Effects of Groundwater Transport from Cave, Delamar, and Dry Lake Valleys on Terrestrial Ecosystems of Lincoln and adjacent Nye and White Pine Counties, Nevada

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Location and Physical Setting

Cave, Delamar, and Dry Lake Valleys are large, high, dry valleys in southeastern Nevada (Figure 1). Collectively, the valleys are about 10-15 km from west to east throughout most of their 170 km north to south length. The valleys are topographically connected, and run parallel to and east of the White River and Pahranagat Valleys. The North and South Pahroc Ranges and the Hiko Range separate Delamar and Dry Lake Valleys from the White River and Pahranagat Valleys. The southern tip of the Egan Range separates Cave Valley from the White River Valley. The system lies mainly within Lincoln County, except for portions of western Cave Valley which extends into Nye County and northern Cave Valley, which extends into White Pine County, Nevada.

Cave, Delamar, and Dry Lake Valleys are like most Nevada valleys in that they trend from north to south and are situated between mountain ranges. These valleys are considerably higher than those to west, and like those to the west, are progressively lower from north to south (Table 1).

Few springs flow in these valleys. In Delamar Valley, aside from water that accumulates at the playa, the nearest free-flowing water is 8 km from the valley floor and 500m in elevation above in the Delamar Mountains at Jumbo Springs. The water from a few springs in the mountains around Dry Lake Valley is diverted to tiny reservoirs at valley low points in the south (Point of Rocks Reservoir) and in the north (Bullfrog Reservoir). The lack of dependability of this water and the nature of the soil conspire to prevent the establishment of ecologically valuable vegetation, as only salt-cedar (*Tamarix ramosissima*) is present at these sites. More springs arise from the mountain fronts surrounding Cave Valley, but these only rarely flow to the valley floor.

Figure 1 (following page). Cave, Dry Lake, and Delamar Valley watersheds (outlined in red) and White River, Pahroc, and Pahranagat Valley watersheds (outlined in orange), Lincoln and Nye Counties, Nevada. US Highway 93 and 6 identified by light yellow lines, Lincoln and Nye County boundaries indicated by light green line. Nevada-Utah boundary indicated on right by light gray line. Map prepared by author.

Table 1. Base elevations of valleys in the study area. Data from USGS (1978a, b, 1979, 1982) topographic maps.

West Valleys (N-S)	Base Elevation (m)	East Valleys (N-S)	Base Elevation (m)

White River	1488	Cave	1824
Pahroc	1169	Dry Lake	1400
Pahranagat	970	Delamar	1390

Cave Valley, Dry Lake Valley, and Delamar Valley Ecosystems

In spite of the initial impression one might have of these valleys, as desolate barren plains, actually the vegetation of the Cave-Dry Lake-Delamar valley system is varied, with several associations. Their dispersion across the landscape is due primarily to soil characteristics and water availability. The coordination of latitude and elevation gradients is apparent as the traveler moves from north to south in the system, as base elevations in the eastern swath of valleys ranges 434 m from Cave to Delamar Valleys.

Figure 2. Four-wing saltbush (*Atriplex canescens*) tall shrubland on playa margin, Delamar Valley. Lincoln County, Nevada. Photograph by the author.

At valley bottoms, small playas or pluvial lakebeds occur in each eastern valley. Playas are a plant-free zone with saline soils comprised of fine silt and clay. Salinity declines moving away from the playa, corresponding with time spent under the pluvial lake. Physical gradients follow as elevation increases away from the playa, and include a decrease in salinity, an increase in soil particle size, and increasing precipitation.

The vegetation communities in the lowest elevations near the playa are xerohalophytic shrubs. These plants tolerate salt, and rely on water in the upper soil profile. The dominant shrub in these lowest vegetated areas of the valley is four-wing saltbush (*Atriplex canescens*)

(Figure 4). This is a tall shrub (up to 1.5 m), which forms a pure stand in a narrow (< 200m) strip around Delamar Dry Lake playa. While four-wing saltbush is not an obligate phreatophyte, it is known to send its roots down up to 12m deep near playas in the Mojave Desert of California (Howard 2003). Intolerant of late season flooding, this shrubland is no doubt sustained by spring seasonal flooding that saturates valley soils and arrives at the playa, where the four-wing continues to harvest it from the deep soils during the growing season.

