicious are aquifer capture and depletion, water diversion and excavation of impoundments, erosion and arroyo cutting, non-native weeds, and overutilization by livestock. The known arid-land spring ciénegas are scattered throughout the state and within a variety private, tribal and government ownerships, which will complicate the plan of action and emphasize the following steps.

- **Additional Inventory.** There are currently many gaps in our knowledge of arid-land spring ciénegas in New Mexico – especially where they all are, their landowners, their condition, and special conservation values such as rare or endemic species. The prospects for additional understanding about these unique wetland resources will not been realized until we obtain more information about their location and extent. This will require continuing surveys for these rare wetlands and maintaining a central database with the results.

- **Ciénega Access.** Access to arid-land spring ciénegas to monitor, protect and restore these important wetlands will require overcoming feelings of trespass not only by private landowners, but also Native American tribes and the managers of lands in government jurisdictions. This requires building trust and respect around shared values and goals.

- **Research and Monitoring.** There are huge knowledge gaps, not only in the locations of arid-land spring ciénegas, but also in their individual hydrology, biota, and ecology

within the local landscape. Basic research on these highly technical aspects must employ the expertise of researchers such as those at academic institutions and government agencies. Understanding the responses of these complex wetlands to environmental and anthropogenic impacts, and successful restoration efforts will require the commitment of arid-land spring ciénega owners and the partners to long-term monitoring projects and sharing of data.

- **NMRAM and Conservation Ranking.** The New Mexico Rapid Assessment Method for Spring Ecosystems is presently under development and can be employed at arid-land spring ciénegas where ever access can be obtained, and personnel are available. Information accrued from NMRAM will assist the SWQB Wetlands Program and funding agencies not only in prioritizing sites for restoration and targeting restoration needs, but also in selecting sites for conservation and protection.

- **Protection and Restoration.** Protecting arid-land spring ciénegas and planning their restoration employs tools for land use planning, land conservation, buffer zones, development site design, agricultural practices, forestry practices and watershed stewardship. There are a variety of applications for these tools to use in rural as well as urban settings.

- **Education and Outreach.** Increasing the use of the unusual word "ciénega," in itself, creates educational opportunities to define its hydrological, historical and ecological importance to landowners, land managers and the public. Several arid-land spring ciénegas occur on parks, nature preserves, wildlife refuges, and other public lands where the appreciation of these unique wetlands can be increased with social media and other on-site education opportunities.

- **Partnerships.** Arid-land spring ciénega management and restoration projects will often require the expertise of natural resource specialists, restoration planners, and fiscal personnel that can be found principally in governmental agencies and conservation NGOs. Ciénega owners who undertake restoration projects will greatly benefit from these partners, especially with projects that involve several different landowners.

- **Companion Jurisdictions.** Arid-land spring ciénegas are also found throughout the arid southwestern U.S. and northern Mexico. Protection and restoration of these unique desert wetlands will benefit from inter-jurisdiction collaboration between agencies, states and countries. Shared experiences for inventory, restoration practices and public outreach can enhance the management and monitoring of ciénegas everywhere.

INTRODUCTION

Arid-land springs are among the most rare and endangered ecosystems of the American Southwest. Arid-land spring ciénegas are wet meadows and marshes that are supported by

springs and groundwater seeps in arid and semi-arid regions, and generally occur at elevations below 2,000 m (6,562 ft). They are biologically and economically important as productive wetland habitats for plants and animals in an otherwise arid landscape. Many of the plant and animal species in arid-land spring ciénegas occur only in these rare habitats and nowhere else. Some arid-land spring ciénegas have been permanent hydrological features for millennia and are the last habitat remnants and refuges for their resident rare species. Arid-land spring ciénegas provide the only habitats for 10 New Mexico rare and endangered plants, of which 3 have been extirpated from the state. There are 23 threatened, endangered or sensitive animals that rely entirely or partially on arid-land spring ciénegas, including 11 vertebrates, 9 mollusks and 3 crustaceans.

Arid-land spring ciénegas are rapidly vanishing across southwestern U.S. and northern Mexico. An initial 2015 inventory identified 50 arid-land spring ciénegas in New Mexico (Cole and Cole 2015). Only 26 of these were assessed as being functional or restorable with the remainder being no longer in existence or severely damaged and/or reduced in size. The New Mexico arid-land spring ciénegas inventory for this WAP identified an additional 119 arid-land spring ciénegas for a total of 169, which is still a small number for such a unique kind of wetland in an arid setting. These are scattered throughout the state (Figure 1), but are especially concentrated around the Roswell, Santa Rosa and La Ciénega artesian basins (Figures 2, 3 and 4).

Most extant arid-land spring ciénegas are damaged from land and water use and continue to be threatened by impacts from aquifer capture and depletion, gully formation, agricultural use, impoundment excavations and dams, non-native plants and animals, and a warming and drying climate.

A Wetlands Action Plan (WAP) provides guidance for protection and restoration of wetlands, as well as emphasizes ecological integrity, water quality benefits, preservation of wildlife corridors, and habitat conservation for threatened and endangered species, migratory birds, and other species of concern. This plan is written for private landowners, local governments, community partnerships, state and local institutions, and conservation groups who are involved in the preservation, conservation, and restoration of arid-land spring ciénegas. This WAP includes descriptive landscape background information and information for three major planning components: resource analysis, resource management, and a local involvement strategy. These planning components help ensure that planning and management activities adequately address arid-land spring ciénega issues. Since certain data and information are currently unavailable, part of the goal of this plan is to identify and fill these information gaps and help direct future action. The development and refinement of the arid-land spring ciénegas WAP for New Mexico will be an ongoing process and hopefully serve as a model for other states where ciénegas are present.

An important initial step in protecting and restoring New Mexico's arid-land spring ciénegas is finding all of them with additional inventory efforts using aerial imagery. On-the-ground assessments of land use impacts and biological inventories will also be necessary to rank the

conservation value and restoration potential of each accessible ciénega. These efforts will be aided by the NM Rapid Assessment Method (NMRAM) for Springs Ecosystems currently being developed by NM Environment Department and Springs Stewardship Institute (SSI). Widespread use of this method, conducting supplemental biological inventories, and ranking restoration potential will require enhancing landowner relationships with education and outreach and publicity for the importance of ciénegas. Non-governmental organizations can play a prominent role in developing these relationships by sharing knowledge and resources, including the volunteers they can bring to restoration projects. There are several landowner assistance programs offered by state and federal agencies and non-profit organizations that could be potential funding sources for ciénega restoration projects. Habitats for rare and endangered species should be priorities for these funds and data from NMRAM can help identify ciénega restoration goals.

BACKROUND

'Ciénega' is Spanish for a bog or marsh. It is also spelled 'ciénaga' throughout much of the Spanish-speaking world – especially South America and the Caribbean. The 'ciénega' spelling is prevalent in the American Southwest and often used in northern México. The origin of the word 'ciénega' is likely derived from the Spanish word for 'mud' – ciéno alluding to an area with wet, muddy soils. The scientific meaning of 'ciénega', however, has more recently evolved into the classification of a particular type of wetland regarded by biologists, anthropologists and historians as something rare and important to the arid regions of the American Southwest.

Climax communities are populations of plants or animals that remain stable and exist in balance with each other and their environment. Ciénegas gained acceptance as distinct climax communities of ecological significance when Hendrickson and Minckley (1985) conducted an assessment of the ciénegas of southeastern Arizona. They defined the ciénega climax community as mid-elevation (1,000-2,000 m) freshwater wetlands with permanently saturated, highly organic, reducing soils occupied by a low-growing herbaceous cover of mostly grasses, sedges and rushes. Sivinski and Tonne (2011) expanded the recognition of ciénega ecosystems to adjacent southern New Mexico but confined them to wet meadows and marshes associated with arid-land springs that could be either fresh water or highly alkaline. Minckley et al. (2012) extended the initial Arizona inventory of ciénegas into the adjacent state of Sonora, México. Cole and Cole (2015) initiated an inventory of all the previously documented ciénegas and added many from the state of Texas, and the Mexican states of Chihuahua and Coahuila. The results of these initial inventories clearly show the rarity of these unique desert wetlands and the fact that many have been irretrievably lost or severely damaged within the last century.

Ciénegas are formally defined by the International Terrestrial Ecological Systems Classification (ITESC) as warm desert, spring-fed, freshwater wetlands, at low elevations (<2,000 m) characterized by non-fluctuating shallow surface water with a flora dominated by low-statured herbaceous hydrophytes (water-loving plants) and only occasional patches of trees. Evaporation often creates saline conditions especially on the margins as evidenced by salt-tolerant species (NatureServe, 2014). New Mexico arid-land spring ciénegas usually fall within

this definition but can be greatly expanded outside the (warm) Chihuahuan Desert into other arid and semiarid ecoregions of the state, such as our table lands covered in shortgrass prairies, piñon-juniper savanna and sagebrush/saltbush scrub. An elevation of below 2,000 m (6,562 ft) is the key criterion because it will generally indicate a relatively dry environment in New Mexico and need not be within a warm desert. The part of the definition about 'non-fluctuating shallow surface water' can be disregarded as inaccurate since most arid-land spring ciénegas in New Mexico have very little surface water and soil saturation depths will seasonally fluctuate by being wettest in late winter and much drier in the summer when temperatures are higher, and vegetation is actively transpiring (Johnson et al. 2016, LeJeune 2018).

The importance of arid-land springs, both biologically and anthropologically, cannot be overstated and is the subject of extensive study and concern (Stevens and Meretsky 2008). Yet not all springs support ciénegas, but all ciénegas are created by groundwater springs and seeps. Low elevation New Mexican springs are critical habitats for many plants and animals in an otherwise arid landscape, especially the aquatic and hydrophytic species that rely on these relatively small, well-watered habitats. Their flowing waters, verdant pastures (ciénegas) and abundant wildlife were critical to prehistoric people, indigenous peoples and colonial settlers (Rea 2008) and remain essential to current agricultural and recreational enterprises. Most arid-land springs have been modified and damaged to some extent and many have been extinguished or so severely damaged they cannot function as complete wetland habitats for the foreseeable future. Now is the time to identify the last arid-land spring ciénegas in New Mexico and plan for their future management and recovery.

INVENTORY AND DISTRIBUTION

Plans for the management, protection and perpetuation of arid-land spring ciénegas in New Mexico first requires an inventory and assessment of their conditions. Previous work by Sivinski and Tonne (2011) and Cole and Cole (2015) summarized the extensive literature research and field experience of the authors and made a starting point for a more comprehensive arid-land spring ciénega inventory. The subsequent inventory for this Wetlands Action Plan closely examined aerial imagery (Google Earth, date) to locate previously undetected ciénegas. This effort was greatly enhanced by the database maintained at the Springs Stewardship Institute of the Museum of Northern Arizona (http://springstewardshipinstitute.org/), which provided coordinates of the thousands of USGS springs mapped for New Mexico. These locations were layered on Google Earth and each spring near or below 2000 m elevation closely examined for pale spring deposits and green wet meadow or textured yellow/gray marsh vegetation that would indicate a ciénega (see Figures 25-29 for examples). The most recent Google Earth imagery available in the 2018 survey was usually in the 2015-2017 date-of-imagery range. An earlier image (2006-2014 range) could sometimes be helpful if it was from a dry year that made wetlands more visible in the dry landscape. The author has many years of experience using aerial imagery to find wetlands followed by field assessments on the ground. Several new arid-land spring ciénegas were discovered using this approach, but many small arid-land spring ciénegas likely remain undetected because they are not mapped as springs by the USGS. A

complete listing of the 169 New Mexico arid-land spring ciénegas is provided in the Appendix to this report.

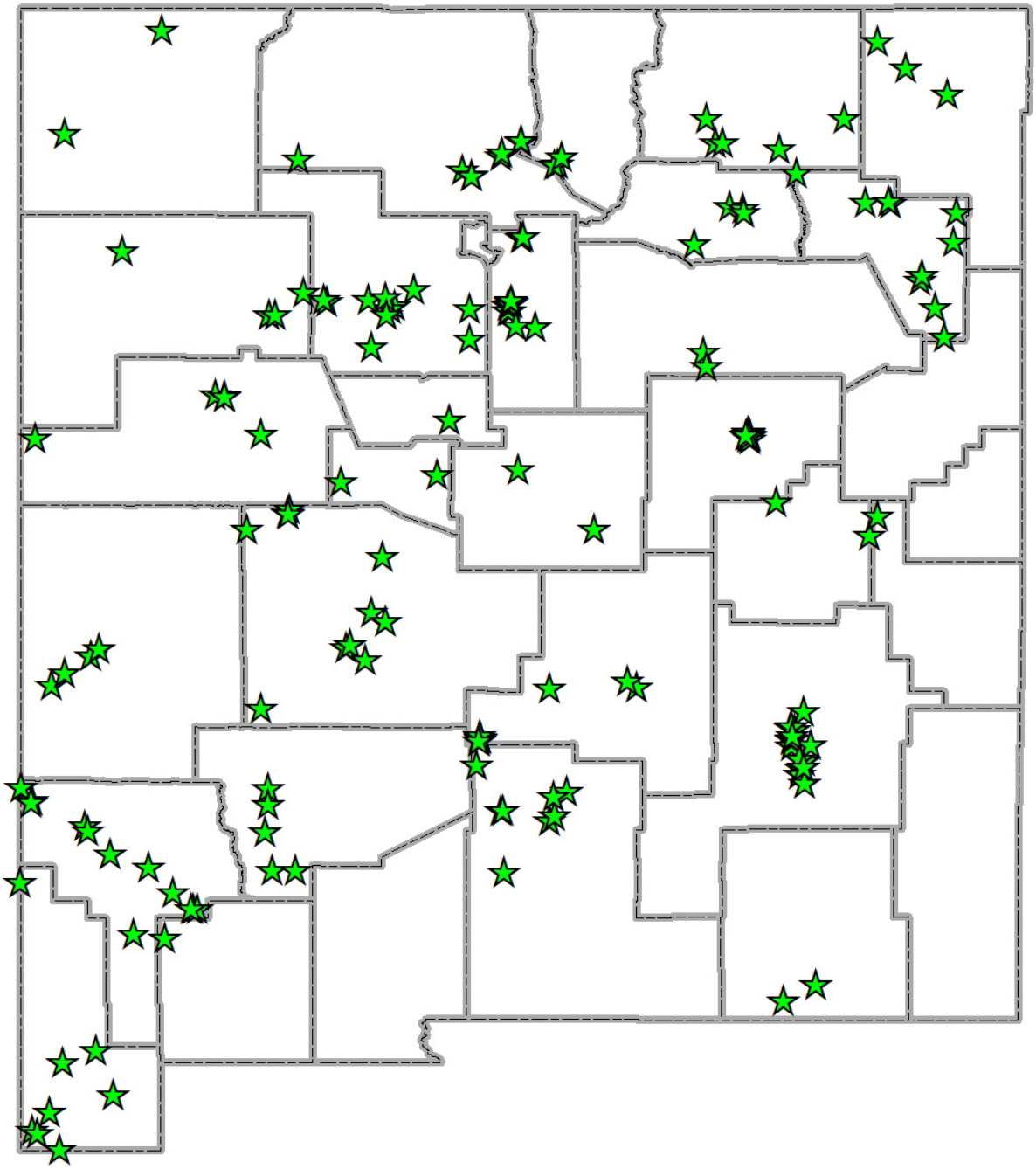

Figure 1. Distribution of arid-land spring ciénegas across New Mexico.

Arid-land spring ciénegas are scattered throughout the state with only Curry, Doña Ana, Lea, Los Alamos and Quay counties lacking documented occurrences (Figure 1). Doña Ana County

likely had arid-land spring ciénegas in the Rio Grande Basin, but that region is now so surficially and hydrologically modified, any traces of historic ciénegas cannot be detected. In New Mexico, most arid-land spring ciénegas are isolated wetlands, except in the following three artesian basins that have unusual concentrations of springs and wetlands. These three regions contain nearly a quarter of all the arid-land spring ciénegas in the state.

Roswell Artesian Basin. The lengthy Pecos River Valley in Chaves County between Roswell and Dexter is a large area of karst topography in gypsum strata that creates numerous sinkhole lakes, springs and spring brooks. Several of the springs create large functional arid-land spring ciénega wetlands on Bitter Lake National Wildlife Refuge (NWR), Bottomless Lakes State Park, and adjacent Bureau of Land Management (BLM) and private lands (Figure 2). These habitats are used by several plant and animal species of concern (MacRae et al. 2001, Sivinski and Tonne 2011).

Santa Rosa Artesian Basin. This karst basin is occupied by the small City of Santa Rosa, which has more wetlands than any other New Mexico municipality with several sinkhole lakes and wetlands (Figure 3). Most of the large springs and spring brooks lack USGS names and create large areas of ciénega habitat (Sivinski and Tonne 2011). The City of Santa Rosa and private landowners own most of the arid-land spring ciénegas, except for the Blue Hole Ciénega Nature Preserve, which belongs to the EMNRD, Forestry Division.

La Ciénega. The numerous springs and spring brooks around the historic Village of La Ciénega a few miles southwest of Santa Fe are created by igneous intrusions that force the regional aquifer to surface (Johnson et al. 2016). These arid-land spring ciénegas are relatively small and impacted by centuries of urban and agricultural use, but many remnants still occur in a concentrated area (Figure 4). They are all owned by private landowners, but the Santa Fe Botanical Garden manages a small ciénega as the Leonora Curtain Wetland Preserve. Wetland maps of this area are available in McGraw and Jansens (2012).

Preliminary arid-land spring ciénega condition assessments were conducted for this WAP and utilized the classification system developed by Cole and Cole (2015). When arid-land spring ciénegas were located using aerial imagery, their condition was assessed by the amount of obvious anthropogenic land use disturbance and encroachment of non-native tree cover. Historic ciénegas that are shrub-covered or look dry were considered dead. The difference between restorable and severely damaged ciénegas was the continued presence of water and wetland vegetation despite the damage in those that are restorable.

Functioning Ciénegas. Ciénegas whose structure and function are essentially unimpaired though possibly reduced from an original size. These have a conservation rank of 1 or 2 depending on size and biological diversity.

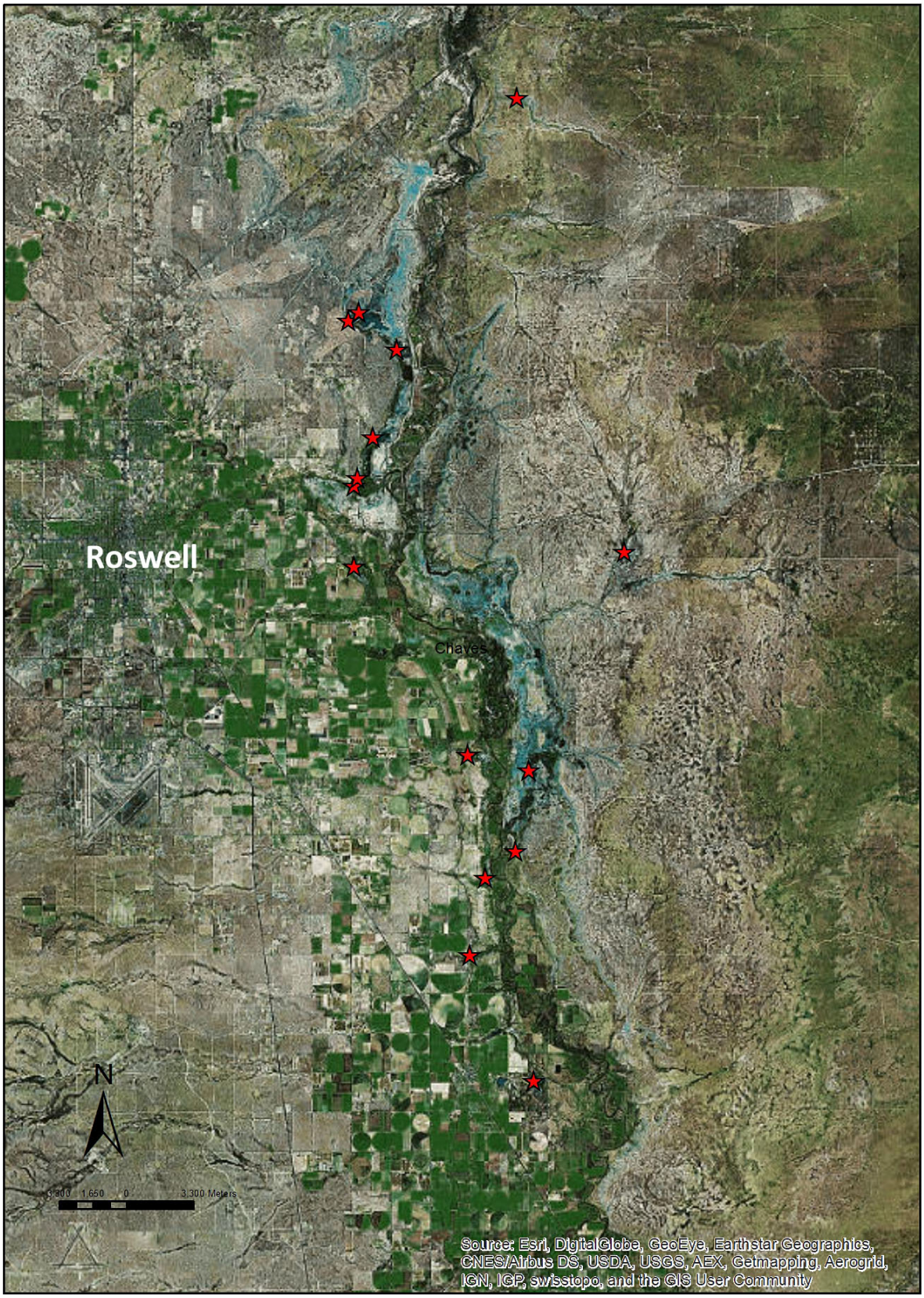

Figure 2. Distribution of arid-land spring ciénegas in the Roswell Artesian Basin, Chaves County.