Figure 3. Winterfat (*Krascheninnikovia lanata*) – big galleta (*Pleuraphis rigida*) steppe, Dry Lake Valley, Lincoln County, Nevada. Photograph by the author.

Smaller, shallow-rooted xerohalophytes such as shadscale (*Atriplex confertifolia*) dominate mixed shrublands outside this strip, phasing rather abruptly into black sagebrush (*Artemisia nova*) shrublands. Overlain on this shrubland transition, Joshua tree woodlands occupy an overstory position to the west, south and east of Delamar Lake and these woodlands ascend into the Delamar Mountains to the east and South Pahroc Range to the west. This series repeats to a lesser extent in the extreme southern portions Dry Lake Valley, where very open Joshua woodlands occupy the piedmont slopes between the valley and the North Pahroc Range to the west and the Burnt Springs Range to the east. Most of the lower part of the east valley system between the playas is dominated by winterfat (*Krascheninnikovia lanata*) dwarf shrublands, whether with abundant grasses such as Indian ricegrass (*Achnatherum hymenoides*) or big galleta (*Pleuraphis rigida*) (Figure 3), in pure stands (Figure 4), or with other shrubs forming a mixed shrubland.

Figure 4. Winterfat (*Krascheninnikovia lanata*) pure stand dwarf shrublands with black sagebrush (*Artemisia nova*) shrublands in the distance. Cave Valley, Lincoln County, Nevada. Photograph by the author.

As one ascends onto the piedmont slopes that rise out of these valleys, the winterfat and saltbushes fade away and sagebrush (*Artemisia* spp.) species become the dominant shrubs, these with an array of other shrubs, forbs, grasses and trees. An unusual community in Dry Lake Valley within the sagebrush is a black sagebrush (*Artemisia nova*) shrubland with an overstory of Fremont Barberry (*Mahonia fremontii*). In spite of their spiny leaves, this large shrub produces edible berries and is highly prized as forage by wildlife and wild horses alike (Fig. 5).

Figure 5. Black sagebrush (*Artemisia nova*) shrublands with Fremont barberry (*Mahonia fremontii*) overstory in Dry Lake Valley, Lincoln County, Nevada. Photograph by the author.

In the southern third of the eastern valley system, Joshua tree (*Yucca brevifolia*) woodlands also arise in the upper piedmont, usually below where sagebrushes establish the dominant shrub in the community. These woodlands rise into both the South Pahroc range to the west of Delamar Valley and to the south and east of the valley into the Delamar Mountains (Fig. 6). Joshua trees find their northern limits near the southern end of Dry Lake Valley, where it ascends into the lower slopes of the Burnt Spring Range and North Pahroc Range. Here it associates with mixed shrublands of four-wing saltbush, spiny hopsage (*Grayia spinosa*), wolfberry (*Lycium andersonii*), rubber rabbitbrush (*Ericameria nauseosa*), and Nevada ephedra (*Ephedra nevadensis*) (Fig. 7). As Joshua tree becomes more uncommon, sometimes four-wing dominates the landscape (Fig. 8). In the extreme south, above Delamar Dry Lake, blackbrush (*Coleogyne ramosissima*) dominates the understory of Joshua tree woodlands in the South Pahroc Range and in the lower elevations of the Delamar Mountains, where its shrublands sometimes occur without Joshua trees, but with blue yucca (*Yucca baccata*) instead.

Figure 6. Joshua tree (*Yucca brevifolia*) woodland with golden cholla (*Cylindropuntia echinocarpa*) and Nevada ephedra (*Ephedra nevadensis*) in Delamar Valley. Nevada. Photograph by the author.

Figure 7. Open woodlands of Joshua trees (*Yucca brevifolia*) with an understory of four-wing saltbush (*Atriplex canescens*) and rubber rabbitbrush (*Chrysothamnus nauseosus*) in southern Dry Lake Valley, Nevada. Photograph by the author.