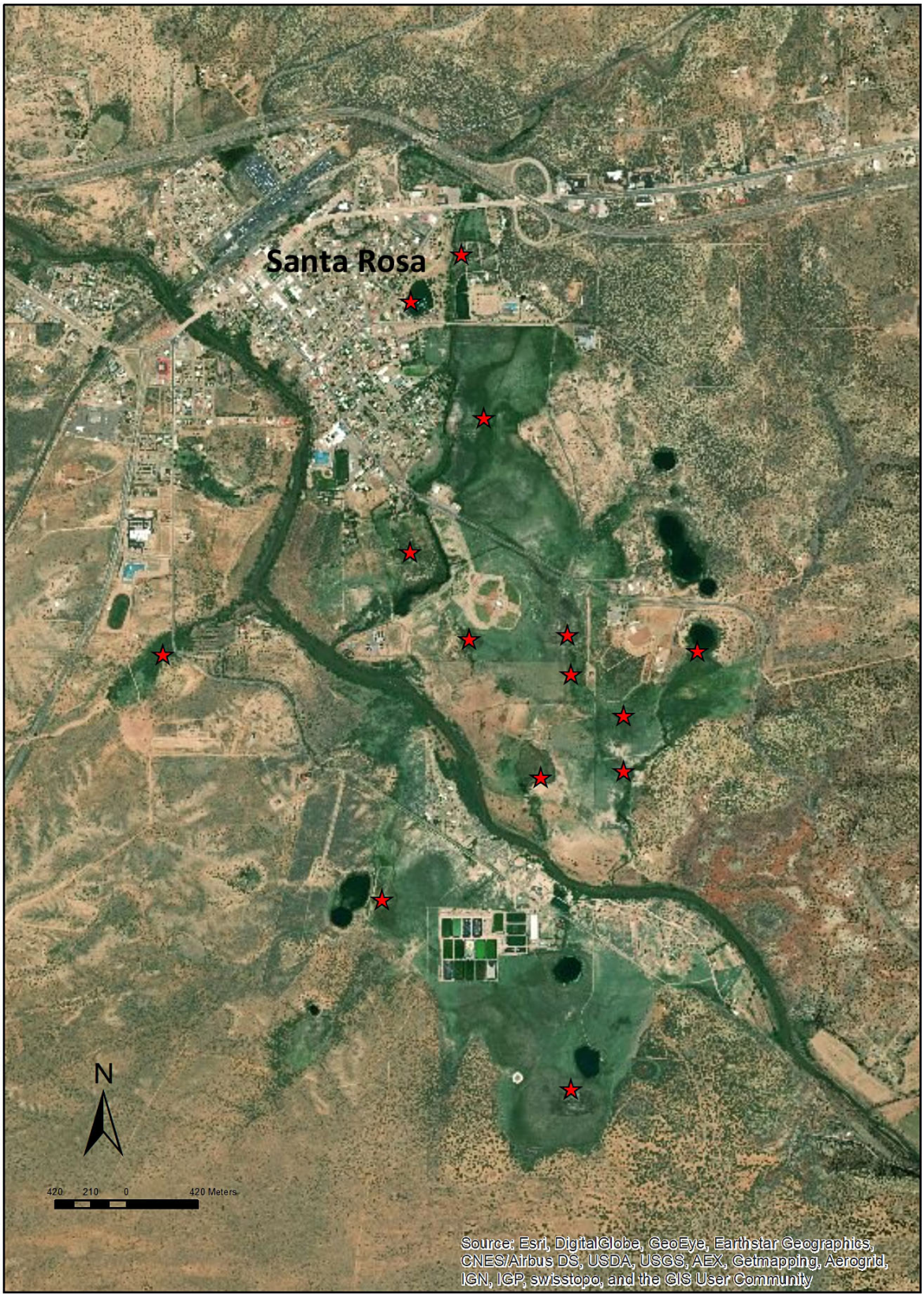

Figure 3. Distribution of arid-land spring ciénegas in the Santa Rosa artesian basin, Guadalupe County.

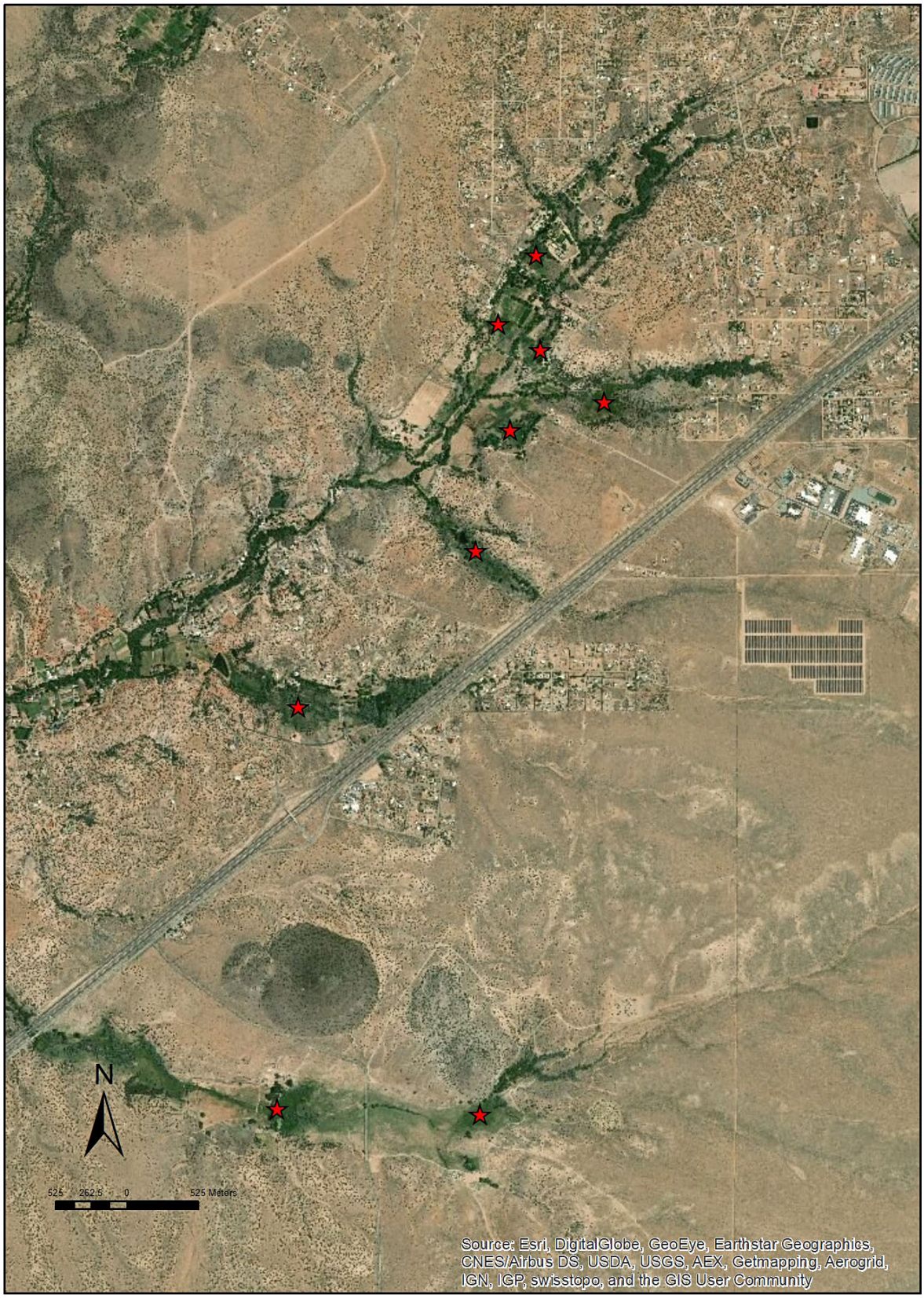

Figure 4. Distribution of arid-land spring ciénegas near the vicinity of La Ciénega, Santa Fe County.

Restorable Ciénegas. These ciénegas still have perennial water and abundant ciénega flora in their marshy reaches, but are dry in other stretches, or have incised channels or constructed drains that function like creeks. These have a conservation feasibility rank of 2.

Severely Damaged Ciénegas. These are ephemeral, periodically wetted by rains, or are so hydrologically and superficially modified (such as arroyos or pond excavation) that their restoration potential is questionable. These have a conservation feasibility rank of 3 or 4 depending on severity of damage.

Dead Ciénegas. These are historical ciénegas that no longer have groundwater at or near the ground surface and likely have water tables so severely depleted that restoration, given today's techniques and economics, is not feasible. These have a conservation feasibility rank of 4.

The initial Cole and Cole (2015) inventory identified 50 arid-land spring ciénegas in New Mexico. Only 26 of these were assessed as being functional or restorable with the remainder being dead or severely damaged. The subsequent literature and aerial imagery survey for New Mexico found an additional 119 arid-land spring ciénegas. Only a few of these new ciénegas were assessed as dead since current aerial imagery could not be used to find dead ciénegas without some historical context. Figure 5 shows the distribution of preliminary rankings for identified arid-land spring ciénegas in New Mexico with the caveat that this WAP inventory was not able to identify dead ciénegas from aerial imagery alone.

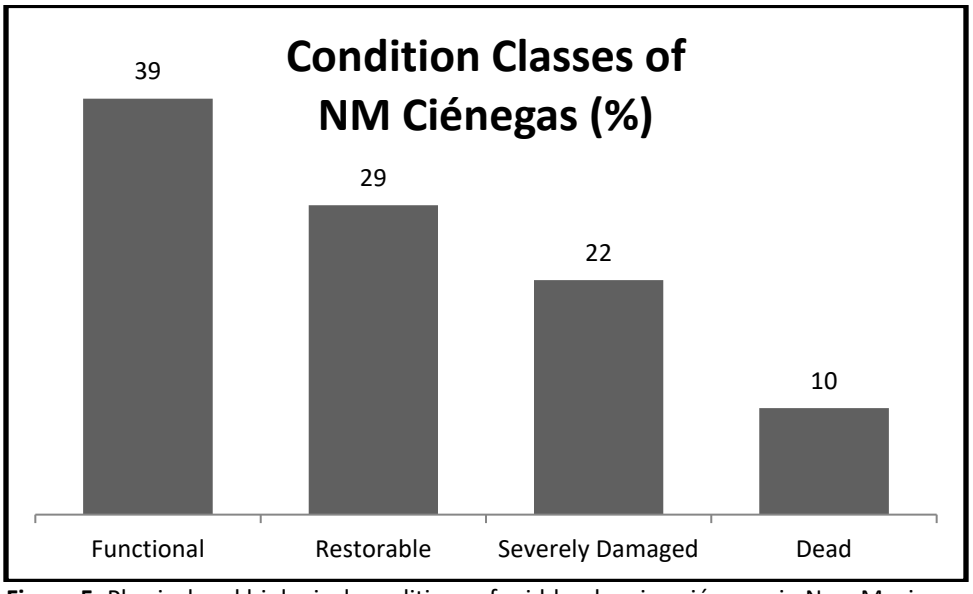

Figure 5. Physical and biological conditions of arid-land spring ciénegas in New Mexico.

GEOMORPHIC AND GROUNDWATER CHARACTERISTICS

Alluvial groundwater seeps in drainage channels are common in New Mexico and often called springs, but these do not fully form ciénega climax communities of plants and animals because of periodic drying in drought and scouring in flood. Springs that support ciénegas are stable wetlands where geologic aquifers intercept the ground surface in artesian basins or along geologic faults and igneous intrusions. They are less impacted by short-term vagaries of weather and tend to support greater ecological permanence. Ciénega springs are more likely to be on slopes in the upper reaches of small drainages, near igneous dikes, in dissolution/subsidence (karst) topography, or on slopes where water-bearing strata have been exposed by erosion or fault scarps. Size of individual arid-land spring ciénegas varies greatly from less than one acre to several hundred acres and is an expression of spring flow and topography. Arid-land spring ciénegas are a subset of slope wetlands characterized by Zeedyk et al. (2014) except that all are spring-fed. A ciénega may begin on a slope and terminate in a depression. In that case, both the depression and slope wetlands are permanent, connected and treated here as one ciénega.

Groundwater quantity and quality will vary with the geologic composition of the aquifer and distance traveled by the groundwater or its residence time. The longer it is moving through geologic substrate, the more mineralized it will become. For instance, low (92 to 152 mg/L) total dissolved solids (TDS) is characteristic of shallow groundwater near La Ciénega, but the discharge at the springs there have an intermediate TDS content (175–305 mg/L) with higher sodium, magnesium and sulfate, indicating a mixture of shallow and deep-water sources (Johnson et al. 2016). The Santa Rosa artesian basin aquifer is so mineralized from limestone and gypsum strata, the City of Santa Rosa must obtain its municipal water from wells 10 miles northwest of the city (LeJeune 2018). The spring brooks and groundwater seeps entering the Pecos River at Santa Rosa are so high in dissolved solids that a river water sample just above the city had TDS of 131 parts per million (ppm) while a sample just below the city had TDS of 1,642 ppm (Sweeting 1972). Other sedimentary formation aquifers in the Pecos Valley and throughout New Mexico can be expected to have relatively high content of dissolved minerals when they discharge at springs.

Hydrogeologists have developed a classification system of 12 kinds of discharge for natural springs (Springer and Stevens 2009). Arid-land spring ciénegas are not confined to any one particular type of spring, but are most often associated with the four kinds of groundwater discharges and geomorphic settings that are described below.

1. **Helocrene** springs emerge from low gradient wetlands with multiple, diffuse and indistinct sources like the sedge/spikerush fens at La Ciénega (Figure 7). In this case, groundwater emerges to form large areas of seeping slopes and valley bottoms. Helocrenes are the most common spring types associated with arid-land spring ciénegas in New Mexico. They can be very small, but some of our largest ciénegas in the Rio Grande and Pecos River valleys, and La Ciénega (Santa Fe County) are created by helocrene springs.

Figure 7. Helocrene spring ciénega at La Ciénega, Santa Fe Co., 35.5748 -106.0977.

Figure 8. Rheocrene spring brook at Alamosa Springs, Socorro Co., 33.5726 -107.6004.

2. **Rheocrene** springs discharge as a flowing stream (a.k.a. spring brook) but in reality, are often the result of larger areas of seeping groundwater that converge on a channel. Alamosa Spring (Figure 8) emerges from the ground as a spring brook and gathers volume as it traverses a narrow length of seeping ciénega on both sides of the channel. Similar spring brooks flanked by ciénega occur in the Roswell, Santa Rosa and La Ciénega artesian basins. In two special cases, Malpais Spring (Tularosa Basin) and Wagon Mound Lake (Mora County), the rheocrene spring brooks flow into enclosed basins creating hundreds of acres of marshy ciénegas.

Figure 9. Carbonate Mound Spring in Sandoval Co., 35.5471 -106.8268.

Figure 10. Hypocrene spring at Batte Way Ciénega, Otero Co., 33.0076 -105.8709.

3. **Carbonate (mound-forming)** springs discharge waters that precipitate calcium carbonate or sulfate upon discharging at the surface, which accumulates to elevate the point of discharge on a growing mound or carbonate deposit over time. Ciénegas associated with mound springs are usually small and sloping. In a few cases where spring flow is sufficient to reach adjacent lower gradients, travertine dams may form creating shallow pools with ciénega vegetation. Mound-forming springs are found in the

Tularosa Basin and southern foot of the Jemez Mountains (Figure 9). The carbonate mounds of some large springs in the Santa Rosa artesian basin are not as obvious because they discharge at the apex of low gently sloping, ciénega-covered hills.

4. **Hypocrene** springs are essentially hillside seeps without surface flow because evaporation and transpiration consume all discharge and there is little or no surface expression of water (Figure 10). Saturated soils, however, are close enough to the surface to support some of the more deeply-rooted wetland plants such as Baltic rush (Juncus balticus), saltgrass, and forb species. These sloping ciénegas can be difficult to detect because they are usually small and not recorded as springs on USGS maps.

SOILS

Arid-land spring ciénegas are wetlands with characteristic soils that develop under anaerobic conditions resulting from the presence of water for extended periods of time (hydric soils). They usually support a dense cover of vegetation, but rarely create peaty or mucky organic soils because of generally high alkalinity and the high temperatures prevalent at low elevation. These mineralized soils often have substantial organic content in the upper horizon, but vary greatly in soil textures and depth to depletion/reduction zones in the deeper profile depending on geologic parent material, proximity to the spring source, and topographic position.

Figure 11. Soil profile of groundwater discharge deposits in a road cut through Batte Way Ciénega (Otero County). Dark layer (arrow) has more organic matter than the gray and white groundwater discharge deposits above and below.

A few ciénegas occur in topographic depressions, but most exist where springs emanate from sloping terrain and in the upper reaches of drainages that receive little or no alluvial or colluvial deposition. The ciénega soils are the result of accumulation of chemical precipitates and organic matter over geologic time that are collectively referred to as groundwater discharge deposits (Springer et al. 2015). The pale precipitate layers are silty or sandy textured and sometimes separated by layers of darker organic deposits from drier intervals (Figure 11).

Some carbonate-rich arid-land springs have groundwater discharge deposits of solid limestone rock, which is called travertine (similar to cave deposits). This travertine layer may support ciénega vegetation while it is wet and will persist as a solid groundwater discharge deposit long after the spring ceases to flow (Figure 12).

Figure 12. Travertine layer (arrow) of a dead ciénega dewatered by gully formation at Ojos de Huelos (Valencia County).

SURFACE WATER

Expressions of surface water vary greatly in arid-land spring ciénegas depending on topographic position and amount of discharge from the aquifer. Dispersed (helocrene) seeps will have shallow or no surface flow on the wet soils where the water evaporates, transpires or seeps back to become groundwater again.

Some large springs, however, can have significant discharge of surface water. For instance, Lea Lake in Bottomless Lakes State Park is not only a sinkhole lake, but a huge spring that discharges a surface flow of 2.5 million gallons/day (Davis and Joseph 1998) into a series of other spring brooks, seeps and ciénegas across hundreds of acres (called the Overflow Wetlands) before reaching the Pecos River. This water flows through gypsum strata so is salty, but still fully supports the designated uses of warm water fishery, wildlife habitat, and recreational swimming (primary contact). Likewise, surface water discharge from Blue Hole Spring is 3,000 gallons/minute (sign at Blue Hole Park, Santa Rosa) which reaches the Pecos River after traversing a large ciénega. This water fully supports recreational swimming and a warm water fishery, and limited use for irrigated agriculture. Alamosa Springs in Socorro County creates Alamosa Creek by discharging 2,000 gallons/minute (Hillard 1969), which is used for irrigated agriculture at Monticello, 12 miles downstream. These are a few examples of the many arid-land springs with ciénegas that contribute to the surface waters of New Mexico. Most are not well-studied or monitored for their water quality and quantity.

CLIMATE

The climate of New Mexico varies along its elevation gradient, but always towards hotter and drier at lower elevations. Spring ciénegas at elevations near or below 2,000 m are wetlands in otherwise arid to semiarid landscapes. Annual precipitation at this 6,550 ft elevation upper limit

is about 12-14 inches and decreases to about 8 inches at lower elevations. Relative humidity greatly exceeds annual precipitation with 110 inches of annual pan evaporation in the southeastern valleys. Individual summer day high temperatures often exceed 100°F below 5,500 ft (Western Regional Climate Center, https://wrcc.dri.edu/). This describes a hot/dry climate where the vegetation is composed of desert-adapted species of warm-season grasses and shrubs with small leaves or succulent stems (cacti) in the Chihuahuan Desert, then ascending to warm-season shortgrass prairie, sagebrush/saltbush scrub and low-statured piñon-juniper woodland of the table lands near 2,000 m elevation. Even the native wetland grasses in the ciénegas of this hot/arid climate are predominantly warm-season, salt-tolerant species. In comparison, elevations above 2,000 m begin trending towards cooler, wetter climes that are more forested and with wet meadows that arise from shallow groundwater fed by snowmelt. These montane wet meadows are usually less salty than ciénegas and the vegetation is a very different suite of cool-season grasses and sedges.

BIOLOGICAL IMPORTANCE

Wetlands are keystone ecosystems in arid environments and comprise only approximately 0.3% of the surface area of the arid Southwest (Cowardin et al. 1979). Arid-land spring ciénegas are a special class of these inland wetlands and are well-known for their biological importance and "endemism" (species being unique to a defined geographic location). Two of the most famous regions of inland aquatic endemism are the arid-land springs and ciénegas of Ash Meadows in the Mojave Desert (Frazer and Martinez 2002) and the Cuatro Ciénegas basin in the Chihuahuan Desert in Mexico, which has been referred to as the Galapagos of North America (Stein et al. 2000).

It is the relative permanence of the spring features that make many arid-land spring ciénega habitats biologically distinct from other types of wetland communities. Arid-land spring ciénegas are typically isolated above river channels where they are protected from the scouring floods that frequently modify river marshes and floodplains. Ciénega spring flows may vary over time during moist and arid cycles of the climate but are less susceptible to variable flooding and drying than in a playa basin wetland for example, which is completely dependent on precipitation for its source of water. Sediment cores from San Bernardino Ciénega in southeastern Arizona show consistent and continuous wetland conditions for most of the last 7,000 years (Minckley and Brunelle 2007). Sediment cores at Cuatro Ciénegas in Coahuila indicate nearly identical ecological conditions for more than 30,000 years (Meyer 1973). Such springs are refugia for species that may have been more widespread and common during wetter periods of the Quaternary. Several vertebrate and invertebrate animals still utilize arid-land spring ciénegas as core habitats in their overall distributions and some species are entirely confined to only one or a few arid-land springs and their associated arid-land spring ciénegas.