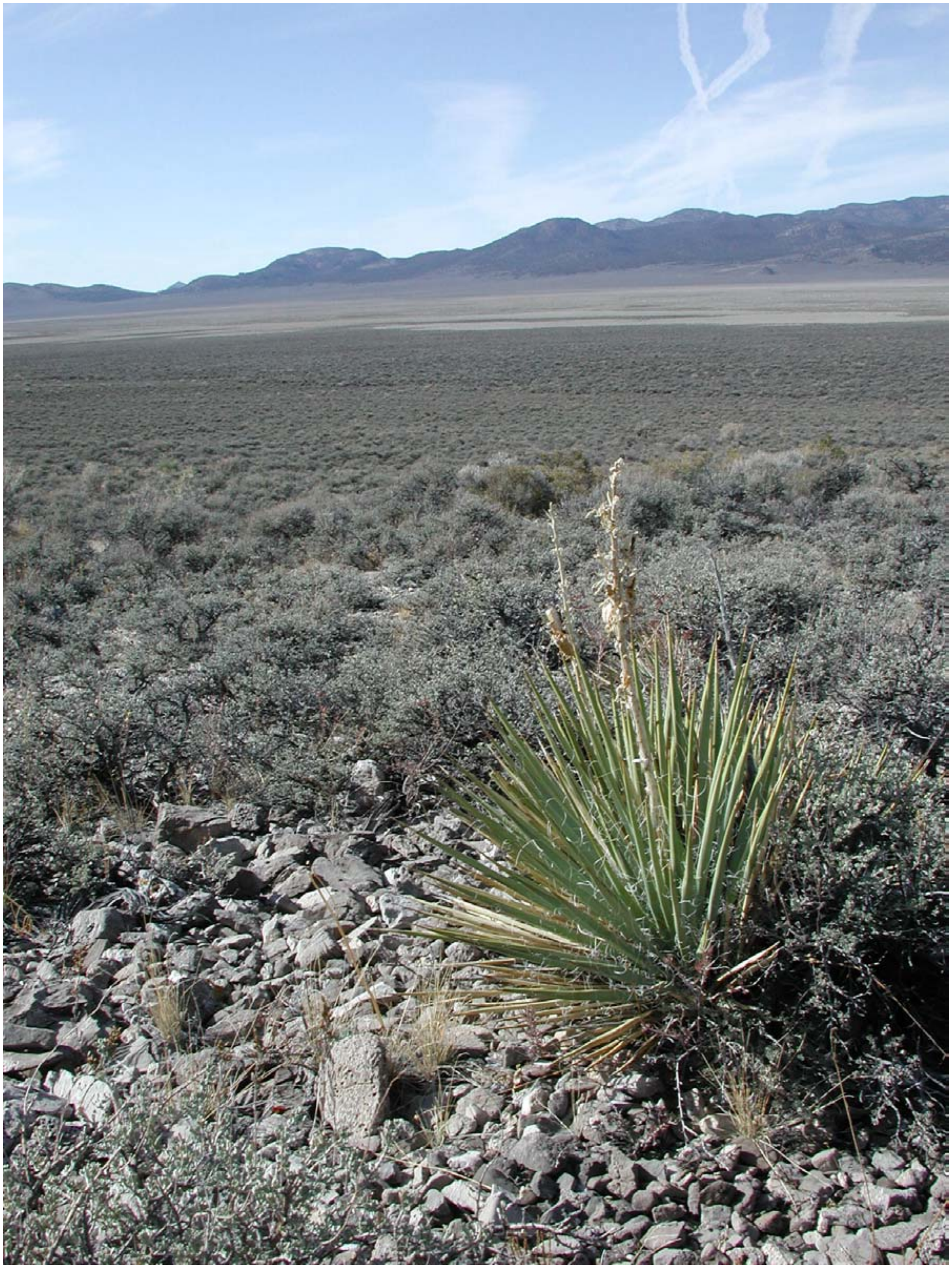
Figure 9. Four-wing saltbush (*Atriplex canescens*) tall shrublands, Dry Lake Valley, Lincoln County, Nevada. Photograph by author.