Arid-Land Spring Ciénega Vegetation

Arid-land spring ciénega vegetation is usually highly productive and dense. A list of plant species for southeastern Arizona ciénegas was assembled by Hendrickson and Minckley (1985). Peterson and David (1998), Milford et al. (2001) and Sivinski and Bleakly (2004) produced lists of ciénega plants for the Pecos River Basin of eastern New Mexico. Most individual arid-land spring ciénegas have relatively low plant species diversity, but contribute a productive and rare subset of wetland species and habitats to an otherwise arid landscape.

Figure 13. Bitter Lake NWR, Chaves Co., ciénega with saltgrass, alkali sacaton and Wright's marsh thistle.

Figure 14. Bitter Lake NWR ciénega with southern cattail, alkali muhly, Pecos sunflower and Wright's marsh thistle.

The most common arid-land spring ciénega plants of the southwestern region are the open water (when present) emergent species of bulrush (*Schoenoplectus* sp., *Bolboschoenus maritimus*) and cattail (*Typha* sp.); sedges and rushes of water-saturated soils (*Eleocharis* sp., *Carex* sp., *Cyperus* sp.); salt and alkali tolerant inland saltgrass (*Distichlis spicata*), scratchgrass (*Muhlenbergia aperifolia*), and Mexican or Baltic rush (*Juncus balticus*) on seasonally saturated and sub-irrigated soils; and alkali sacaton (*Sporobolus airoides*) on the drier ciénega margins. Native woody plants are usually not a significant part of ciénega vegetation because of the water saturated soils or high soil salinity. Patches of coyote willows (*Salix exigua*) may occur along spring brooks and willow baccharis (*Baccharis salicina*) can be locally abundant on drier ciénega margins, which can also have a scattering of riparian trees such as cottonwood (*Populus deltoides*), or Goodding's willows (*Salix gooddingii*) (Figures 17 and 18).

Some unique plant communities occur only in arid-land spring ciénegas such as dense stands of beaked spike rush (*Eleocharis rostellata*) which is otherwise very rare in other kinds of New Mexico wetlands (Figure 15). Unusual analogs of the Great Plains tallgrass prairie with stands of Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*) occur in at least two New Mexico arid-land spring ciénegas – Santa Rosa ciénegas (Guadalupe County) and Cloverdale Ciénega (Hidalgo County) (Figure 16). Several common, widespread wetland plants occur in New Mexico exclusively at arid-land springs and ciénegas including limy brookweed (*Samolus ebracteatus*), tall dropseed (*Sporobolus compositus*), prairie gentian (*Eustoma exaltatum*), hairy fimbry (*Fimbristylis puberula*), southwestern sea-lavender (*Limonium limbatum*), clasping yellowtops (*Flaveria chlorifolia*), rough goldeneye (*Heliomeris hispida*) and others.

Figure 15. Malpais Spring ciénega, Otero Co., with acres of beaked spikerush and saltgrass. Flower is prairie gentian.

Figure 16. Blue Hole Ciénega, Guadalupe Co., with Indian grass and tall dropseed. The white flowers are heath aster and the yellow are clasping yellowtop.

Some plant species occupying only arid-land spring ciénegas are rare throughout their range and require special consideration and monitoring (Sivinski 2012a). New Mexico has already lost three ciénega plant species when their only known New Mexico populations at Playas Springs were made extinct by agricultural and industrial dewatering of the springs there. The Las Playas Springs spine aster (*Leucosyris blepharophylla*), slender spiderflower (*Peritoma multicaulis*) and Arizona eryngo (*Eryngium sparganophyllum*) will likely never be seen again in New Mexico. Plant species found in arid-land spring ciénegas that are in danger of extinction or extirpation from the state are listed in Table 1. The Pecos sunflower (*Helianthus paradoxus*) is listed as threatened under the federal Endangered Species Act and two additional ciénega plants, Wright's marsh thistle

(*Cirsium wrightii*) and Leoncita false foxglove (*Agalinis calycina*), are currently proposed for federal listing as threatened or endangered.

Figure 17. Simmons Ciénega (35.5781 -106.1025), Santa Fe Co. with field sedge, alkali muhly, Baltic rush and few Rio Grande cottonwood trees.

Figure 18. Lang Ciénega (31.3361 -108.8106), Hidalgo Co. with Chihuahua sedge, flatsedge, alkali muhly and scattered Goodding's willow trees.

Table 1. Special status species (state or federal) plants in New Mexico arid-land springs, spring brooks and ciénegas. Federally Threatened (FWS-T), Federally Proposed Endangered (FWS-PE), BLM Sensitive (BLM-S), US Forest Service – Sensitive (USFS-S), New Mexico Endangered (NM-E), New Mexico Species of Concern (NM-SOC). (EMNRD-Forestry 2017 and NMRPTC 1999)

Plants		**Status**
Leoncita false foxglove	*Agalinis calycina*	NM-SOC
Chihuahua sedge	*Carex chihuahuensis*	USFS-S
Wright's marsh thistle	*Cirsium wrightii*	FWS-PE, NM-E, BLM-S, USFS-S
Arizona eryngo	*Eryngium sparganophyllum*	NM-SOC
Pecos sunflower	*Helianthus paradoxus*	FWS-T, NM-E
Las Playas Springs spine aster	*Leucosyris blepharophylla*	NM-SOC
Chiricahua mudwort	*Limosella pubiflora*	USFS-S
Slender spiderflower	*Peritoma multicaulis*	NM-SOC
Parish's alkaligrass	*Puccinellia parishii*	NM-E, BLM-S
GP lady's tresses orchid	*Spiranthes magnicamporum*	NM-E

Arid-Land Spring Ciénega Wildlife

Zoologists have long recognized that very small arid-land spring habitats can be habitats for the only populations of rare and endemic animals (mostly invertebrates) or may provide refugia for wetland animals that also use adjacent more unstable wetland habitats that regularly dry or flood. While many common upland and wetland animals use arid-land spring ciénegas for water, cover and forage, several aquatic species are very specific to springs that have maintained relatively stable flow for millennia – especially fish (Meffe 1989), springsnails (Taylor 1987, Hershler et al. 2014) and crustaceans (Gervasio et al. 2004).

Figure 19. Chiricahua leopard frog. Jim Rorabaugh

Several federal and state threatened or endangered species of animals occur in arid-land spring ciénegas in New Mexico. At least 10 species of rare fish and leopard frogs (3 federally threatened or endangered) utilize arid-land spring ciénegas as well as other spring-fed habitats throughout part or most of their ranges (Table 2). At least 7 springsnail species (6 federally endangered) have their world-wide range within just one or a few isolated arid-land springs in New Mexico (Table 2). It is notable that a locally endemic crustacean, Noel's amphipod (*Gammarus desperatus*) occurs in some of the same Roswell spring ciénegas as three endemic springsnails (*Assiminea pecos, Juturnia kosteri, Pyrgulopsis roswellensis*) and all four were given endangered species status. These co-occur with the endangered Pecos sunflower, Wright's

marsh thistle and Leoncita false foxglove. Even a geographically isolated spring ciénega like Alamosa Spring in Socorro County can have an assemblage of endangered species such as the Alamosa springsnail (*Tryonia alamosae*), Chiricahua leopard frog (*Lithobates chiricahuensis*) and Wright's marsh thistle.

Table 2. Special status species (state or federal) animals in arid-land springs, spring brooks and ciénegas in New Mexico. Federally Endangered (FWS-E), Federally Threatened (FWS-T), New Mexico Endangered (NM-E), New Mexico Theatened (NM-T), New Mexico Species of Greatest Conservation Need (NM-SGCN). (NMDGF 2017 and NMDGF BISON-M)

Vertebrates		**Status**
American bittern	*Botaurus lentiginosus*	NM-SGCN
Chiricahua leopard frog	*Lithobates chiricahuensis*	FWS-T, NM-SGCN
Plains leopard frog	*Lithobates blairi*	NM-SGCN
Rio Grande leopard frog	*Lithobates berlandieri*	NM-SGCN
Pecos gambusia	*Gambusia nobilis*	FWS-E, NM-E
Pecos pupfish	*Cyprinodon pecosensis*	NM-T
White Sands pupfish	*Cyprinodon tularosa*	NM-T
Greenthroat darter	*Etheostoma lepidum*	NM-T
Mexican tetra	*Astyanax mexicanus*	NM-T
Gray redhorse	*Moxostoma congestum*	NM-SGCN
Gila topminnow	*Poeciliopsis occidentalis*	FWS-E, NM-T
Crustaceans		
Socorro isopod	*Thermosphaeroma thermophilum*	FWS- E, NM-E
Noel's amphipod	*Gammarus desperatus*	FWS-E, NM-E
Great Plains fairy shrimp	*Streptocephalus texanus*	NM-SGCN
Mollusks		
Alamosa springsnail	*Tryonia alamosae*	FWS-E, NM-E
Chupadera springsnail	*Pyrgulopsis chupaderae*	FWS-E, NM-E
Pecos springsnail	*Pyrgulopsis pecosensis*	NM-T
Roswell springsnail	*Pyrgulopsis roswellensis*	FWS-E, NM-E
Socorro springsnail	*Pyrgulopsis neomexicana*	FWS-E, NM-E
Koster's springsnail	*Juturnia kosteri*	FWS-E, NM-E
Pecos assiminea	*Assiminea pecos*	FWS-E, NM-E
Wrinkled marshsnail	*Stagnicola carperata*	NM-E
Texas hornshell	*Popenaias popei*	FWS-E, NM-E

Additional genetic research is needed on New Mexican spring ciénega animals, especially invertebrates, to identify and protect local endemic species that are likely to occur but are yet undetected. Genetic analysis of some Pecos Basin amphipod populations indicates several localized cryptic species in arid-land springs (Gervasio et al. 2004). Even a new species of spring brook fish has come to light with the discovery of a genetically distinct population of round-nose minnow in the spring brooks of Santa Rosa, NM (Schönhuth et al. 2012).

Figure 20. Endangered Noel's amphipod and Pecos assiminea from Bitter Lake National Wildlife Refuge.

Most of the springs and ciénegas of the Roswell Artesian Basin have been designated a Ramsar Wetland – one of only two spring-fed wetlands designated in the southwestern U.S. The Ramsar Convention on Wetlands of International Importance, especially as waterfowl habitat, is an international treaty for the conservation and sustainable use of wetlands. It is also known as the Convention on Wetlands. It is named after the city of Ramsar in Iran, where the Convention was signed in 1971. This particular designation, however, emphasizes the endemic invertebrate populations at these springs and ciénegas by noting "The Ramsar Site supports a diverse collection of plants and animals including several endemic species such as the Roswell springsnail (*Pyrgulopsis roswellensis*), Koster's springsnail (*Juturnia kosteri*), and Noel's amphipod (*Gammarus desperatus*) as well as many migratory songbirds, waterfowl, and wading birds such as the Sandhill Crane (*Grus canadensis*); and a large amount of dragonflies and damselflies." (https://www.ramsar.org/news/usa-designates-roswell-artesian-wetlands-in-new-mexico)

OWNERSHIP AND LAND USE

The majority (63%) of known arid-land spring ciénegas in New Mexico belong to private landowners (Figure 21). About 10% are tribal or state trust lands so are managed much like private property. Municipalities own 4% with the City of Roswell owning an arid-land spring ciénega adjoining Hunter Marsh at Bitter Lake NWR, and the City of Santa Rosa owning several parcels with ciénega habitats. The remaining ciénegas belong to various state and federal government agencies or have multiple kinds of ownership.

Almost all private, tribal, state trust, BLM, and National Forest arid-land spring ciénegas are grazed by livestock as the primary land use. A few are well managed, but many are severely grazed because they are wet, productive ecosystems in an otherwise arid unproductive

landscape. Some arid-land spring ciénegas have been converted into agricultural fields and even aquiculture ponds – specifically fish hatcheries.

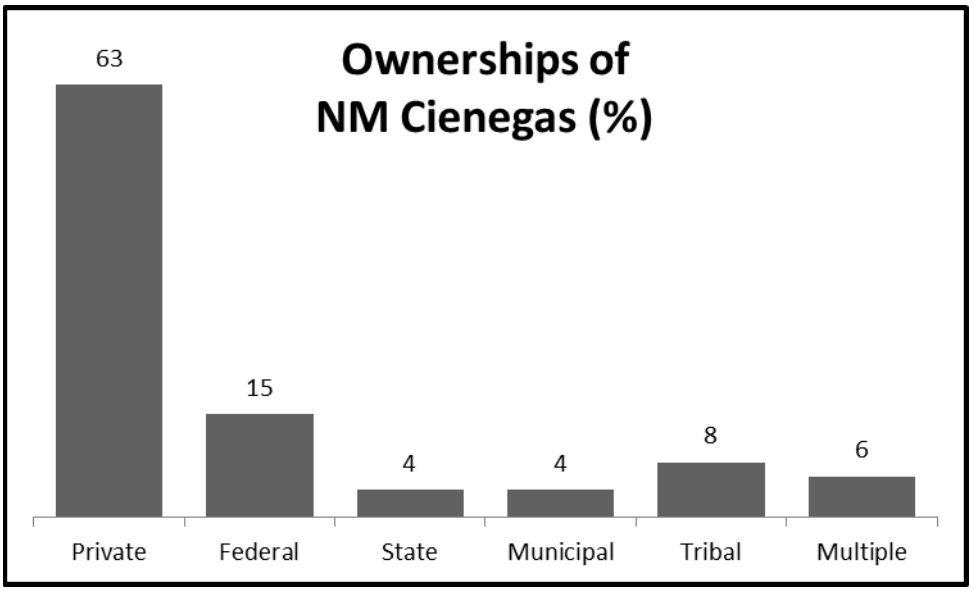

Figure 21. Ciénega landowners in New Mexico.

Table 3. New Mexico arid-land spring ciénegas in wildlife management areas and nature preserves.

Name	Owner/Manager	County	Approx. Ciénega Size
Bitter Lake National Wildlife Refuge	US Fish & Wildlife Service	Chaves	350 acres
Overflow Wetlands Wildlife Habitat Area	Bureau of Land Management	Chaves	500 acres
Bottomless Lakes State Park	NM Parks Division	Chaves	50 acres
City of Rocks State Park	NM Parks Division	Grant	3 acres
Blue Hole Ciénega Nature Preserve	NM Forestry Division	Guadalupe	116 acres
La Joya Waterfowl Management Area	NM Department of Game and Fish	Socorro	400 acres
Wagon Mound Lake (Salt Lake) Waterfowl Management Area	NM Department of Game and Fish	Mora	15 acres
Leonora Curtin Wetland Preserve	Santa Fe Botanical Garden	Santa Fe	20 acres

A few arid-land spring ciénegas are used for nature preserves that provide public recreation and education (Table 3). The Leonora Curtin Wetland Preserve in La Ciénega has well-maintained trails and volunteer docents to lead and educate more than 8,000 visitors and students each year. Bottomless Lakes State Park has constructed an elevated boardwalk to allow visitors to

walk a short distance into the overflow wetlands below Lea Lake. Bitter Lake NWR has bird watching and waterfowl hunting on part of the refuge and schedules its public Dragonfly Festival weekend to coincide with the bloom of dense stands of Pecos sunflowers in the roadside ciénegas. La Joya Waterfowl Management Area on the Rio Grande is also open to hunters. Perch Lake and Twin Lakes are sinkhole lakes with ciénegas in Santa Rosa that are developed for picnicking, swimming and fishing. These activities often generate income for the ciénega owners/managers and the local communities.

THREATS AND IMPAIRMENTS

The interaction of humans with arid-land springs and ciénegas is a prehistoric tale of early and prolonged dependence (Haynes 2008; Rhea 2008) with a more recent history of almost universal destruction or diminution during the last two centuries (Unmack and Minckley 2008, Cole and Cole 2015). Populations of freshwater animal species are estimated to have declined by 37% since 1970 (WWF 2012), but arid-land spring ciénegas are likely in worse condition than that. The Cole and Cole (2015) assessment of 155 ciénegas in the southwest found 87 (56%) were either dead or so severely compromised that there is no prospect for their restoration.

Groundwater Impairments

Aquifer depletion is the most damaging impact inflicted upon arid-land springs and is the leading cause of death for ciénega wetlands. Draw-down of groundwater from wells that divert the water to agricultural fields, copper smelters, and urban uses have diminished or eliminated many important ciénega springs in the desert southwest (Brune 1981, Hendrickson and Minckley 1985, Unmack and Minckley 2008). In New Mexico, 22 historic springs and seeps on the west side of the Playas Basin in Hidalgo County seen by Schwennesen (1918) were greatly diminished by 1958 just from regional agricultural wells (Doty 1960) and finally eliminated by the groundwater demands of the Playas Smelter. The huge San Simon Ciénega in Hidalgo County on the NM/AZ border was completely eliminated when nearby irrigated cotton fields captured and depleted the aquifer (Sivinski and Tonne 2011) (Figure 22). The smelter at Hurley drew-down the aquifers of Apache Tejo Spring, Kennecott Warm Spring and Cold Spring, killing those ciénegas. Most recently, irrigated farm fields near Oasis Dairy Ciénega in Roswell sufficiently depressed the aquifer level to cause cessation of spring flow and dense stands of endangered Pecos sunflower to be replaced by non-native annual weeds (Sivinski and Tonne 2011).

Groundwater pollution effects on arid-land spring ciénega plants and animals have received very little attention in New Mexico. A single study on Bitter Lake NWR found elevated concentrations of mercury and lead in Hunter Marsh adjacent to a City of Roswell sewage storage facility, but no other concentrations of contaminants throughout the remainder of the refuge (MacRae et al. 2001). A leaking sewer pipeline appears to be a chronic issue through a City of Santa Rosa ciénega, but this pollution is very localized (Sivinski 2012b). Construction of oil or gas wells and pipelines has the potential to pollute larger aquifers in the lower Pecos Valley where there are numerous springs and a high concentration of energy development.

Figure 22. Middle of San Simon Ciénega, Hidalgo County, New Mexico, April 2010. A few old cottonwood trees on the outer margin are still living, but are not reproducing, and this large ciénega is completely dead.

Global warming will create significant hydrological challenges in the near future as the New Mexico climate becomes hotter and drier (UCS 2016). Decreasing mountain snowpack and its earlier melt and runoff will mean less surface water for agricultural and urban use just when rising temperatures will be increasing demand for water. The state will become increasingly reliant on groundwater while the growing aridity will diminish opportunities for aquifer recharge. Large spring ciénegas will likely contract and some smaller springs with ciénegas may disappear altogether.

Surface Impairments

Livestock grazing is the most prevalent land use impact to arid-land spring ciénegas, but can be a double-edged sword simply because wet meadows are such productive pastures. Those without large ungulate grazing or occasional fire tend become overgrown, unproductive, and begin to lose their species diversity (Kodric-Brown and Brown 2007, Sivinski 2012a, Roth 2018). Yet poorly managed grazing can eliminate the most palatable plant species and trample wet soils. For instance, at least one population of endangered springsnail (*Pyrgulopsis chupaderae*) has been extirpated by continuous livestock trampling of its small spring seep habitat (FWS 2012).

Head-cut and gully erosion is also frequently caused by livestock trailing up small drainages containing springs. Gullies can further erode into deep arroyos that depress the shallow aquifers of seeping ciénegas to levels too low to support wetland vegetation. While the transitions between dry and wet climate phases appear to be the primary driver of arroyo formation in the American Southwest, anthropogenic land uses (stock tanks, livestock trailing, roads) are often the triggers for arroyo down-cutting since mid-nineteenth century (Waters and Haynes 2001, Minckley et al. 2013).

Figure 23. Diversion dike construction impounding and redirecting spring flow at Bass Lake ciénega in Santa Rosa.

Most arid-land springs that are still flowing have been physically modified to support the current land use. Spring box diversion to pipelines and stock troughs, diversion channels, impoundment excavations and dams are so common it is rare to find a natural spring that has not been modified. Small ciénegas are often diminished or eliminated by excavating a large basin and dam in the ciénega surface to create a pond that serves little purpose other than aesthetics (Figure 23). Spring ponds become habitat for only cattails and non-native bullfrogs at the expense of the original ciénega biota. For instance, some endemic springsnail populations have been completely destroyed by impoundment excavations (Taylor 1987).

Some very large ciénegas at state and federal wildlife management areas (La Joya and Bitter Lake) have been greatly modified, and likely diminished, by extensive channel and dike systems to create open water impoundments for waterfowl and fish. Several rare or sensitive ciénega plants and animals were impacted by these hydrologic changes and are only fairly recently being considered in current management plans (Sivinski 2011).

Many other privately owned arid-land spring ciénegas in New Mexico have been severely damaged by channeling and damming spring flow to irrigate pastures and agricultural fields – especially in the Santa Rosa and La Ciénega regions.

Figure 24. Russian olive infesting a Pecos sunflower critical habitat ciénega in Santa Rosa.

Non-native invasive species cause serious problems in almost all New Mexican wetlands, including arid-land spring ciénegas. The most obvious are the noxious weed trees – salt cedar (*Tamarix chinensis*) and Russian olive (*Elaeagnus angustifolia*) (Figure 24). Ciénegas are wide open meadows that cannot persist in an understory of tree canopy. There is also evidence that a forest of riparian trees can drop a ciénega water table several feet during summer months of active transpiration (Johnson et al. 2016). Non-native herbaceous plants that threaten arid-land spring ciénegas in New Mexico include perennial pepperweed (*Lepidium latifolium*), Russian knapweed (*Acroptilon repens*), meadow fescue (*Schedonorus pratensis*), and Canada thistle (*Cirsium arvense*) just to name a few. Non-native fish, bullfrogs and invertebrates also infest many arid-land springs where they threaten and displace the native aquatic fauna (USFWS 2006, 2018).

CURRENT REGULATIONS FOR PROTECTION

Activities in the waters of the United States are regulated under Section 404 of the federal Clean Water Act with the basic premise that no discharge of dredged or fill material may be permitted if: (1) a practicable alternative exists that is less damaging to the aquatic environment or (2) the nation's waters would be significantly degraded. The Section 404 permitting process is delegated to the U.S. Army Corps of Engineers, which oversees the delineation of wetlands, assessment of water quality impacts, and compensatory mitigations. Many arid-land spring ciénegas with direct connection to the watersheds of interstate rivers are jurisdictional wetlands protected by the Clean Water Act.

Many other arid-land spring ciénegas, however, are not jurisdictional wetlands and receive no federal protection because they are isolated or occur within closed basins. In these cases, water quality standards are regulated in the New Mexico Administrative Code (NMAC) Title 20, Chapter 6, and Part 4 "Water Quality Standards for Interstate and Intrastate Surface Waters". In addition to some general criteria, some specific criteria for all perennial surface waters apply to warm water aquatic life, livestock watering, wildlife habitat and primary contact uses. The criteria applicable to establish these Designated Uses are established in NMAC 20.6.4.900 D, F, G and H.

Rules adopted by the Oil and Gas Conservation District (OCD) and NMED under NMAC Title 19, Chapter 15 attempt to avoid contamination of groundwater, springs and wetlands from oil and gas activities through the following requirements:

19.15.16.9
A. During the drilling of an oil well, injection well or other service well, the operator shall seal and separate the oil, gas and water strata above the producing or injection horizon to prevent their contents from passing into other strata.
B. The operator shall take special precautions by methods satisfactory to the division in drilling and abandoning wells to guard against loss of artesian water from the strata in which it occurs, and the contamination of artesian water by objectionable water, oil or gas.

19.15.17.10
A. (1) An operator shall not locate a temporary pit containing low chloride fluid:
(a) where ground water is less than 25 feet below the bottom of the pit;
(d) within 200 feet of a spring;
(f) within 100 feet of a wetland.
(3) An operator shall not locate a temporary pit containing fluids that are not low chloride fluids:
(a) where ground water is less than 50 feet below the bottom of the pit;
(d) within 500 feet of a spring;
(f) within 300 feet of a wetland.

National Pollutant Discharge Elimination System (NPDES) regulations require that communities meeting the definition of MS4 (40 CFR Part 122.26) obtain permit coverage for storm water discharges from their jurisdictions. Communities that meet the Phase I requirements (population above 100,000) or Phase II requirements (within an Urbanized Area as defined by the U.S. Census Bureau/population density of 1000 people per square mile) must submit a permit application to EPA. This requirement applies only to jurisdictional waters of the U.S. so may provide some limited protection to arid-land spring ciénegas within or adjoining the La Ciénega, Roswell and Santa Rosa urban areas.

TOOLS FOR CONSERVATION

Identification and Inventory

Locating and identifying arid-land spring ciénegas with USGS data for springs is only partially useful because most ciénegas are associated helocrene springs, which are not often identified as springs on USGS maps. The primary tool for finding and identifying arid-land spring ciénegas is aerial imagery that is readily available to the public through Google Earth and with the higher resolution services to which many government agencies and research institutions already subscribe. Once located, spring ciénegas can be brought to the attention of their landowners and, hopefully, assessed on the ground for their biological and land use values. The following examples show how to use aerial imagery to identify ciénegas and assess their conditions.

Figure 25. Animas Ciénega, Hidalgo Co., 31.7826 -108.7909

The northern end of the large Animas Ciénega (Figure 25) shows spring seeps with green meadow adjacent to a riparian woodland (on right) in an otherwise dry landscape. The pale gray surface soils are dry calcareous groundwater discharge deposits from millennia of spring seepage. USGS does not map this area as a spring. A 2011

ground survey of this site found surface water at the small round spring (upper center) and wet soils throughout the green meadow of alkali muhly, rushes and sedges. The brown area in the lower center is a dense stand of cattails with scattered Goodding's willow trees.

Figure 26. Batte Way Ciénega, Otero Co., 33.0076 -105.8709.

Even very small ciénegas are visible on good aerial imagery. Batte Way Ciénega (Figure 26) is a hillside spring seep with a small 25 x 80 m ciénega. It is severely grazed, so no tall wetland vegetation is visible, but it is green in an otherwise dry landscape. The telltale pale grey groundwater discharge deposits indicate a spring seep of great age. This spring is not identified by USGS. A 2010 ground survey of this ciénega found a small wet area of spikerush (lower left) below a meadow of alkali muhly, Baltic rush and alkali sacaton. Despite its small size, there are several other ciénega indicator plant species at this location (Sivinski and Tonne 2011).

Lobo Ciénega (Figure 27) is also not identified as a spring by USGS but is mapped as a wetland. It is an apparent helocrene ciénega with diffuse areas of discharge. The green meadow stands out from the adjacent arid landscape, but in this case the pale calcareous groundwater discharge deposits are not so obvious at the ciénega. Many of the numerous trees appear to have been purposely planted – especially near the building.

Figure 27. Lobo Ciénega, Grant Co., 32.9543 -108.6395

Figure 28. Macho Ciénega, Lincoln Co., 33.7085 -105.4034

Macho Ciénega (Figure 28) is a spring pool surrounded by several other points of discharge and ciénega across a broad valley. The lower spring (upper left) has been captured into a channel likely damaging the nearby ciénega. The upper springs (lower right) are intact and appear well-managed with a livestock exclusion fence around the spring pool and a pasture fence around most of the ciénega.

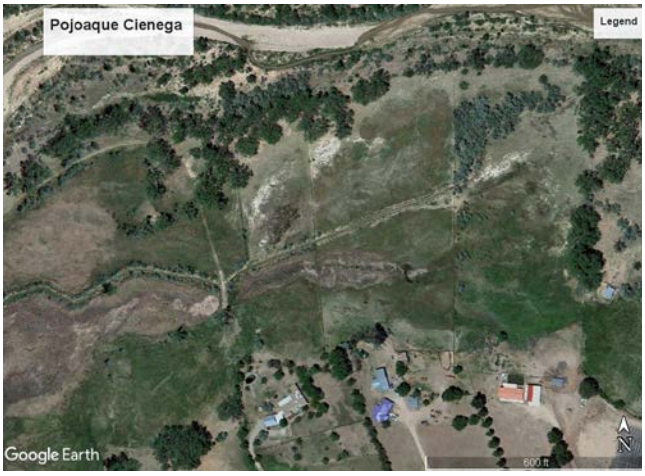

Figure 29. Pojoaque Ciénega, Santa Fe Co., 35.8964 -106.0314

The upper part of Pojoaque Ciénega (Figure 29) shows the buildings and fences of multiple private owners. A drain channel has been cut through the entire ciénega in an attempt to dry the surface. This may be the reason some pale groundwater discharge deposits are showing through the vegetation at the margins. Most of these landowners are removing weed trees except for the bluish patch of Russian olives in the upper right.

When ciénegas are found with aerial imagery or ground surveys, their coordinates and any additional information should be made available to land managers and researchers in a public natural resources database that can updated as new information accumulates.

Rapid Assessment Method for Springs and Conservation Ranking

The Surface Water Quality Bureau of the New Mexico Environment Department is developing methods for condition assessment of wetlands in New Mexico. The SWQB is currently modifying and adapting their rapid assessment method (NMRAM) to accurately measure the condition of springs ecosystems in New Mexico. This NMRAM methodology is being developed at spring sites in southwestern New Mexico in 2018 and 2019 and should be applicable to arid-land spring ciénegas throughout the state. The resulting NMRAM Field Guide for Springs Ecosystems will be available on line at https://www.env.nm.gov/surface-water-quality/wetlands-rapid-assessment-methods/.

This methodology will be transferred to agencies, stakeholders and other states through workshops, meetings of the New Mexico Wetlands Roundtables, training sessions, and presentations at other venues. The New Mexico Environment Department Surface Water Quality Information Database (SQUID), will be updated to accept new data for spring wetlands.

Developing an assessment methodology to determine the condition of springs will assist NMED in prioritizing wetlands in need of restoration, help identify stressors that are causing degradation of wetlands, and will help development of methods for protecting spring ciénegas in particular. In the meantime, each arid-land spring ciénega thus far located has been given a conservation rank that reflects the perceived feasibility for its restoration and preservation (Figure 31). A conservation rank of 1 is for functional ciénegas or restorable ciénegas that are large and occupied by sensitive or endangered species. A conservation rank of 2 applies to most restorable ciénegas. Severely damaged ciénegas that retain some small remnant are given a

conservation rank of 3. Dead ciénegas or those that are hopelessly damaged have a conservation rank of 4. Most of the ciénegas identified in the Appendix of this plan have not been visited and are ranked by aerial assessment. Rankings can be easily changed when these ciénegas have future NMRAM assessments or better up-to-date aerial imagery.

Education and Outreach

The initial inventory of New Mexico arid-land spring ciénegas (Appendix) was completed in the summer of 2018. Many county tax assessors make their landowner contact information available on the Internet and those that do not were sometimes responsive to email inquiries. Mailing addresses for most landowners with functional or restorable ciénegas were obtained and each mailed a brochure describing the importance of ciénegas and inviting them to a stakeholders' workshop on the development of an Arid-land Spring Ciénega Wetlands Action Plan. The SWQB list of cooperators was used to email the same brochure to agency and organization stakeholders.

Two ciénega workshops were conducted for stakeholders – one at Blue Hole Ciénega Nature Preserve in Santa Rosa and another at Leonora Curtin Wetland Preserve in La Ciénega (Figure 30). Program managers for agencies that assist wetland landowners were present to describe their programs and application processes. Then the participants toured the nature preserves to view and discuss ciénega characteristics and management challenges.

Figure 30. 2018 ciénega workshops at Santa Rosa (left) and La Ciénega (right).

Workshop participants will have access to the final Arid-land Spring Ciénega WAP and the summary of the plan will be presented at a 2019 SWQB Wetlands Roundtable meeting. Once completed, this Plan will be available through the SWQB Wetlands Program web page https://www.env.nm.gov/surface-water-quality/wap/. An Excel spreadsheet of arid-land spring ciénegas will also be available upon request.

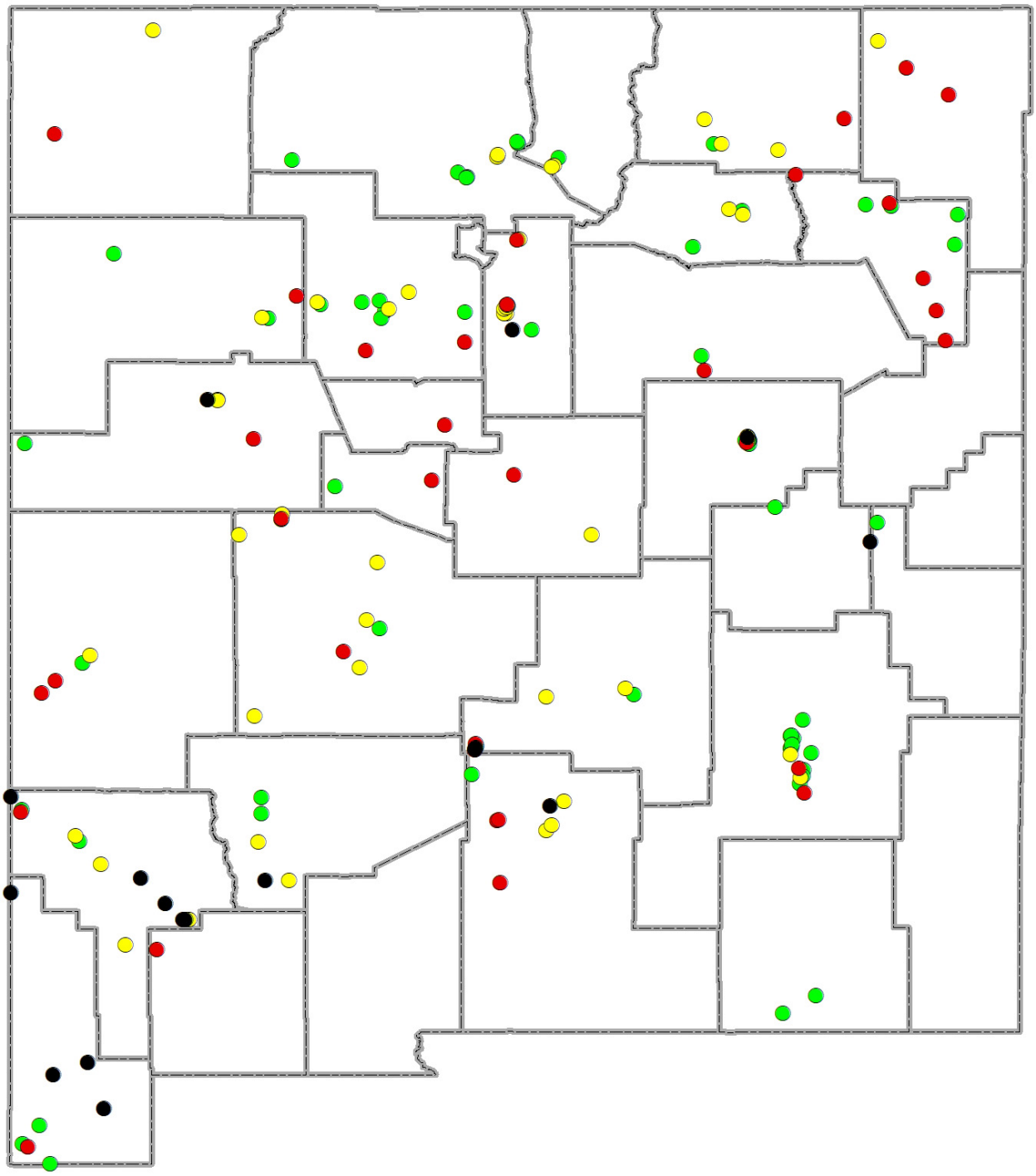

Figure 31. Conservation ranks for New Mexico ciénegas. Green = 1 (functional ciénegas or restorable ciénegas that are large or occupied by sensitive species); Yellow = 2 (restorable ciénegas); Red = 3 (severely damaged ciénegas); Black = 4 (Dead and hopelessly damaged ciénegas).

CIÉNEGA RESTORATION AND CONSERVATION PROGRAMS

No government agency or non-governmental organization has a program yet specifically for the conservation of arid-land spring ciénegas. Ciénega owners must look to partners and assistance programs for natural resources, springs, or wetlands in general.

Springs Stewardship Institute (SSI) is a non-profit at the Museum of Northern Arizona that is committed to advancing research and stewardship of springs ecosystems throughout the world. This organization has contracted spring assessment and restoration work for various tribal, state and federal agencies. The SSI team has expertise in hydrogeology, water quality, ecological assessment and restoration, biological inventory (including aquatic invertebrates), monitoring, and data management. SSI is presently partnering with SWQB to develop a Rapid Assessment Methodology for Springs Ecosystems in New Mexico.

University of New Mexico – Natural Heritage New Mexico (NHNM) is a branch of the UNM Museum of Southwestern Biology and is available to state and federal agencies for ecological assessment, biological inventory (including aquatic invertebrates), monitoring, and data management. The NHNM team has extensive experience with riparian and wetland assessment and assists SWQB in implementing its Rapid Assessment Methodology for Wetlands. NHNM has made spring surveys for Bureau of Land Management in New Mexico (Milford et al. 2001a and 2001b).

Quivira Coalition is a non-profit dedicated to fostering ecological, economic, and social health on working landscapes through education, innovation, and collaboration. Quivira's partnership with SWQB and Zeedyk Ecological Consulting, LLC produced a definitive guide to the restoration and management of "slope wetlands" (after Brinson, 1993) (Zeedyk et al. 2014). Many arid-land spring ciénegas are slope wetlands and the restoration practices illustrated with wet mountain meadows in this guide can also be applied to lower elevation arid-land spring ciénegas.

Institute for Applied Ecology (IAE) is a non-profit that assists agencies and landowners with ecological restoration planning and projects, including wetlands. IAE specializes in collaborations for planning and project management, especially for weed control and developing sources for local native plant seeds used in reclamation.

The Nature Conservancy (TNC) is a non-profit that has become a champion of regional or landscape-scale land and water conservation initiatives. TNC is especially effective in assembling partnerships and funding opportunities for habitat acquisition, protection and restoration.

Native Plant Society of New Mexico is a non-profit that strives to educate the public about native plants by promoting knowledge of plant identification, ecology, and fostering plant conservation and the preservation of natural habitats.

Carter Conservation Fund assists communities and educators with grants up to $1,500 for native plant education and conservation projects.

New Mexico Forestry Division of the Energy, Minerals and Natural Resources Department has several programs that can potentially assist private and government landowners with arid-land spring ciénegas.

Invasive Plant Management in Forested Areas: This is an annual US Forest Service grant to the State of New Mexico to control noxious weeds in forested areas. Ciénega owners can apply for weed control assistance if there are at least some native trees (cottonwoods or tree willows) in, or adjacent to, their ciénega. These funds must be granted to the local Cooperative Weed Management Area (CWMA) or Soil and Water Conservation District (SWCD) so a collaborative effort is required. For instance, the weed tree management grant application and planning for the Leonora Curtin Wetland Preserve was managed by IAE and the funds granted to, and managed by, the Santa Fe-Pojoaque SWCD. There is a 50% project cost-matching requirement of supplies or services for this grant.

Inmate Work Camp: Governmental ciénega owners can use NM Forestry crews of minimum security inmates from the Los Lunas Correctional Facility who are trained as fire fighters, sawyers and herbicide applicators for forest restoration projects including removal and prescribed burning of weed trees such as saltcedar and Russian olive. These inmate crews are employed for projects on local, state and federal jurisdictions, but are not available to private landowners.

Land Conservation Incentives Act: Charitable donations of land, or an interest in land (conservation easement), to public or private conservation agencies for conservation purposes are eligible for a state tax credit through the New Mexico Land Conservation Incentives Act. The maximum tax credit is 50% of the appraised value of the donation and a maximum of $250,000 per individual donor. A taxpayer has a maximum of 20 years to fully use the tax credit or the tax credit may be transferred (sold) to another taxpayer through a tax credit broker in minimum increments of $10,000.

Seedling Program: Forestry Division provides seedlings of native riparian woody plants to landowners for restoration projects. Planting woody species in or near a ciénega can enhance species diversity, but must be used very strategically and sparingly. Woody plants may be temporarily needed to help aggrade erosion channels in damaged ciénegas, but are not prominent in natural ciénegas and will compete with herbaceous vegetation for space, light and groundwater. DO NOT plant and maintain a woodland to restore a ciénega.

New Mexico Department of Game and Fish

Share with Wildlife Program: Provides grants for biological research projects and for public education on wildlife and habitat issues.

New Mexico Soil and Water Conservation Districts SWCDs are independent subdivisions of state government that coordinate assistance from all available sources (public and private, local, state and federal) in an effort to develop locally driven solutions to natural resource concerns.

Natural Resources Conservation Service (NRCS) has several programs that can assist private landowners with arid-land spring ciénegas.

Environmental Quality Incentives Program: EQIP is a voluntary program that provides technical and financial assistance to agricultural producers and forest landowners who want to improve and protect the condition of soil, water, air, plants and animals. EQIP is a highly successful program that provides financial and technical assistance to implement structural (fences, erosion control, etc.) and conservation practices that address natural resource concerns. The costs for these practices change every year and are shared by the landowner and NRCS. The payment schedule is calculated using a regional average of the typical cost. Low-income participants can receive up to 90% of the estimated cost and historically underserved participants can receive up to 75%. Landowner requests are awarded based on a ranking process and availability of funds.

Conservation Stewardship Program: CSP is a multi-year program that offers annual incentive payments to agricultural producers and forest owners for installing conservation plans and activities that provide wildlife habitat, pollinator habitat, or restore rare and declining habitats (ciénegas).

Wetlands Reserve Program: This program has been used to offer a permanent conservation easement or a 30-year easement or contract, and a restoration cost-share agreement. Now, however, only former or degraded wetlands are eligible for this easement and restoration program. For example, if the hydrology has been significantly degraded or modified due to long-term grazing or agricultural practices such as diversions, dams, ditches or other water management infrastructure, and the hydrology and vegetative structure can be restored by the implementation of a Wetland Reserve Plan of Operation, then the site is eligible for conservation easement and restoration. Depending on the enrollment option, NRCS may pay 75 to 100 percent of the easement and restoration costs. Easement compensation is based on the fair market value, a geographic area rate cap, or landowner offer. Landowners pay taxes on the property, retain title to the land and thus, the right to control access and recreational use.

US Fish and Wildlife Service

Partners for Fish and Wildlife Program is a voluntary program that provides technical and financial assistance to non-federal landowners to restore and improve fish and wildlife habitats for federal trust species (e.g., threatened, endangered, and candidate species, migratory birds, and other declining species) by fencing sensitive areas, removing invasive plants and planting native plants. Landowners generally provide 25 percent or more of the cost-share funding and/or in-kind services (labor, maintenance, and materials). All arid-land spring ciénegas are used by migratory birds so there is always an incentive for the Partners Program to assist ciénega owners, even when threatened or endangered species are not present.

CIÉNEGA ACTION PLAN STRATEGY

There are currently many gaps in our knowledge of arid-land spring ciénegas in New Mexico – especially where they all are, their landowners, their conditions, special conservation values such as rare or endemic species and educational opportunities, and ecological services of habitats and carbon sinks. Arid-land spring ciénegas are scattered throughout state in a variety of jurisdictions and ownerships, which makes it especially challenging to unify behind a

common concern for these rare and vanishing ecosystems and adopt a plan for their protection and recovery. The following are the needs and aspects central to a call for action.

Additional Inventory

The inventory research for this WAP tripled the number of arid-land spring ciénegas for New Mexico. Although significant time and effort was put into searching aerial imagery for arid-land spring ciénegas, New Mexico is the fifth largest state and there are certainly more of these small wet meadows to be found – perhaps an additional 25% more. More people need to take up the search of aerial imagery for ciénegas.

Currently the SWQB Wetlands Program is updating the National Wetlands Inventory (https://www.fws.gov/wetlands/Data/Mapper.html) for New Mexico, excluding tribal lands. Wetlands are being mapped at 1:12,000 with a minimum mapping resolution of at least one-half acre, in compliance with the National Wetlands Mapping Standard. Several classifications are being applied to these mapped wetlands including the "Hydrogeomorphic Classification" of Brinson (1993) which can be found at (https://www.env.nm.gov/surface-water-quality/wetlands/). Using the Hydrogeomorphic Classification, a subclass of wetlands termed "slope wetlands" is applied to groundwater or spring-dependent wetland mapped features throughout New Mexico. Many of these slope wetlands occurring below 2,000 m (6,562 ft) ABS may be arid-land spring ciénegas. Additional review and ground-truthing of these mapped features will likely identify and confirm more arid-land spring ciénegas in New Mexico.

State and federal land managers should be aware of all the wetland features within their jurisdictions and can justify the time spent to identify them. Academic or conservation-minded volunteers can also take up the search of aerial imagery for arid-land spring ciénegas with publicly available imagery of the Earth's surface that has no boundaries.

There should, however, be a central authority for confirming the identity of arid-land spring ciénegas to avoid the inclusion of other kinds of wetlands. This should be the responsibility of data managers who keep track of such an inventory. There are currently three choices for managing the data generated by an inventory of arid-land spring ciénegas. Since all ciénegas are groundwater discharges, the Springs Stewardship Institute (SSI) would like to manage all spring related information on their Springs and Springs-Dependent Species Online Database. And since all arid-land spring ciénegas are rare ecosystems, Natural Heritage New Mexico (NMNH) at UNM Museum of Southwestern Biology would also like to keep a New Mexico ciénega inventory in its research database. Finally, the Aridland Ciénegas of Western North America Google-based fusion table is just beginning to take shape as a more interactive database for field biologists and conservationists. NMNH would be an obvious choice for storing New Mexico ciénega information, but would need to develop search capabilities for these ecological sites. SSI is an appropriate central point for coordination of multiple states in the inventory and management of arid-land spring ciénegas across the American Southwest.

Impressions of Trespass

The majority of arid-land spring ciénegas are on private property, some are on tribal lands, and several are in the public domain of city, state and federal land management agencies. All landowners, land managers, and indigenous occupiers of the lands have deep and recognizable relationships with their lands, cultures, or jurisdictions. Private landowners who readily allow access to strangers to obtain information about their property and land use are very rare and most have an impression of trespass upon their interests. This makes the gathering of information on ciénegas even more difficult. Approaching ciénega landowners and managers for access is most successful when initiated by non-governmental organizations in a spirit of concern and cooperation. Reluctant landowners should also be educated, whenever possible, that owning an endangered ecosystem, even one with endangered species, is unlikely to curtail their land use and may have the benefit of attracting government and NGO funding for restorative land management. For instance, the flow of federal and state funding for Russian olive removal on several City-owned and private ciénegas in Santa Rosa is mostly the result of being included within the critical habitat of the federally threatened Pecos sunflower. Likewise, the willingness of the Pitchfork Ranch to host reintroduced populations of the endangered Gila topminnow and Chiricahua leopard frog greatly enhanced the landowner's applications for assistance in restoring Burro Ciénaga and its immediate watershed.

To further a respect for ownership interests on private and tribal lands, any arid-land spring ciénega information obtained and recorded should be given the level of sensitivity requested by the landowner. Even those who wish to visit an arid-land spring ciénega at a wildlife management area or nature preserve should request permission and be mindful of any rules or restrictions for entering those lands.

Research and Monitoring

Figure 32. Constructing a groundwater monitoring piezometer at Blue Hole Ciénega in Santa Rosa.

There is a substantial deficiency of information and data on the ecology, abundance and distribution of the many plant and animal species that rely on arid-land spring ciénegas. Biological inventories require the expertise of trained biologists such as those at academic institutions and employed by land management agencies. Not nearly enough funding has been directed to biological sampling and taxonomic assessments of desert wetlands in general and arid-land spring ciénegas in particular. Arid-land spring ciénegas are biologically important because they are so rare and are habitats for many unique and endemic species. We know this from previous biological discoveries, however, less than half of arid-land spring ciénegas have been assessed by a botanist and probably less than one-tenth have been sampled for macroinvertebrate diversity. Renewed interest in biological surveys of arid-land

spring ciénegas by university museums, US Fish and Wildlife Service, NM Department of Game and Fish, non-profit conservation organizations and others, is crucial before more of these unique wetland habitats and their unique wildlife and plants are lost. Species diversity and rarity, and pervasiveness of non-native species will be considered in the process of ranking arid-land spring ciénegas for restoration and protection. Some of the sampling for these data can be done in the NMRAM process, but will require supplemental expertise for identifying species.

Additional research is also needed for hydrological processes, water quality and water chemistry and their influence on ecological processes at arid-land spring ciénegas. Monitoring of the effects of groundwater fluctuations on native and non-native vegetation will provide useful insight into the impacts of future aridification as the climate changes. Impacts from groundwater pumping from local aquifers and potential ground and surface water contamination are also important areas needing more attention. Studies and long-term monitoring on weed control, ciénega species reintroductions, frequency of prescribed burns, various intensities of livestock grazing, and other land use and land management activities will also be useful for arid-land spring ciénega restoration and management plans. Restoration actions would also benefit from developing and identifying sources of plant materials for reclaiming damaged ciénegas, including seeds, cuttings, and container plants of both common and rare species.

NMRAM and Conservation Ranking

The NM Rapid Assessment Method for Springs Ecosystems is currently being developed and tested at springs in southwestern New Mexico. This will be a valuable tool to easily assess spring wetland health and restoration needs. SWQB will make this method available through the Wetlands Roundtable, training workshops and on the SWQB website at https://www.env.nm.gov/surface-water-quality/wetlands-rapid-assessment-methods/.

Information accrued using NMRAM for Spring Ecosystems for assessing arid-land spring ciénegas will assist the SWQB Wetlands Program not only in prioritizing sites for restoration and targeting restoration needs, but also selecting sites for conservation and protection. Other criteria for conservation ranking have been applied to arid-land springs ciénegas and several arid-land spring ciénegas have risen to conservation prominence. For instance, the arid-land spring ciénegas of the Roswell artesian basin are collectively designated a Ramsar Wetland (officially known as the “Roswell Artesian Wetlands”) (https://www.ramsar.org/wetland/united-states-of-america) because of their number, size, species diversity, and concentration of endangered species. Some springs and spring brooks at Bitter Lake NWR have up to eight species of federal and state endangered plants and animals at each location. This is truly a world class concentration of arid-land spring ciénegas that need monitoring and careful management. Other spring ciénegas with critical habitat for endangered species will also be priorities for conservation and restoration activities.

Protection and Restoration

Arid-land spring ciénegas are scattered across New Mexico in various ownerships and jurisdictions. Ideally, each arid-land spring ciénega owner will adopt an attitude and goal to

preserve important ecological functions and any unique ciénega species that may be present. The general public and regulatory agencies can participate whenever there is an opportunity in land use planning or environmental regulation. The Center for Watershed Protection (2005) recommends tools for protecting wetlands resources that are applicable to arid-land spring ciénegas. Table 4 lists some of these tools and how they are applied.

Table 4. Tools and applications for protecting arid-land spring ciénegas in urban and rural settings (adapted in part from Center for Watershed Protection, 2005).

TOOL	APPLICATION
Land Use Planning	• Identify all spring-fed and groundwater seep wetlands in land use plans and prescribe sustainable uses. • Maintain adequate flow to spring-fed wetlands in planning or permitting points of diversion for water rights. • Adopt a local wetland protection ordinance. • Adopt a wetland buffer ordinance. • Include wetland buffers in post-construction storm water management ordinances. • Exchange storm water credits for wetland/wildlife corridors. • Manage and reduce groundwater pumping and groundwater usage that affect local springs and seeps. • Minimize damaging recreational uses of wetlands.
Land Conservation	• Purchase land for conservation use. • Apply conservation easements. • Structure mitigation requirements to restore and preserve. • Protect springs and spring recharge areas. • Develop conservation incentive programs for agricultural uses.
Buffer Zones	• Include natural vegetated buffer requirements around arid-land spring ciénegas. • Use wetland buffers to connect wetlands with other habitats. • Develop arid-land springs and arid-land spring ciénega buffer zones. • Use wetland functional boundaries to define buffer widths.
Development Site Design	• Discourage land use designs that cross wetlands and buffers. • Discourage roads and trails that cause gullies or cross wetlands and buffers. • Discourage land use that fragments wetlands and buffers. • Discourage land use that interferes with wildlife corridors that link wetlands. • Provide more distributed storm water management. • Restrict discharges of untreated storm water to ciénegas. • Prevent development practices that will increase erosion and sedimentation in wetlands.

Agricultural Practices	• Discourage overgrazing or over utilization of wetlands. • Discourage plowing and planting in natural wetlands. • Use barrier fences across drainages approaching springs to prevent gully formation in livestock and wildlife trails. • Create pasture fences around arid-land spring ciénegas to control timing and intensity of livestock use. • Remove non-native plant species, replant with a diversity of local native species. • Discourage draining and hydrologic alterations of arid-land spring ciénegas. • Discourage excavation of open-water ponds in arid-land spring ciénegas. • Discourage excessive nutrient discharges to wetlands. • Improve natural hydrology with restoration techniques. • Create natural undisturbed buffers between farmed or grazed lands and wetlands. • Leave wetland areas natural and open to wildlife use and connected to uplands and wildlife corridors.
Forestry Practices	• Use prescribed fire to restore arid-land spring ciénegas that become overgrown with herbaceous vegetation. • Prevent the use of fire retardants in wetlands. • Prevent erosion and damage to wetlands from forest thinning practices.
Watershed Stewardship	• Incorporate arid-land spring ciénegas (when present) into all watershed planning. • Post signs to identify wetlands and buffer zones. • Develop Adopt-a-Wetland program that includes natural springs. • Establish partnerships for ciénega protection and restoration. • Encourage wetland landowner stewardship. • Provide input to state and federal permitting programs.

Figure 33. Russian olive removal from the ciénega at Leonora Curtin Wetland Preserve in La Ciénega.

Almost all arid-land spring ciénegas in New Mexico are damaged to some degree by land and water use. Some are so severely damaged they cannot be reclaimed, but those that retain some water and ecological function should be restored. A common impact is infestation of non-native plant – especially weed trees, which can convert an open wet meadow into a tree-covered forest. There are various methods for exotic tree removal (Parker et al. 2005), but landowners and funding agencies must be

aware that all successful methods require the use of herbicides and multiple years of treatment. Tree removal will also result in a great amount of wood on the ground which must be burned, masticated/chipped, or hauled away as firewood. Financial responsibility is ultimately with the landowner, but there are several funding agencies that may share the cost (see Possible Funding Sources).

Many arid-land ciénegas have also been damaged by spring capture and diversion to livestock troughs and diversion channels to ponds and stock tanks. These may only be remedied by reconfiguring diversion to allow natural flow through the ciénega before the water is captured and transported away. Agencies that assist landowners in wildlife habitat restoration are a source of design expertise and a potential source of funding. Erosion of deep gullies and arroyos have also destroyed or diminished many arid-land ciénegas by dropping the level of the underlying aquifer. Methods to control this type of erosion are described by Zeedyk et al. (2014) and have been effective in attracting state and federal funding and volunteer participation from various NGOs (see Partnerships).

Figure 34. Prescibed burn at Blue Hole Ciénega in Santa Rosa.

Arid-land spring ciénegas damaged by livestock or feral horse and burro use may only need some strategic placement of pasture and drift fences to control timing/duration of grazing and trail erosion to effectively restore ecological function. Potential partners for fencing projects include the NRCS and wildlife management agencies. Arid-land spring ciénegas in parks, nature preserves and wildlife refuges that do not allow livestock grazing may become overgrown with dead vegetation that can only be removed by a prescribed fire or wildfire. Prescribed burn plans must be approved by local fire departments, NM Environment Department, and can be greatly assisted by professional fire fighters at land management agencies or the EMNRD-Forestry Division (for private landowners).

<u>Education and Outreach</u>

Public education and outreach will continue to be effective in conveying the importance of desert wetlands, but need to be expanded to the media and other venues. Agency web sites and media should highlight their arid-land springs and ciénega plants and animals – especially in places the public is allowed to access. Additional public field trips and nature walks to some less-visited privately owned ciénegas should be scheduled and publicized so local ciénega owners can participate and share something special that they take pride in owning and managing. All ciénega-owning land management agencies and nature conservation NGOs need to incorporate the word “ciénega” into their ecological concept vocabulary and conservation goals.

Leonora Curtin Wetland Preserve receives more than 8,000 visitors per year and many of these are school children and youth groups. The Santa Fe Botanical Garden sponsors this venue and educates the public on what a ciénega wetland actually is, since it is within the community of La Ciénega. Santa Rosa is also a community of ciénegas with easy access to City-owned ciénegas and the Blue Hole Ciénega Nature Preserve, which are adjacent to its swimming parks and convention center. Ciénega signage and interpretive displays would be seen by the many visitors and local people who use these recreational venues. The City of Santa Rosa could also construct a nature trail through an easily accessible ciénega to facilitate public nature tours and outdoor natural history classrooms for school children.

Bitter Lake NWR makes great strides in public education with numerous events such as its Dragonfly Festival and monthly endangered species tours, but makes little or no mention of its extensive arid-land spring ciénegas as a rare and unique type of wetland. Additional interpretation (on website and tours) of the ecological concept of "ciénega" should be a unifying focus for this very important and world-class ciénega wetland. The nearby Bottomless Lakes State Park also makes no mention of its "ciénega" at the Lea Lake outflow even though it has made great effort to construct an elevated boardwalk across it. Perhaps offering t-shirts or bumper stickers at the Visitors Center with "I have a sinkhole feeling I'm in a ciénega" will prompt the question "What's a ciénega?" and provide an opportunity for public education. Finally, the Ramsar Wetland designation of Bitter Lake and Bottomless Lakes as a globally important wetland should be modified to acknowledge its extensive arid-land spring ciénegas.

NGOs can also educate the public on arid-land spring ciénegas to help conserve these important wetlands. Pitchfork Ranch has made an educational website and video on Aridland Ciénagas describing their settings, threats and restoration efforts at Burro Ciénaga. High Country News featured this ciénega restoration effort (McGaha 2015). The Santa Fe Garden Club has recently made a grant to a videographer to produce a public educational documentary video of the ciénega restoration efforts in Santa Rosa and endangered plant habitat there. A podcast with audio descriptions of these ciénegas would widen the public reach of these educational efforts. Native Plant Society of New Mexico (NPSNM) makes occasional educational field trips to ciénegas and should add new public and privately owned ciénegas to its field trip schedule. NPSNM should undertake a public participation botanical survey of the ciénega at the La Joya Waterfowl Management Area, which is habitat for the endangered Pecos sunflower and should be valued for more than a duck hunting location. Quivira Coalition, Malpai Borderlands Group, and TNC also have a unique opportunity with the ciénegas on the Diamond A Ranch to provide workshops or educational tours to local ranchers and the public for sustainable uses of ciénega wetlands on working ranches.

The semi-annual New Mexico Wetlands Roundtables organized by NMED-SWQB Wetlands Program have a large attendance of hydrologists, wetland ecologists, agency natural resource managers and conservation NGOs. This venue is essential for distributing current news on arid-land spring ciénegas and maintaining professional interest in these rare wetlands.

Partnerships

Arid-land spring ciénega management and restoration projects can require the expertise of biologists, hydrologists, grant writers, project planners, fiscal agents, government program managers and a variety of contractors and vendors (for materials, construction, weed control, etc.). Ciénega owners may be able to provide all the necessary labor and project management for small projects, but most large successful conservation projects are partnerships of several entities – often to satisfy conditions of the funding agency. Partnerships for wetland conservation and restoration often greatly benefit from NGOs, such as TNC, IAE, Quivira Coalition, NM Wildlife Federation and others because of their grant writing and management expertise and their ability to mobilize volunteers who not only supply labor, but also the financial match that is required by most government grants.

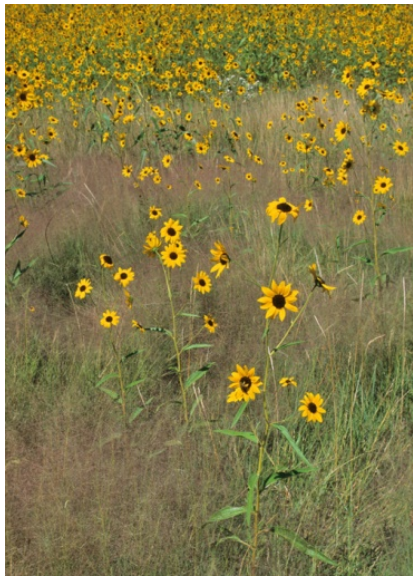

Figure 35. Pecos sunflower and alkali muhly at Blue Hole Ciénega.

Weed tree control projects at ciénegas infested with Russian olive or saltcedar have been especially useful in fostering ciénega restoration goals with landowners, government funding agencies and non-profit volunteers. For example, the watershed restoration project funded by US Fish and Wildlife Service, New Mexico Water Trust Board, USDA Forest Service and NRCS is a regional treatment for weed tree removal (mostly Russian olive) in the Santa Rosa artesian basin, which involves an extensive collaboration of local, state and federal actors. Planning and execution of this wide-ranging project is utilizing the expertise of EMNRD-Forestry Division (Las Vegas District, Rare and Endangered Plant Program, Inmate Work Camp), NRCS (EQIP), and the Guadalupe Soil and Water Conservation District. Numerous private landowners are participating and assisting with this restoration effort, as is the City of Santa Rosa on its municipal wetlands. It has, thus far, resulted in the removal of weed trees from hundreds of acres of wetlands (mostly ciénegas), a prescribed burn of the Blue Hole Ciénega critical habitat for the endangered Pecos sunflower, a conservation easement on additional City-owned Pecos sunflower habitat, and a new appreciation for wetland conservation by all participating landowners and the local community. Extensive partnerships like this are especially effective in areas with numerous ciénegas and at ciénegas with multiple kinds of landowners.

POSSIBLE FUNDING SOURCES

U.S. Environmental Protection Agency (EPA) and National Fish and Wildlife Foundation

- Five-Star Wetlands Restoration Grants

https://www.epa.gov/wetlands/5-star-wetland-and-urban-waters-restoration-grants

U.S. Fish and Wildlife Service

• Partners for Fish and Wildlife Program in New Mexico
https://www.fws.gov/southwest/es/NewMexico/PFW_home.cfm
• North American Wetlands Conservation Act (NAWCA)
https://www.fws.gov/birds/grants/north-american-wetland-conservation-act.php
• The Landowner Incentive Program
https://wsfrprograms.fws.gov/Subpages/GrantPrograms/LIP/LIP.htm

Natural Resources Conservation Service (NRCS)
• Environmental Quality Incentives Program
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/
• Conservation Reserve Program; https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index
• Conservation Innovation Grants;
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/cig/
• Wetlands Reserve Program
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/wetlands/

National Fish and Wildlife Foundation (NFWF) and NRCS
• Conservation Partners Program
https://www.nfwf.org/conservationpartners/Pages/home.aspx

New Mexico Department of Game and Fish (NMDGF)
• Share with Wildlife Program
http://www.wildlife.state.nm.us/conservation/share-with-wildlife/

New Mexico Forestry Division (EMNRD-Forestry)
• Invasive Plant Management in Forested Areas
http://www.emnrd.state.nm.us/SFD/contact.html

New Mexico Water Trust Board
• Watershed Restoration and Management
https://www.nmfa.net/financing/water-programs/water-project-fund/

New Mexico Soil and Water Conservation Districts
http://www.nmda.nmsu.edu/apr/soil-and-water-conservation-districts/

Native Plant Society of New Mexico
• Carter Conservation Fund; https://www.npsnm.org/nps-sponsored-grants-donations/

REFERENCES CITED

Aridland Ciénegas of Western North America. Inventory at: https://fusiontables.google.com/DataSource?docid=1n9Z5nJ7BXY0TLBbGjFYzFcRooMWCWK_AQDQVAV24#map:id=3

Bartlett, J.R. 1854. Personal narrative of explorations and incidents in Texas, New Mexico, California, Sonora, and Chihuahua, connected with the United States and Mexican Boundary Commission during the years 1850, '51, '52, and '53, Volume 1. D. Appleton and Co., NY.

Brune, G. 1981. Springs of Texas. Vol. 1. Branch-Smith, Inc., Fort Worth, TX. 566 p.

Cappiella, K., Schueler, T., Tasillo, J., Wright, T. 2oo5.Wetlands and Watershed Article Series. Article 3: Adapting Watershed Tools to Protect Wetlands. Center for Watershed Protection, Ellicott City, MD.

Cole, A.T. and C. Cole. 2015. An overview of aridland ciénagas, with proposals for their classification, restoration, and preservation. In: Proceedings of the Fourth "Natural History of the Gila" Symposium. The New Mexico Botanist, Special Issue No. 4: Avaliable: https://floraneomexicana.org/the-new-mexico-botanist-newsletter

Cowardin L.M., V. Carter, F.C. Golet, E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States (U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.; Northern Prairie Wildlife Research Center Online, Jamestown, ND), Version 04DEC1998. Available: https://www.fws.gov/wetlands/Documents/classwet/index.html

Davis, D.R. and S.J. Joseph. 1998. Water quality assessments for selected New Mexico lakes. New Mexico Environment Department, Surface Water Quality Bureau. Available https://www.env.nm.gov/swqb/documents/swqbdocs/MAS/Surveys/Lakes-1998.pdf Daily spring flow of about 2,500,000 gallons

Dinerstein, E., D. Olson, J. Atchley, C. Loucks, S. Contreras-Balderas, R. Abell, E. Iñigo, E. Enkerlin, C. Williams, and G. Castilleja. 2000. Ecoregion-based conservation in the Chihuahuan Desert: A biological assessment. World Wildlife Fund.

Doty, G.C. 1960. Reconnaissance of ground water Playas Valley, Hidalgo County, New Mexico. Technical Report 15. New Mexico State Engineer, Santa Fe, NM.

EMNRD- Forestry Division. 2017. New Mexico Rare Plant Conservation Strategy. Prepared and developed by Daniela Roth and the New Mexico Rare Plant Conservation Strategy Partnership. Santa Fe, NM. Available: http://www.emnrd.state.nm.us/SFD/ForestMgt/Endangered.html

Gervasio, V., D.J. Berg, B.K. Lang, N.L. Allan and S.I. Guttman. 2004. Genetic diversity in the *Gammarus pecos* species complex: Implications for conservation and regional biogeography in the Chihuahuan Desert. American Society of Limnology and Oceanography 49(2), 2004, 520–531.

Haynes, C.V. 2008. Quaternary cauldron springs as paleoecological archives. In: L.E. Stevens and V.J. Meretsky (eds.) Aridland springs in North America: ecology and conservation. The University of Arizona Press and The Arizona-Sonora Desert Museum, Tucson. p. 76-97.

Hendrickson, D.A. and W.L. Minckley. 1985. Ciénegas – Vanishing climax communities of the American Southwest. Desert Plants 6(3): 131-175.

Hershler, R., H. Liu, and J. Howard. 2014. Springsnails: A new conservation focus in western North America. BioScience 64: 693–700.

Hillard, **P.D.** 1969. Geology and beryllium mineralization near Apache Warm Springs, Socorro County, New Mexico. New Mexico Bureau of Mines and Mineral Resources Circular 103.

Johnson, P.S., D.J. Koning, S.S. Timmons, and B. Felix. 2016. Geology and hydrology of groundwater-fed springs and wetlands at La Cienega, Santa Fe County, New Mexico: New Mexico Bureau of Geology and Mineral Resources Bulletin 161, 92p.

Julyan, R. 1996. The place names of New Mexico. University of New Mexico Press, Albuquerque.

Kodric-Brown, A. and J.H. Brown. 2007. Native fishes, exotic mammals, and the conservation of desert springs. Frontiers in Ecology and the Environment 5(10): 549-553. Available: https://biology.unm.edu/kodric/Pubs/Kodric-Brown&Brown2007FEcoEnv.pdf

Land, L. and G.F. Huff. 2010. Multi-tracer investigation of groundwater residence time in a karstic aquifer: Bitter Lakes National Wildlife Refuge, New Mexico, USA: New Mexico Bureau of Geology and Mineral Resources Open-File Report no. 521.

LeJeune, C. 2018. Blue Hole Cienega Nature Preserve, Santa Rosa, New Mexico: Groundwater monitoring project, final report FY 2016-2017. Unpublished report to New Mexico Forestry Division. Available: http://www.emnrd.state.nm.us/SFD/ForestMgt/documents/S6_HELPAR.31b.pdf

MacRae, R.K., J.D. Lusk and W.R. Radke. 2001. Investigation of the role of environmental contaminants upon ecological sentinel species and their habitats at Bitter Lake National Wildlife Refuge, New Mexico. US Fish and Wildlife, Region 2, Project ID#2N27 6920001A.

McGaha, A. 2015. The story behind a saved ciénega in New Mexico. High Country News, Dec 21.

McGraw, M.M. and Jansens, J.W. eds. 2012. Exploring springs and wetlands and their relationship with surface flows, geology, and groundwater in the La Cienega area Santa Fe County, New Mexico. Wetlands Program Project Report, New Mexico Environment Department, Surface Water Quality Bureau, 125 pp. Available: https://www.env.nm.gov/swqb/documents/swqbdocs/WPS/Wetlands/LaCienega/LaCienega02-28-2013.pdf

Meffe G.K. 1989. Fish utilization of springs and cienegas in the arid Southwest. In: Freshwater Wetlands and Wildlife Conference, DOE Symposium Series No. 61.

Meyer, E.R. 1973. Late-Quaternary paleoecology of the Cuatro Ciénegas Basin, Coahuila, México. Ecology 54(5): 982-995.

Milford, E., E. Muldavin, Y. Chavin and M. Freehling. 2001a. Spring vegetation and aquatic invertebrate survey 2000. Final Report to Bureau of Land Management, Roswell Field Office. 91 p. Available http://nhnm.unm.edu/.

Milford, E., E. Muldavin, Y. Chavin and M. Freehling. 2001b. Spring vegetation and aquatic invertebrate survey 2000. Final Report to Bureau of Land Management, Albuquerque Field Office. 77 p. Available http://nhnm.unm.edu/.

Miller, R.R., J.D. Williams and J. E. Williams. 1989. Extinctions of North American fishes during the past century. Fisheries 14(6):22-38.

Minckley, T.A. and A. Brunelle. 2007. Paleohydrology and growth of a desert ciénega. Journal of Arid Environments 69: 420-431.

Minckley, T.A., D.S. Turner and S.R. Weinstein. 2013. The relevance of wetland conservation in arid regions: A re-examination of vanishing communities in the American Southwest. Journal of Arid Environments 88:213-221.

Minckley, T.A., A. Brunelle and D. Turner. 2013. Paleoenvironmental framework for understanding the development, stability, and state-changes of ciénegas in the American Deserts. In: Merging science and management in a rapidly changing world: Biodiversity and management of the Madrean Archipelago III; 2012 May 1-5; Tucson, AZ. Proceedings. RMRS-P-67. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

NatureServe Explorer. 2014. North American Warm Desert Cienega. http://explorer.natureserve.org/servlet/NatureServe

New Mexico Department of Game and Fish (NMDGF), Biota Information System of New Mexico (BISON-M) website, http://www.bison-m.org/index.aspx

New Mexico Department of Game and Fish NMDGF). 2005. Recovery and Conservation Plan for Four Invertebrate Species: Noel's Amphipod (*Gammarus desperatus*), Pecos Assiminea (*Assiminea pecos*), Koster's Springsnail (*Juturnia kosteri*), and Roswell Springsnail (*Pyrgulopsis roswellensis*). Santa Fe, NM.

New Mexico Department of Game and Fish (NMDGF). 2017. Comprehensive Wildlife Conservation Strategy for New Mexico. New Mexico Department of Game and Fish. Santa Fe, New Mexico. Available: http://www.wildlife.state.nm.us/download/conservation/swap/New-Mexico-State-Wildlife-Action-Plan-SWAP-Final-2017.pdf

New Mexico Rare Plant Technical Council (NMRPTC). 1999. New Mexico Rare Plants. Albuquerque, NM: New Mexico Rare Plants Home Page. http://nmrareplants.unm.edu (Latest update: 1 January 2018).

New Mexico Department of Game and Fish (NMDGF). 2005. Recovery and conservation plan for four invertebrate species: Noel's amphipod (*Gammarus desperatus*), Pecos assiminea (*Assiminea pecos*), Koster's springsnail (*Juturnia kosteri*) and Roswell springsnail (*Pyrgulopsis roswellensis*). Available http://www.wildlife.state.nm.us/conservation/documents/ChavesCountyRecoveryPlan4Invert.pdf

Parker, D.L., M. Renz, A. Fletcher, F. Miller and J. Gosz. 2005. Strategy for Long-Term Management of Exotic Trees in Riparian Areas for New Mexico's Five River Systems. USDA-Forest Service, Region 3 and EMNBRD-Forestry Division. Available: https://weeds.nmsu.edu/pdfs/Mgmt_of_Exotic_Trees.pdf

Pearce, T.M., I.S. Cassidy, and H.S. Pearce. 1965. New Mexico place names: A geographical dictionary. University of New Mexico Press, Albuquerque.

Peterson, R.S. and I.L. David. 1998. Plants of Bitter Lake National Wildlife Refuge, Chaves County, New Mexico. New Mexico Naturalist's Notes 1(2):1-23.

Rea, A. 2008. Historic and prehistoric ethnobiology of desert springs. In: Aridland springs in North America: Ecology and conservation. L.E. Stevens and V.J. Meretsky eds. University of Arizona Press, Tucson.

Roth, D. 2018. Pecos Sunflower (*Helianthus paradoxus*) 2013 - 2017 monitoring report, Blue Hole Cienega Nature Preserve, Santa Rosa, NM. Unpublished report to U.S. Fish & Wildlife Service, Region 2 Albuquerque, NM. Available: http://www.emnrd.state.nm.us/SFD/ForestMgt/documents/S6-HELPAR.31.pdf

Sivinski R. 2011. *Agalinis calycina* (Leoncita false-foxglove): A Conservation Status Assessment. Unpublished report for NM Energy, Minerals and Natural Resources Department and USDI-Fish & Wildlife Service, Region 2, Albuquerque, NM.

Sivinski, R.C. 2012a. Southwestern ciénegas: Rare habitats for endangered wetland plants. Calochortiana 1:17-24.

Sivinski, R.C. 2012b. *Cirsium wrightii* (Wright's marsh thistle): A 2012 population assessment. Unpublished report prepared for NM EMNRD-Forestry Division, Santa Fe.

Sivinski, R.C. and D. Bleakly. 2004. Vascular plants of some Santa Rosa wetlands, east-central New Mexico. The New Mexico Botanist 29: 1-5. Available: https://floraneomexicana.files.wordpress.com/2014/08/29.pdf

Sivinski, R.C. and P. Tonne. 2011. Survey and Assessment of Aridland Spring Ciénegas in the Southwestern Region. Submitted to NM EMNRD-Forestry Division and USDI-Fish & Wildlife Service, Region 2 Office, Albuquerque. Available: http://www.emnrd.state.nm.us/SFD/ForestMgt/documents/SWCienegaSurvey2.pdf

Schönhuth, S., D.M. Hillis, D.A. Neely, L. Lozano-Vilano, A. Perdices, R.L. Mayden. 2012. Phylogeny, diversity, and species delimitation of the North American round-nosed minnows (Teleostei: *Dionda*), as inferred from mitochondrial and nuclear DNA sequences. Molecular Phylogenetics and Evolution 62:427–446. Available: http://www.lifesci.utexas.edu/faculty/antisense/papers/Dionda2012MPE.pdf

Springer, A.E. and L.E. Stevens. 2009. Spheres of discharge of springs. Hydrogeology Journal 17: 83. https://doi.org/10.1007/s10040-008-0341-y.

Springer, K.B., C.R. Manker and J.S. Pigati. 2015. Dynamic response of desert wetlands to abrupt climate change. PNAS 112(47):14522-14526. Available: http://www.pnas.org/content/112/47/14522

Stein, B.A., L.S. Kutner, J.S. Adams, editors. 2000. Precious Heritage: The Status of Biodiversity in the United States. Oxford University Press, Oxford. http://www.desertfishes.org/cuatroc/index.php

Schwennesen, A.T. 1918. Ground water in the Animas, Playas, Hachita and San Luis basins, New Mexico. USDI-Geological Survey, Water-Supply Paper 422.

Sweeting, M.M. 1972. Karst and solution phenomena in the Santa Rosa Area, New Mexico. In V.C. Kelly and F.D. Trauger, eds. New Mexico Geological Society: Guidebook of East-Central New Mexico. U.S. Geological Society, Denver, CO. p. 168-170.

Taylor D.W. 1987. Fresh-water molluscs from New Mexico and vicinity. New Mexico Bureau of Mines and Mineral Resources Bulletin 116: 1–50.

The Nature Conservancy. 2015. Fresh Water Ecoregions of the World. http://www.feow.org/

Union of Concerned Scientists (UCS). 2016. Confronting climate change in New Mexico. www.ucsusa.org/NewMexicoClimateChange.

Unmack, P.J. and W.L. Minckley. 2008. The demise of desert springs. In: L.E. Stevens and V.J. Meretsky (eds.) Aridland springs in North America: ecology and conservation. The University of Arizona Press and The Arizona-Sonora Desert Museum, Tucson. p. 11-34.
USFWS. 2006. Draft Chiricahua leopard frog (*Rana chiricahuensis*) recovery plan. Region 2 Office, Albuquerque, NM.

USFWS. 2018. Draft recovery plan for four invertebrate species of the Pecos River Valley: Noel's amphipod (*Gammarus desperatus*), Koster's springsnail (*Juturnia kosteri*), Roswell springsnail (*Pyrgulopsis roswellensis*), and Pecos assiminea (*Assiminea pecos*). Region 2 Office, Albuquerque, NM.

USFWS. 2012. Endangered and threatened wildlife and plants; determination of endangered status for the Chupadera springsnail and designation of critical habitat. Federal Register 77: 41088–41106.

Waters, M.R., and C.V. Haynes. 2001. Late Quaternary arroyo formation and climate change in the American Southwest. Geology 29(5): 399–402.

World Wildlife Fund (WWF). 2012. Living Planet Report 2012: Biodiversity, Biocapacity and Better Choices. WWF. (6 June 2014; http://awsas-sets.panda.org/downloads/1_lpr_2012_online_full_size_single_pages_final_120516.pdf

Zeedyk, W.D., M. Walton, and T. Gadzia. 2014. Characterization and restoration of slope wetlands in New Mexico: A guide for understanding slope wetlands, causes of degradation and treatment options. New Mexico Environment Department, Surface Water Quality Bureau, Wetlands Program Technical Guide #2. Available: https://www.env.nm.gov/wp-content/uploads/2018/02/Characterization_of_Slope_Wetlands.pdf

APPENDIX

Inventory of the Arid-Land Spring Ciénegas

in New Mexico

169 currently known arid-land spring ciénegas in New Mexico are listed below. The arid-land spring ciénegas are sorted by County. Additional information includes the Site Identification number in the National Hydrologic Dataset (NHD) (which is the unique Site Identification number used by Springs Stewardship Institute database at https://springsdata.org/index.php), the name of the location (some names are not official), and the most recent source of information about the ciénega.

The next columns provide the status and condition rank. Most of the ciénegas identified in the Appendix of this plan have not been visited, and the status and preliminary condition are ranked by aerial assessment and utilizing the classification system developed by Cole and Cole (2015). A conservation rank of 1 is for functional ciénegas or restorable ciénegas that are large or occupied by sensitive or endangered species. A conservation rank of 2 applies to most restorable ciénegas. Severely damaged ciénegas that retain some small remnant are given a conservation rank of 3. Dead ciénegas or those that are hopelessly damaged have a conservation rank of 4. Status and rankings can be easily changed through on-the ground visits, the provision of additional information, or when these ciénegas have future NMRAM assessments or better up-to-date aerial imagery.

The location of each ciénega is provided as latitude-longitude coordinates, elevation, and general ownership information. The Freshwaters of the World Ecoregion Basin (The Nature Conservancy, 2015) in which the ciénega is found is provided in the next column. General observations about the ciénega are provided in the last column.

In order to sort the arid-land spring ciénegas alphabetically by name, rank or any other listed element, an Excel spreadsheet of arid-land spring ciénegas will be available upon request to NMED Surface Water Quality Bureau Wetlands Program.

NM_Co.	NHD_Site ID	Name	A.K.A.	Citation/Source	Status	Cons_Rank	Lat/Long	Latitude	Longitude	elev_ft	elev_m	Owner	Ecoregion_basin	Notes
Bernalillo	111383	Coyote Spring		Google Earth	Severely Damaged	3	34.9986 -106.4715	34.9986	-106.4715	5855	1785	Private	Upper Rio Grande	Sandia Lab. Impoundment excavated across lower end of cienega.
Catron		Apache Creek Cienaga		Cole and Cole (2015)	Functional	1	33.8332 -108.6211	33.8332	-108.6211	6422	1957	Private	Gila	In Apache Creek valley, but supported by upland spring seeps.
Catron		Aragon Cienega		Google Earth	Restorable	2	33.8708 -108.5745	33.8708	-108.5745	6565	2001	Private	Gila	Tularosa River valley below Aragon. Broad wet meadow across valley bottom with no clearly defined channel.
Catron		Cienaga del Cuervo		Old Territory and Military Department of NM	Not located			0	0				Gila	Not located. Appears on the Military Map of New Mexico (1864) near 33.22 -108.98.
Catron		Hidden Springs		Google Earth	Severely Damaged	3	33.6860 -108.8615	33.686	-108.8615	6365	1940	Private	Gila	Spring captured and channed to series of 5 earth dam impoundments. Small cienega remnant between first and second ponds.
Catron	138404	Hudson Spring		Google Earth	Severely Damaged	3	33.7480 -108.7789	33.748	-108.7789	5900	1798	Private	Gila	2.6 miles NW of Reserve. Junction of two seeping drainages becoming incised.
Catron	139741	SU Spring		Google Earth	Severely Damaged	3	33.7077 -108.81229	3.7077	-108.81229	6150	1875	Private	Gila	3 miles W of Reserve. Damaged by stock tank excavated below spring.
Chaves		Bitter Lake Farm Cienega		Sivinski and Tonne (2011)	Restorable	2	33.3837 -104.4214	33.3837	-104.4214	3474	1059	USDI-FWS	Pecos	West side of Bitter Lake NWR farm. Habitat occupied by Pecos sunflower.
Chaves		Bitter Lake outflow		Sivinski personal observation	Functional	1	33.4635 -104.4025	33.4635	-104.4025	3500	1067	USDI-FWS	Pecos	Drainage from SE side of Bitter Lake. Habitat occupied by Leoncita false foxglove, Pecos sunflower, Wright's marsh thistle.
Chaves		BLM North Dexter Cienega		Sivinski and Tonne (2011)	Restorable	2	33.26915 -104.36353	33.26915	-104.36353	3434	1047	BLM	Pecos	Upper cienega on private land dried by a well. Small patch of Pecos sunflower below earth dam on BLM.
Chaves		BLM Overflow Wetland		Sivinski and Tonne (2011)	Functional	1	33.3089 -104.3443	33.3089	-104.3443	3444	1050	State Parks, BLM, private	Pecos	Outflow of Lea Lake and springs further south create this large salt marsh/cienega. Habitat occupied by Pecos sunflower, Pecos pupfish.
Chaves		City Springs		Google Earth	Functional	1	33.4135 -104.4213	33.4135	-104.4213	3480	1060	City of Roswell	Pecos	Several springs and seeps on municiple land just east of Bitter Lake NWR - Hunter Marsh. Habitat occupied by Pecos sunflower, Noel's amphipod, Pecos assiminea.
Chaves	137532	Comanche Spring		Milford et al. (2001)	Functional	2	33.38927 -104.30219	33.38927	-104.30219	3565		Private, BLM	Pecos	Several seeps and pools for more than 1 km in upper Comanche Draw. Scattered salt cedar.
Chaves		Dexter Cienega		Sivinski and Tonne (2011)	Functional	1	33.2407 -104.37015	33.2407	-104.37015	3452	1052	Private	Pecos	Intact spring run and cienega. Critical habitat for Pecos sunflower.
Chaves		Dexter Fish Hatchery		Sivinski and Tonne (2011)	Severely Damaged	3	33.1945 -104.3421	33.1945	-104.3421	3413	1040	USDI-FWS	Pecos	Town of Dexter. Damaged by a dam and water diversion to fish hatchery. Small patch of Pecos sunflower.
Chaves		Hunter Marsh Spring		Land and Huff (2010)	Functional	1	33.4162 -104.4197	33.4162	-104.4197	3480	1060	USDI-FWS	Pecos	Springs and seeps in SE corner of Bitter Lake NWR. Critical habitat for Noel's amphipod, Roswell springsnail, Koster's sringsnail, Pecos assiminea, Pecos sunflower.
Chaves		Lloyds Spring		Milford et al. (2001)	Functional	2	33.5559 -104.3494	33.5559	-104.3494	3545	1080	BLM	Pecos	Small seep in valley bottom and fairly dry cienega just below. Small popn of Helianthus paradoxus. Scattered salt cedar.
Chaves		Lost River Cienega		Google Earth	Functional	2	33.4741 -104.4237	33.4741	-104.4237	3500	1067	USDI-FWS	Pecos	Inflow at SW side of Bitter Lake. Critical habitat for Noel's amphipod, Roswell springsnail, Koster's sringsnail, Pecos assiminea, wrinkled marshsnail, Pecos sunflower.
Chaves	130370	Oasis Dairy Cienega		Sivinski and Tonne (2011)	Severely Damaged	4	33.31449 -104.3712	33.31449	-104.3712	4560	1390	Private	Pecos	Critical habitat for Pecos sunflower, which was nearly extirpated by 2010 from growndwater pumping in nearby farm fields. Not recently assessed.
Chaves		Sago Spring		Land and Huff (2010)	Functional	1	33.4773 -104.4190	33.4773	-104.419	3500	1067	USDI-FWS	Pecos	Inflow at NW side of Bitter Lake. Critical habitat for Noel's amphipod, Roswell springsnail, Koster's sringsnail, Pecos assiminea, Pecos pupfish, Pecos gambusia, Pecos sunflower.
Chaves		Sink Hole Cienega		Sivinski and Tonne (2011)	Functional	2	33.2789 -104.3502	33.2789	-104.3502	3445	1050	State Land Office	Pecos	This small sinkhole appeared in the mid-1990s. Habitat for Pecos sunflower.
Chaves		Snail Unit springs		Land and Huff (2010)	Functional	1	33.4314 -104.4128	33.4314	-104.4128	3480	1060	USDI-FWS	Pecos	West side of Bitter Lake NWR. Critical habitat for Noel's amphipod, Roswell springsnail, Koster's springsnail, Pecos assiminea, Pecos gambusia, Pecos sunflower. Also occupied by Mexican tetra, Wright's marsh thistle and Leoncita false foxglove.

Cibola	144495	Acoma Spring		Google Earth	Severely Damaged	3	34.93273 -107.60484	34.93273	-107.60484	6280	1915	Tribal Lands	Upper Rio Grande	Spring run channelled into a lage stock pond.
Cibola	128499	Corral Spring		Google Earth	Restorable	2	35.1205 -107.8207	35.1205	-107.8207	6417	1956	Tribal Lands	Upper Rio Grande	N side of I-40 just E of Grants. Small spring cienega near Rancho del Padre Spring. May be habitat for Pecos sunflower.
Cibola	139281	Ojo del Gallo	San Rafael Spring	Google Earth	Dead	4	35.12233 -107.87581	35.12233	-107.87581	6465	1970	Private	Upper Rio Grande	North side of Town of San Rafael. Hwy 53 cuts across large area of dry organic soil that indicates a large dead cienega.
Cibola	112556	Rancho del Padre Spring		Google Earth	Restorable	2	35.11648 -107.82031	35.11648	-107.82031	6418	1956	NPS, Private	Upper Rio Grande	Just east of Grants. Impacted by I-40 and fill for buildings. Severely grazed on NPS side of I-40. Critical habitat for Pecos sunflower.
Cibola	144861	Sacred Spring		Google Earth	Functional	2	34.9084 -108.9595	34.9084	-108.9595	6305	1922	Tribal Lands	Lower Colorado	Spring creates a marsh in a small natural basin.
Colfax		Miami Lake Cienega		Google Earth	Functional	3	36.3526 -104.8786	36.3526	-104.8786	6310	1923	Private	Canadian	Broad marshy valley bottom below Miami Lake dam. Possible seepage from dam and not natural.
Colfax	139277	Ojo del Llano		Google Earth	Severely Damaged	3	36.47147 -104.10500	36.47147	-104.105	6490	1978	Private	Canadian	Eastern Colfax Co. Small narrow spring cienega severely damaged by stock tank excavation and overgrazing.
Colfax		Philmont Cienega		Google Earth	Restorable	1	36.4705 -104.9318	36.4705	-104.9318	6535	1991	Private	Canadian	Springs seeps on N side of Cimarroncito Creek at Philmont Scout Ranch. Damaged by stock tank excavations.
Colfax		Salado Creek Cienega		Google Earth	Restorable	2	36.3538 -104.8327	36.3538	-104.8327	6265	1910	Private	Canadian	2 miles W of Miami. Upper reach of small drainage. Damaged by stock tank.
Colfax		Taylor Springs		Google Earth	Restorable	2	36.3237 -104.4936	36.3237	-104.4936	5685	1733	Private	Canadian	6 miles ESE of Springer. Stock pond excavated on spring source. Outflow to small cienega.
DeBaca		Salado Creek Cienega		Google Earth	Functional	2	34.5973 -104.5131	34.5973	-104.5131	4370	1332	Private	Pecos	Broad alkaline cienega 7 miles W of Sumner Lake Dam on south side of Salado Creek valley.
DeBaca	140036	Stinking Spring		Google Earth	Dead	4	34.43109 -103.95056	34.43109	-103.95056	4175	1273	Private	Pecos	Small, apparently dead, spring cienega adjacent to center pivot irrigated field.
Eddy		Black River Marsh		Google Earth	Functional	1	32.0947 -104.468	32.0947	-104.468	3645	1111	BLM, Private	Pecos	Black River is a long spring run with a wide marsh at this point. Habitat occupied by Texas hornshell, gray redhorse.
Eddy		Blue Spring Cienega		Sivinski and Tonne (2011)	Functional	1	32.1803 -104.273	32.1803	-104.273	3282	1000	Private	Pecos	Large spring run marsh that flows into Black River. Habitat occupied by Pecos gambusia, Wright's marsh thistle.
Grant		Apache Tejo Spring		Sivinski and Tonne (2011)	Dead	4	32.6449 -108.1287	32.6449	-108.1287	5375	1638	Private	Guzman - Samalayuca	Spring dewatered by Hurley copper mill. Small patch of coyote willow appeared just below well heads since 2000. Restorable?
Grant	121121	Burro Cienega	Hawk Spring, Ojo de Inez, Cienaga Spring	Cole and Cole (2015)	Restorable	1	32.4343 -108.3652	32.4343	-108.3652	5351	1631	Private	Gila	Incised channel of Cienega Spring brook being repaired and aggraded by landowner. Introduced populations of endangered Gila topminnow and Chiricahua leopard frog.
Grant	138716	Cold Spring Cienega	Lindaur Spring	Sivinski and Tonne (2011)	Dead	4	32.5636 -108.0094	32.5636	-108.0094	5047	1538	Private	Guzman - Samalayuca	Spring dewatered by Hurley copper mill.
Grant	128468	Faywood Cienega		Sivinski and Tonne (2011)	Restorable	1	32.5613 -107.9875	32.5613	-107.9875	5042	1537	NM State Parks, private	Guzman - Samalayuca	Spring outflow on City of Rocks State Park. Most habitat occupied by Parish's alkaligrass is on the western private portion of the cienega.
Grant		Harden Cienega		USGS Topo Map	Dead	4	33.1729 -109.0435	33.1729	-109.0435	5420	1652	Private, USFS	Gila	Only three excavated stock tanks in a dry valley with no evidence of a cienega or spring.
Grant		Howard Cienega		Google Earth (2013)	Restorable	3	32.9792 -108.6598	32.9792	-108.6598	4699	1432	Private	Gila	Appears severely eroded and converted to riparian woodland.
Grant	140462	Kennecott Warm Spring		Sivinski and Tonne (2011)	Dead	4	32.56425 -108.02420	32.56425	-108.0242	5040	1536	Private	Guzman - Samalayuca	Spring dewatered by Hurley copper mill.
Grant		La Cienega de San Vicente		Cole and Cole (2015)	Dead	4	32.77 -108.276	32.77	-108.276	5932	1808	Private	Guzman - Samalayuca	Formerly occupying the site that is now Silver City, there were dozens of springs that fed the periphery of the extensive meadowlands of the Silver City floodplain at the confluence of the Silva and Pinos Altos Creeks.
Grant		Larremore Spring		Google Earth	Functional	2	33.1112 -108.9777	33.1112	-108.9777	5300	1615	Private	Gila	Small spring seep cienega 1.4 miles SW of Mule Creek. A few additional small areas of seeping ground about 450 m NE of Larremore Spring.
Grant		Lobo Cienega		Google Earth	Functional	1	32.9543 -108.6395	32.9543	-108.6395	4700	1433	Private	Gila	1.6 miles WSW of Cliff. USGS map shows this as a wetland, but not a spring.

Grant	139147	Mule Spring		Hayes, Frank pers. comm. (2014)	Severely Damaged	4	33.09917 -108.98254	33.09917	-108.98254	5365	1635	Private	Gila	Located near a long-occupied pre- and post-Classic Mimbres cultural site with a long history of occupancy, many cienega plants represented.
Grant	121608	Mangus Springs	Mangus Lake	Google Earth	Restorable	3	32.83917 -108.50900	32.83917	-108.509	4750	1448	Private	Gila	Mangus Creek. Seeps on E side of valley still somewhat natural. Larger wetland on W side of channel may be artificial. Extensively damaged by levees and channels.
Guadalupe		Ball Field Cienega		Sivinski personal observation	Functional	2	34.9257 -104.6761	34.9257	-104.6761	4580	1396	City of Santa Rosa	Pecos	Santa Rosa. Cienega created by excavated channel flow from nearby mound spring NHD Site ID# 122356. Habitat for Wright's marsh thistle, Great Plans Lady's tresses orchid.
Guadalupe		Bass Lake Cienega		Sivinski personal observation	Severely Damaged	3	34.9144 -104.6807	34.9144	-104.6807	4585	1398	Private	Pecos	Santa Rosa. Cienega below Bass Lake Spring NHD Site ID# 136835. Recently severely altered by construction of a dewatering collection gallery and excavated channel. Wright's marsh thistle habitat likely destroyed.
Guadalupe		Blue Hole Cienega		Sivinski and Tonne (2011)	Functional	1	34.9353 -104.6753	34.9353	-104.6753	4580	1396	NM Forestry Division	Pecos	Santa Rosa. 116-acres purchased and restored by NM-Forestry in 2005 for a nature preserve. Critical habitat for Pecos sunflower. Also occupied by Wright's marsh thistle, Great Plans Lady's tresses orchid.
Guadalupe		Elevario Cienega		Sivinski personal observation	Functional	2	34.9242 -104.6707	34.9242	-104.6707	4585	1398	Private	Pecos	Santa Rosa. Unnamed spring seep with Wright's marsh thistle and Pecos sunflower.
Guadalupe		Fairgrounds Cienega		Sivinski personal observation	Functional	1	34.9224 -104.6679	34.9224	-104.6679	4582	1397	City of Santa Rosa	Pecos	Santa Rosa. Cienega created by excavated channel flow from nearby mound spring. Location of spring NHD Site ID# 122361 is wrong and should be 34.9215 -104.6675. Habitat occupied by Pecos sunflower, Wright's marsh thistle and Great Plains lady's tresses orchid.
Guadalupe		Freeman Cienega		Sivinski personal observation	Functional	1	34.9200 -104.6679	34.92	-104.6679	4563	1391	Private	Pecos	Santa Rosa. Cienega and adjacent spring run habitat for Wright's marsh thistle and genetically distict population of round-nose minnow.
Guadalupe		Redhawk Cienega	Agua Negra Ranch, Swan Lake	Sivinski personal observation	Functional	1	34.9062 -104.6707	34.9062	-104.6707	4600	1402	Private, USDA-NRCS	Pecos	Santa Rosa. Huge cienega around Rock Lake and Post Lake. Swan Lake is not a lake, but a large spring marsh. Rock Lake is the water source for the adjacent fish hatchery. The entire wetland is covered by a perpetual NRCS conservation easement. Habitat occupied by Wright's marsh thistle, Great Plains lady's tresses orchid and a few Pecos sunflowers.
Guadalupe		Old Fish Hatchery		Sivinski personal observation	Restorable	3	34.9424 -104.6765	34.9424	-104.6765	4590	1400	City of Santa Rosa	Pecos	Santa Rosa. Damaged by fill and pond excavations, but western outslope is still functional. Critical habitat for Pecos sunflower and also occupied by Wright's marsh thistle.
Guadalupe	139359	Park Lake		Sivinski personal observation	Dead	4	34.94034 -104.67916	34.94034	-104.67916	4600	1402	City of Santa Rosa	Pecos	Santa Rosa. Entire cienega obliterated by excavation of a recreational lake.
Guadalupe		Perch Lake		Sivinski personal observation	Functional	2	34.9252 -104.6640	34.9252	-104.6792	4600	1402	City of Santa Rosa	Pecos	Santa Rosa. Sink hole lake that seeps from S side on to private land. Habitat occupied by Wright's marsh thistle.
Guadalupe		Robinson Cienega		Roth (2014)	Restorable	2	34.9295 -104.6792	34.9295	-104.6792	4565	1391	Private	Pecos	Santa Rosa. Habitat occupied by Pecos sunflower.
Guadalupe		Santa Rosa Cienega		Sivinski personal observation	Functional	1	34.9259 -104.6709	34.9259	-104.6709	4590	1400	City of Santa Rosa	Pecos	Santa Rosa. Large mound spring that flows N to Hwy 93. Habitat occupied by Wright's marsh thistle.
Guadalupe		Sheehan Cienega		Sivinski personal observation	Functional	1	34.9197 -104.6723	34.9197	-104.6723	4785	1458	Private	Pecos	Santa Rosa. Unnamed spring and upper spring run fenced from livestock. Remainder severely grazed. Habitat occupied by Wright's marsh thistle.
Guadalupe	122366	West-Side Spring		Sivinski personal observation	Functional	1	34.92504 -104.69227	34.92504	-104.69227	4580	1396	Private	Pecos	Santa Rosa. Spring cienega in valley bottom. Critical habitat for Pecos sunflower.
Harding	137179	Buffalo Spring		Google Earth	?	4	35.68307 -103.65076	35.68307	-103.65076	4355	1327	Private	Canadian	Aerial imagry unclear. Small cienega suspected.
Harding	135677	Carrizo Creek Cienega		Google Earth	Functional	1	36.06089 -103.97834	36.06089	-103.97834	5520	1682	Private	Canadian	About 15 miles NE of Roy. Several spring seeps with cienega in upper reach of Carrizo Creek.
Harding		DeHaven Cienega		Sivinski personal observation	Functional	1	36.0561 -103.8271	36.0561	-103.8271	5370	1637	Private	Canadian	About 22 air miles NE of Roy. Adjacent Alamocita Creek is a spring brook with this and some smaller sloping spring seeps on the both sides of the valley for 1 mile through DeHaven Ranch.
Harding	138094	Gato Spring		Google Earth	Severely Damaged	3	36.20670 -104.38887	36.2067	-104.38887	5775	1760	Private	Canadian	E of Canadian River just S of Harding Co. line. Spring run deeply eroded. Imagery indistinct for wetland plants.

Harding	138199	Hackberry Spring		Google Earth	Functional	2	35.8717 -103.4488	35.8717	-103.4488	4835	1474	Private	Canadian	Small valley bottom cienega below 3 springs on E side of Harding Co.
Harding	135787	High Spring		Google Earth	Severely Damaged	4	35.70688 -103.63386	35.70688	-103.63386	4380	1335	Private	Canadian	Just N of Buffalo Spring. Small spring seep cienega nearly eliminated by 2 stock tanks.
Harding	135711	Logan Springs		Google Earth	Severely Damaged	3	35.40868 -103.50475	35.40868	-103.50475	3835	1169	Private	Canadian	Small spring seep cienega at N arm of Ute Lake. Eroded and with concentrated livestock use.
Harding		Meadow Seep		Google Earth	Severely Damaged	3	35.5525 -103.559	35.5525	-103.559	4118	1255	Private	Canadian	Small spring seep cienega almost completely converted to plowed agriculture.
Harding	121181	Pedernal Creek		Google Earth	Functional	2	36.01315 -103.42847	36.01315	-103.42847	4934	1504	Private	Canadian	NE corner of Harding Co. Few small spring seeps with small cienegas in head of Pedernal Creek.
Harding		Upper Alamocita		Google Earth	Severely Damaged	3	36.0678 -103.837	36.0678	-103.837	5390	1643	Private	Canadian	Severely eroded spring seep cienega on W side of Alamocita Creek just N of DeHaven.
Hidalgo		Animas Cienega		Housman (2010) and Minckley and Brunelle (2007)	Dead	4	31.782571 -108.79088	31.78257	-108.79088	4662	1421	Private	Gila	Southeast of Rodeo, Hidalgo County NM, this point is now a dry part of Animas Creek south of the town of Animas that once was, but no longer is, a cienega.
Hidalgo		Animas Creek Cienega		Minckley et al. (2012)	Functional	1	31.528 -108.873	31.528	-108.873	5127	1563	Private	Gila	Although somewhat damaged, this cienega, has several active surface spring seeps.
Hidalgo		Cienaga-Town		Cole and Cole (2015)	Dead	4	32.69509 -109.04513	32.69509	-109.04513	3795	1157	Private	Gila	This point in the Gila Valley between Virden and Duncan, AZ has long-been converted to cropland.
Hidalgo		Cloverdale Cienega		Sivinski and Tonne (2011)	Functional	1	31.4367 -108.9764	31.4367	-108.9764	5390	1643	USFS, Private	Guzman - Samalayuca	Discontinuous area of wet valley bottom contains a 20.2 ha remnant of a formerly large cienega with extensive plant diversity. Habitat occupied by Chihuahua sedge.
Hidalgo	121635	Cloverdale Spring		Sivinski personal observation	Severely Damaged	3	31.42036 -108.94277	31.42036	-108.94277	5295	1614	Private	Guzman - Samalayuca	About 2 miles downstream of Cloverdale Cienega at barn and corral. Lower end excavated for stock pond with a small area of remnant cienega plants.
Hidalgo	137420	Lang Cienega	Cienega Spring	Sivinski and Tonne (2011)	Functional	1	31.3361 -108.8106	31.3361	-108.8106	5158	1572	Private	Guzman - Samalayuca	Approximately 90% of the cienega lies in US and 10% in Mexico, covering 24.3 ha (60 ac) and 4 km (2.5 mi) long, this important cienega has high plant diversity and no problem with invasive plants. Habitat occupied by Chihuahua sedge.
Hidalgo	138676	Ojo de las Cienegas	Las Cienegas Spring	Schwennesen (1918); Doty (1960)	Dead	4	31.6157 -108.4917	31.6157	-108.4917	4383	1336	Private	Guzman - Samalayuca	Surface flow eliminated by nearby agricultural wells. Google Earth image shows water (groundwater?) in excavated stock tank.
Hidalgo	129480	Playas Springs		Schwennesen (1918); Doty (1960)	Dead	4	31.84567 -108.58938	31.84567	-108.58938	4293	1309	Private	Guzman - Samalayuca	Doty (1960) says Schwennesen's 1917 survey counted 22 springs and seeps. All dry by 1958. Wright collected Leucosyris blepharophylla, Eryngium sparganophyllum and Peritoma multicaulis here in 1851. All now extirpated from NM.
Lincoln	137298	Carrizozo Spring		Google Earth	Restorable	2	33.66988 -105.86996	33.66988	-105.86996	5400	1646	Private	Tularosa Basin	Just N of Carrizozo. Large spring cienega reduced by a dam, stock tank excavations and an agricultural field. Small upper portion still functional.
Lincoln	111424	Dead Oryx Mound Spring		Sivinski and Tonne (2011)	Dead	4	33.41709 -106.28715	33.41709	-106.28715	4320	1317	DOD	Tularosa Basin	This is a very small pool with little vegetation and barely alive.
Lincoln	111441	Hare Mound Spring		Sivinski and Tonne (2011)	Dead	4	33.40997 -106.29319	33.40997	-106.29319	4305	1312	DOD	Tularosa Basin	This spring, a mere 25 cm in diameter (10 in), is the smallest of five in a cluster and is going naturally extinct.
Lincoln	138650	Kyle Harrison Spring		Google Earth	Functional	2	33.67803 -105.35024	33.67803	-105.35024	6085	1855	Private	Pecos	N foot of Capitan Mts. Small cienega below two springs.
Lincoln	138841	Cienega del Macho	Macho Spring	Google Earth	Restorable	1	33.70845 -105.40341	33.70845	-105.40341	5920	1804	Private	Pecos	Plain N of Capitan Mts. Larg spring pool. Some water being captured by pipeline. Associated unnamed spring seep 200 m W and another unnamed spring (129280) 580 m to NW, which is captured by an excavated channel to a stock tank.
Lincoln	111543	Main Mound Spring		Sivinski and Tonne (2011)	Functional	2	33.4257 -106.2848	33.4257	-106.2848	4347	1325	DOD	Tularosa Basin	The largest of five clustered mound springs. Provides habitat for the White Sands pupfish.
Lincoln	111421	North Mound Spring		Sivinski and Tonne (2011)	Severely Damaged	4	33.4353 -106.2896	33.4353	-106.2896	4365	1330	DOD	Tularosa Basin	One in a cluster of mound springs. Vegetation recovering from severe feral horse damage.
Lincoln	111425	South Mound Spring		Sivinski and Tonne (2011)	Severely Damaged	3	33.40613 -106.29471	33.40613	-106.29471	4295	1309	DOD	Tularosa Basin	The second largest of five springs, South Mound Spring is sparsely vegetated and fenced from feral horses.
Luna		Cow Springs	Ojo de la Vaca	Cole and Cole (2015)	Severely Damaged	3	32.4121 -108.1793	32.4121	-108.1793	5042	1537	Private	Guzman - Samalayuca	Closely surrounded by buildlings and trees. Spring captured and capped to prevent undermining the nearby ranch headquarters.

McKinley	107989	Coal Spring		Milford et al. (2001)	Severely Damaged	3	35.6231 -107.3504	35.6231	-107.3504	6330	1929	USDI-BLM	Upper Rio Grande	Eastern Mckinley Co. Small cienega below spring destroyed by stock pond excavation. A few Parish's alkali grass present in 1995, but missing in 2002 and 2016
McKinley	137791	Doctor Spring		Sivinski personal observation	Restorable	2	35.5178 -107.5539	35.5178	-107.5539	6605	2013	Private	Upper Rio Grande	Near Lee Ranch Coal Mine. Spring cienega damaged by draining water to 3 stock troughs. A few Parish's alkali grass present in 1995, but missing in 2002.
McKinley	137898	El Dado Spring		Google Earth	Functional	2	35.51501 -107.51650	35.51501	-107.5165	6596	2010	Private	Upper Rio Grande	Near Lee Ranch Coal Mine. Cienega in a large seeping depression.
Mckinley	145654	Toyee Springs		Google Earth	Functional	1	35.82685 -108.43184	35.82685	-108.43184	6100	1859	Tribal Lands	Lower Colorado	About 16 miles NW of Crownpoint. Cocentration of mound springs with some cienega in outflow.
Mora	117434	Dry Lake Cienega		Google Earth	Functional	1	35.8595 -105.0021	35.8595	-105.0021	6560	1999	Private	Canadian	2.2 miles SSE of Fort Union. Cienega at N end of Dry Lake playa below two springs.
Mora	132274	Jarosa Springs		Google Earth	Restorable	2	36.0408 -104.7878	36.0408	-104.7878	6520	1987	Private	Canadian	5 miles NW of Wagon Mound. Small cienegas at 3 springs in valley bottom. Channel may be eroded.
Mora	136953	Salt Lake Springs		Sivinski personal observation	Functional	2	36.0322 -104.7110	36.0322	-104.711	6168	1880	NMDGF	Canadian	Just N of Wagon Mound. 5 hillside springs with small cienegas on W side of Salt Lake State Game Management Area.
Mora		Wagon Mound Cienega		Sivinski personal observation	Restorable	1	36.0137 -104.7049	36.0137	-104.7049	6200	1890	Private	Canadian	Very large and complicated spring/playa cienega. Runs from Santa Clara Spring NHD Site ID# 139813 east under I-25 then under RR tracks then into the large playa N of town. Impacted by channelled spring run, Hwy and RR fill, and building fill. Multiple land owners. Good plant diversity.
Otero	111475	Barrel Spring Cienega		Sivinski and Tonne (2011)	Severely Damaged	3	33.0558 -106.1606	33.0558	-106.1606	4120	1256	DOD	Tularosa Basin	Located west of Alamogordo NM, Barrel Spring is a small, severely impacted, dredged for impoundment.
Otero		Batte Way Cienega		Sivinski and Tonne (2011)	Restorable	2	33.0076 -105.8709	33.0076	-105.8709	5700	1737	State Land Office	Tularosa Basin	Located northeast of Alamogordo, this 70 x 30 m cienega is severely grazed and damaged by a road cut, although it persists due to being wetted by a small seep spring.
Otero	155372	Borunda Spring		Sivinski personal observation	Restorable	2	33.0314 -105.8383	33.0314	-105.8383	6590	2009	USFS, Private	Tularosa Basin	Cienega extends from USFS land across Laborcita valley onto adjacent private land where it has been channelled and converted to pasture.
Otero	111518	Guilez Spring	Tula Pond	Sivinski and Tonne (2011)	Severely Damaged	3	33.0599 -106.1537	33.0599	-106.1537	4143	1263	DOD	Tularosa Basin	50 ft diameter dredged pond further damaged by recreational use, exotic fish introduction, and road construction.
Otero	138223	Harrington Spring		Sivinski personal observation	Severely Damaged	3	32.74694 -106.14380	32.74694	-106.1438	4030	1228	Private	Tularosa Basin	Basin S of White Sands National Monument. Cienega destroyed by channelling outflow to excavated pond.
Otero	111538	Malpais Spring Cienega		U.S. Dept. of Defense. Sivinski and Tonne (2011)	Functional	1	33.2865 -106.3108	33.2865	-106.3108	4140	1262	DOD	Tularosa Basin	Hundreds of acres of salt marsh cienega. Habitat occupied by White Sands pupfish.
Otero		Mescalero Creek		Google Earth	Restorable	1	33.1532 -105.7679	33.1532	-105.7679	6575	2004	Tribal Lands	Tularosa Basin	Large cienega remnant on W side of Mescalero Fish Hatchery. Marshes in this valley have been drying for the last 2 decades. Historical habitat for Wright's marsh thistle, but not recently assessed.
Otero	139202	Nogal valley	Nogal Springs	Sivinski personal observation	Dead	4	33.12969 -105.84643	33.12969	-105.84643	6215	1894	Private	Tularosa Basin	Wide valley with numerous side springs and seeps creating multiple cienegas from the confluence with Mescalero Creek near Bent upstream for 2.5 miles. Wetlands completely eliminated by agricultural fields, drains, acequias and ponds.
Rio Arriba	146341	CCC Spring		Google Earth	Restorable	2	36.2878 -106.1637	36.2878	-106.1637	6437	1958	USFS	Upper Rio Grande	3.8 miles SSE of El Rito. Small cienega on W side of the creek. Needs weed tree control.
Rio Arriba		Cienega de la Madera		Google Earth	Functional	2	36.3556 -106.0397	36.3556	-106.0397	6650	2027	Private	Upper Rio Grande	3.6 mile N of Ojo Caliente. Small cienega on seeping bench of W-facing valley slope.
Rio Arriba	158741	Trail Spring		Google Earth	Functional	2	36.2179 -106.3948	36.2179	-106.3948	6295	1919	USFS	Upper Rio Grande	4.3 miles WNW of Abiquiu. Small cienega below hillside spring in roadless area.
Rio Arriba	118334	Ojito de las Vegas		Google Earth	Functional	2	36.1935 -106.3393	36.1935	-106.3393	6310	1923	Private	Upper Rio Grande	1.5 miles SW of Abiquiu. Small cienega below hillside spring.
Rio Arriba	139258	Ojito Seco		Google Earth	Functional	2	36.19147 -106.34220	36.19147	-106.3422	6300	1920	Private	Upper Rio Grande	1.7 miles SW of Abiquiu. Small cienega below hillside spring.
Rio Arriba	118294	Ojitos de la Madera		Google Earth	Functional	2	36.3615 -106.0436	36.3615	-106.0436	6620	2017	Private	Upper Rio Grande	4 mile N of Ojo Caliente. Small cienega below springs on W-facing valley slope.

Rio Arriba		Otero Ranch Cienega		Google Earth	Functional	2	36.2755 -107.3768	36.2755	-107.3768	6555	1998	Tribal Lands	Upper Colorado	Small side tributary of Largo Canyon 6.4 miles NE of Councilor. Small alkaline spring cienega. Another small cienega to the west near abandoned ranch house results from a flowing well.
Rio Arriba		Sapawe Cienega		Google Earth	Restorable	2	36.3016 -106.1558	36.3016	-106.1558	6515	1986	State Land Office	Upper Rio Grande	Small drainage on W side of EL Rito valley adjacent to Sapawe Pueblo ruins and just S of Town of El Rito. Fairly exstensive.
Roosevelt	137194	Bull Tank Spring		Google Earth	Functional	2	34.52483 -103.90626	34.52483	-103.90626	4348	1325	Private	Pecos	5.3 miles NNE of Tolar. Small spring cienega.
Sandoval	144670	Cajon Spring		Google Earth	Restorable	2	35.63999 -106.68544	35.63999	-106.68544	5840	1780	Tribal Lands	Upper Rio Grande	1.5 mile SW of Ponderosa. Small spring cienega. Needs weed tree control.
Sandoval		Kewa Marsh		Sivinski and Tonne (2011)	Functional	1	35.5459 -106.3516	35.5459	-106.3516	5548	1691	Tribal Lands	Upper Rio Grande	Extensive cienega/marsh complex partly wetted by springs on E side of Rio Grande flood plain. Pueblo has recently removed several acres of salt cedar.
Sandoval		Maestas Spring		Sivinski (2017)	Restorable	2	35.5614 -106.8029	35.5614	-106.8029	5517	1682	USDI-BLM	Upper Rio Grande	1.4 miles WNW of San Ysidro. Narrow cienega in seeping valley bottom. Needs salt cedar control.
Sandoval	95929	Mound Springs		Sivinski (2017)	Functional	2	35.54714 -106.82684	35.54714	-106.82684	5520	1682	USDI-BLM	Upper Rio Grande	2.8 miles WSW of San Ysidro. Cienegas surrounding several thermal mound springs. Low plant diversity.
Sandoval	145610	Ojito		Google Earth	Functional	1	35.59141 -106.96076	35.59141	-106.96076	5786	1764	Tribal Lands	Upper Rio Grande	10.5 miles WNW of San Ysidro. Alkaline spring cienega. Habitat for Parish's alkaligrass
Sandoval	109481	Ojo Atascoso		Sivinski personal observation	Functional	2	35.5807 -107.2068	35.5807	-107.2068	6095	1858	USDI-BLM	Upper Rio Grande	Small spring seep cienega 11 miles SW of San Luis. Cienega fenced from livestock, but wire usually cut.
Sandoval	144936	Ojo del Tuerto		Google Earth	Severely Damaged	3	35.39878 -106.35087	35.39878	-106.35087	5500	1676	Tribal Lands	Upper Rio Grande	5.9 mile SE of San Felipe Pueblo. Small spring cienega damaged by excavation of 2 stock tanks.
Sandoval	109492	Ojo Frio		Milford et al. (2001)	Restorable	2	35.5921 -107.2273	35.5921	-107.2273	6240	1902	USDI-BLM	Upper Rio Grande	11.6 miles SW of San Luis. Small spring cienega damaged by livestock facilities and water capture for stock trough. Habitat occupied by Parish's alkaligrass.
Sandoval		Peñasco Springs		Google Earth	Functional	2	35.60171 -106.85604	35.60171	-106.85604	6050	1844	Tribal Lands	Upper Rio Grande	Several travertine mound springs in Peñasco Arroyo with small alkaline cienegas at outflow.
Sandoval	139810	Sandoval Spring		Google Earth	Severely Damaged	3	35.36007 -106.93952	35.36007	-106.93952	5865	1784	Private	Upper Rio Grande	SE of Mesa Prieta. Small spring cienega nearly eliminated by stock pond excavation.
Sandoval	95938	White Mesa Cienega		Sivinski (2017)	Functional	2	35.5169 -106.8477	35.5169	-106.8477	5645	1721	USDI-BLM	Upper Rio Grande	4.6 miles SW of San Ysidro. Alkaline cienega below travertine spring. Low plant diversity.
San Juan	141486	Barrel Spring Cienega		Sivinski personal observation	Restorable	1	36.89278 -108.20008	36.89278	-108.20008	5720	1743	State Land Office, Private	Upper Colorado	Large cienega 2.5 miles SSW of La Plata PO. Broad long cienega in upper reach of Allen Arroyo. Damaged by agriculture and channel, dam and pond excavations. Some salt cedar.
San Juan	145425	Tocito Springs		Google Earth	Severely Damaged	3	36.39832 -108.78143	36.39832	-108.78143	5712	1741	Tribal Lands	Upper Colorado	Cluster of small springs 4.5 miles SW of Little Water. Damaged by excavation. Cienega 350 m N may be natural. Infested with salt cedar.
San Miguel	136669	Agua Azul		Google Earth	Functional	2	35.33439 -104.95067	35.33439	-104.95067	5255	1602	Private	Pecos	14 miles NE of Anton Chico. Small ciengas below cluster of 3 springs.
San Miguel	139271	Ojo de la Gallina	Park Spring	Google Earth	Severely Damaged	3	35.26231 -104.93062	35.26231	-104.93062	5145	1568	Private	Pecos	8.8 miles NE of Dilia. Cienega nearly eliminated by excavation of dam and pond.
Santa Fe	117576	Alamo Cienega		Google Earth	Restorable	2	35.5370 -106.1065	35.537	-106.1065	6070	1850	Private	Upper Rio Grande	E side of I-25 E of La Cienega. Head of Alamo Creek. Damaged by pond excavation and Russian olive.
Santa Fe		Bonanza Cienega		Google Earth	Restorable	2	35.5373 -106.1199	35.5373	-106.1199	6020	1835	Private	Upper Rio Grande	E side of I-25 E of La Cienega on Alamo Creek. Damaged by pond excavation and Russian olive.
Santa Fe		Cienega Creek Cienega		Sivinski personal observation	Functional	1	35.5753 -106.0983	35.5753	-106.0983	6085	1855	Private	Upper Rio Grande	S side of Cienega Creek in La Cienega. Slightly damaged by old dam and creek diversion. Russian olive removed.
Santa Fe	138070	Galisteo Spring		Google Earth	Functional	2	35.45845 -105.95743	35.45845	-105.95743	6320	1926	Private	Upper Rio Grande	Small spring cienega 4.6 miles WSW of Lamy. Within a Galisteo Basin conservation easement.
Santa Fe		Jacona Cienega		Sivinski personal observation	Severely Damaged	3	35.8923 -106.0429	35.8923	-106.0429	5757	1755	Private	Upper Rio Grande	S side of Rio Pojoaque in Jacona. Severely damaged by building, road and pond excavation. Some small remnant areas could be preserved.
Santa Fe		La Cienega 1		Google Earth	Restorable	2	35.5795 -106.1053	35.5795	-106.1053	6070	1850	Private	Upper Rio Grande	In La Cienega. Damaged by pond excavation and agriculture field.
Santa Fe		La Cienega 2		Google Earth	Restorable	2	35.5738 -106.1045	35.5738	-106.1045	6070	1850	Private	Upper Rio Grande	Large cienega in La Cienega. Damaged by channel and pond excavations, but large remnant remaining. Russian olive infestation.
Santa Fe		Lagunitas Cienega		Google Earth	Restorable	2	35.5589 -106.1185	35.5589	-106.1185	6020	1835	Private	Upper Rio Grande	La Cienega. Large long cienega extensively damaged by channel and pond excavations, road fill and housing development. Infested with Russian olive.

Santa Fe		Leonora Curtin Cienega		Sivinski personal observation	Restorable	2	35.5673 -106.1068	35.5673	-106.1068	6060	1847	Private	Upper Rio Grande	La Cienega. Narrow cienega damaged by pond excavation. A non-profit wetland preserve. Russian olive infestation initially treated in 2017.
Santa Fe		Pojoaque Cienega		Google Earth	Restorable	2	35.8964 -106.0314	35.8964	-106.0314	5800	1768	Tribal Lands	Upper Rio Grande	S side of Rio Pojoaque in on S edge of Pojoaque reservation. Damaged by a drain channel.
Santa Fe	139792	San Marcos Spring		Google Earth	Dead	4	35.45953 -106.06916	35.45953	-106.06916	6020	1835	Private	Upper Rio Grande	San Marcos Arroyo at Hwy 14. Dewatered by domestic wells and weed tree infestation.
Santa Fe		Simmons Cienega		Sivinski personal observation	Restorable	2	35.5781 -106.1025	35.5781	-106.1025	6085	1855	Private	Upper Rio Grande	La Cienega. Hillside cienega damaged by channel and pond excavations.
Santa Fe		Sunrise Spring		Sivinski personal observation	Severely Damaged	3	35.5832 -106.1028	35.5832	-106.1028	6085	1855	Private	Upper Rio Grande	La Cienega. Severely damaged by pond excavation and fill for resort development. Small remnant remaining.
Sierra		Lake Valley Cienega		Sivinski and Tonne (2011)	Dead	4	32.7581 -107.5353	32.7581	-107.5353	5090	1551	Private	Upper Rio Grande	Berrenda Creek flow diverted and valley bottom mostly converted to ag field. Spring run at east end deeply incised. Wright's marsh thistle extirpated.
Sierra		Palomas Canyon Cienega		Sivinski and Tonne (2011)	Functional	2	33.1714 -107.5596	33.1714	-107.5596	5392	1643	Private	Upper Rio Grande	Seeping cienega on Ladder Ranch with beaver dam at lower end.
Sierra		Seco Canyon Cienega		Sivinski and Tonne (2011)	Functional	2	33.0900 -107.5583	33.09	-107.5583	5495		Private	Upper Rio Grande	Small seeping cienega on Ladder Ranch.
Sierra	139893	Shorthorn Spring		Sivinski and Tonne (2011)	Restorable	3	32.7578 -107.3968	32.7578	-107.3968	4483	1366	Private	Upper Rio Grande	16 mi northeast of Hatch, this spring is captured for a cattle drinker, although overflow wets a small grassy area.
Sierra	121243	Warm Spring		Google Earth	Restorable	2	32.9498 -107.5758	32.9498	-107.5758	5535	1687	Private	Upper Rio Grande	Approx 2 mi N of Hillsboro. Small cienega around spring box threatened with headcut erosion.
Socorro	121293	Alamosa Springs Cienega	Ojo Caliente	Sivinski and Tonne (2011)	Restorable	1	33.57258 -107.60042	33.57258	-107.60042	6210	1893	Private	Upper Rio Grande	A complex of springs, seeps and spring runs, some warm, at head of Monticello Box. Habitat occupied by Wright's marsh thistle, Chiricahua leopard frog and the only known (critical) habitat for the Alamosa springsnail.
Socorro	137419	Cienega Spring		Cole and Cole (2015)	Severely Damaged	3	33.8737 -107.0900	33.8737	-107.09	6163	1878	Private	Upper Rio Grande	Excavated stock pond in front yard of ranch house.
Socorro	137546	Cook Spring		Sivinski and Tonne (2011)	Restorable	2	34.0476 -106.9375	34.0476	-106.9375	4899	1493	Private	Upper Rio Grande	Located only 4 km west of Socorro, the status of this Cienega is unclear, but a small amount of Cienega habitat is apparent on aerial imagery and it is presumably restorable.
Socorro	137912	Elias Spring Cienega		Google Earth	Severely Damaged	3	34.5419 -107.4416	34.5419	-107.4416	5982	1823	Private	Upper Rio Grande	9 miles NNE of Alamo. Original cienega destroyed by headcut erosion from stock pen and watering facilities. Some more recent cienega created by flow from man-made artesian well drilled at 34.5409 -107.4518.
Socorro	138060	Friday Spring		Google Earth	Restorable	2	34.56371 -107.43528	34.56371	-107.43528	6000	1829	Private	Upper Rio Grande	10.5 miles NNE of Alamo. Cienega damaged by stock pond and channel excavation.
Socorro	145577	INM Spring		Google Earth	Restorable	3	34.46200 -107.68922	34.462	-107.68922	6512	1985	Tribal Lands	Upper Rio Grande	11.4 miles WNW of Alamo. Small alkaline cienega on N bank of Alamocita Creek. Infested with salt cedar.
Socorro		La Joya Cienega		Sivinski personal observation	Restorable	1	34.3282 -106.8707	34.3282	-106.8707	4700	1433	NMDGF	Upper Rio Grande	Large cienega on La Joya Waterfowl Management Area. From seeps on W side of Rio Grande valley. Habitat occupied by Pecos sunflower. Damaged by earth dams, channel excavations, and salt cedar.
Socorro		Rhodes Cienega		Sivinski personal observation	Functional	1	34.0028 -106.8567	34.0028	-106.8567	4580	1396	Private	Upper Rio Grande	E side of Rio Grande floodplain between Socorro and San Antonio. Pecos sunflower planted here in 2008 and had several 100,000 individuals in 2017, but only within livestock exclusion fence.
Socorro		South Elias Spring		Google Earth	Functional	2	34.5386 -107.4397	34.5386	-107.4397	5983	1824	Private	Upper Rio Grande	Small alkaline spring seep 0.5 km SE of Elias Spring.
Socorro	110356	Torreon Spring		Google Earth	Severely Damaged	2	33.8907 -107.0705	33.8907	-107.0705	6050	1844	Private	Upper Rio Grande	12 miles WSW of San Antonio. Damaged by channel and pond excavations. Tiny remnant of cienega, but spring is critical habitat for endangered Socorro springsnail.
Socorro		Willow Springs		Cole and Cole (2015)	Restorable	2	33.8105 -106.9778	33.8105	-106.9778	5350	1631	Private	Upper Rio Grande	Narrow cienega below excavated stock ponds. Spring is critical habitat for the endangered Chupadera springsnail.
Taos		Glen Woody Cienegas		Google Earth	Restorable	2	36.2501 -105.8243	36.2501	-105.8243	6010	1832	Private	Upper Rio Grande	N slope of Rio Grande Canyon just E of Glen Woody Bridge. Several seeps from below basalt cap. Damaged by pipeline. Large eastern cienega has adjacent buildings. Several Russian olive trees on cienega margins.

Taos	114752	Lava Spring Cienegas		Google Earth	Restorable	2	36.24328 -105.83940	36.24328	-105.8394	6210	1893	Private	Upper Rio Grande	N slope of Rio Grande Canyon just W of Glen Woody Bridge. Several seeps from below basalt cap. Damaged by excavation of drain channels. Several Russian olive trees on cienega margins.
Taos		Pilar Cienega		Google Earth	Functional	2	36.2852 -105.7965	36.2852	-105.7965	6340	1932	Private	Upper Rio Grande	W slope of Rio Grande Canyon just above Pilar Bridge. Seep from below basalt cap. Several Russian olive trees on cienega margins.
Torrance	137947	Estancia Spring		Google Earth	Severely Damaged	4	34.75673 -106.06173	34.75673	-106.06173	6120	1865	Private	Upper Rio Grande	Small village park in Estancia with spring captured into a pond and completely surrounded by buildings and pavement.
Torrance	128483	Gyp Springs		Google Earth	Restorable	2	34.46209 -105.60265	34.46209	-105.60265	6005	1830	Private	Upper Rio Grande	South end of gypsum playa E of Pine Mountain. Small cienega damaged by spring box and corral.
Union	119025	Cienequilla Creek	Cieneguilla del Burro	Pearce et al. (1965)	Severely Damaged	3	36.58743 -103.48426	36.5936	-103.0023	5580	1700	Private	US Southern Plains	Pearce et al. (1965) clearly placed this cienega 3 miles N of Mt. Dora (along Seneca Creek) where there are still remnants of a nearly dry cienega.
Union	119482	Folsom Spring		Google Earth	Restorable	3	36.8409 -103.9025	36.8409	-103.9025	6410	1954	Private	US Southern Plains	0.8 miles SE of Folsum. Small cienega impacted by spring box and livestock pen.
Union	119017	South Branch Springs		Google Earth	Severely Damaged	3	36.71258 -103.73584	36.71258	-103.73584	6168	1880	Private	US Southern Plains	6.3 miles SE of Des Moines. Spring captured by channel to earth dam impoundment.
Union		Spring Hill Cienegas		Google Earth	Restorable	2	36.5863 -103.2818	36.5863	-103.2818	5110	1558	Private	US Southern Plains	1 mile NE of Clayton Lake dam in tributary of Seneca Creek. A few hillside seeps with narrow cienegas.
Valencia	139286	Ojos de Huelos	Ojo Alamo	Sivinski personal observation	Severely Damaged	3	34.731 -106.5467	34.731	-106.5467	5414	1650	Private	Upper Rio Grande	Mostly dry. Just a few hillside seeps and dry travertine on the hillslopes.
Valencia		Stairway Cienega		Google Earth	Functional	1	34.6983 -107.1206	34.6983	-107.1206	5780	1762	Private	Upper Rio Grande	19 miles W of Belen. Large area of seeps in Salado Arroyo forming a series of terraced shallow pools behind natural travertine dams.