Further north in the eastern valley system, the vegetation series near the lakebed of Cave Valley has saltbush-dominated shrublands, these mainly shadscale (*Atriplex confertifolia*) but the braided washes that traverse the valley possess the taller four-wing and big Great Basin sagebrush (*Artemisia tridentata* ssp. *tridentata*). These saltbush shrublands also give way first to winterfat, but then through a narrower band of mixed shrublands until black sagebrush (*Artemisia nova*) dominates the landscape (Fig. 10). Black sagebrush is dominant in areas of hardpan and is a short-rooted *Artemisia*, usually occurring in areas with hardpan or caliche 2 feet or less beneath the soil surface. Terpenes of black sagebrush, like all other *Artemisia* species, are toxic to the microfauna of ruminants such as deer, cattle, and sheep (Young and Sparks 1985), but palatable to the well-adapted pronghorn (*Antilocarpa americana*). In the far north of the eastern valley system, open woodlands of Utah juniper (*Juniperus osteosperma*) overlay the black sagebrush shrublands and approach the valleys on the piedmont slopes of the Egan and Schell Creek Ranges flanking Cave Valley (Fig. 11). These ascend the slopes of these massive ranges, until they are themselves overcome by heavy precipitation and cold temperatures, giving way to montane forests of white fir (*Abies concolor*) and subalpine forests of bristlecone (*Pinus longaeva*) and limber (*Pinus flexilis*) pine.

Figure 10. Black sagebrush (*Artemisia nova*) shrublands in Cave Valley, Lincoln County, Nevada.

Figure 11. Open woods of Utah juniper (*Juniperus osteosperma*) with black sagebrush (*Artemisia nova*) in Cave Valley, Lincoln County, Nevada.

Figure 12. Soaptree yucca (*Yucca elata*) with black sagebrush (*Artemisia nova*) overlooking the south end of Cave Valley, Lincoln County, Nevada. Black sagebrush shrublands extend downslope toward the silvery sheen in the lower portion of the valley, which are winterfat (*Krascheninnikovia lanata*) dwarf shrublands.



Ecosystems of White River Valley, Pahranagat Valley, and Pahroc Valley Watersheds

The western valley system is similar to the eastern valley system mainly because these valleys are narrow and arranged from north to south in declining elevation. In addition, they share many of the same xeric plant formations such as winterfat and black sagebrush shrublands (Fig. 13), and Joshua tree woodlands.

Figure 13. Winterfat (*Krascheninnikovia lanata*) shrubland, with black sagebrush (*Artemisia nova*) island near center of photograph, dominating the White River Valley, Nye County, Nevada. Seaman Range in the distance. Note the 27 pronghorn (*Antilocarpa americana*) on the winterfat plain. Photograph by the author.

The valley systems are similar in that the western system descends 513 m in elevation from the White River Valley in the north to Pahranagat Valley in the south, and the system follows a 220 km latitudinal gradient from near Ely in the north to south of Alamo.

The valley systems are different due to the lower elevations of the western system, and their somewhat larger size. The southern half of the Pahranagat Valley possesses creosote bush (*Larrea tridentata*) shrublands that are absent from the higher, eastern valleys. But the valley systems are vastly different from one another in that the western system has surface water and associated vegetation features. These features include extensive wetlands in all three valleys (Fig.14) which are the focal points for Wildlife Management Areas (WMAs) administered by the Nevada Department of Wildlife (NDOW) in White River Valley and Pahroc Valley watersheds, as well as the Pahranagat National Wildlife Refuge (NWR) administered by the US Fish and Wildlife Service (USFWS) in the Pahranagat Valley watershed.

Figure 14. Wetlands dominated by bulrushes (*Scirpus* spp.), Kirch Wildlife Management Area, White River Valley, Lincoln County, Nevada. Photograph by the author.

In addition, these wetlands are associated with arboreal elements at the Key-Pittman WMA and the Pahranagat NWR. The Key-Pittman WMA has stands of willow (*Salix laevigata*), while the Pahranagat NWR as well as the agricultural areas in the valley have riparian galleria of Goodding willow (*Salix gooddingii*), Fremont cottonwood (*Populus fremontii*), and velvet ash (*Fraxinus velutina*) (Fig. 15). Tightly associated with the springs in the valleys are wet meadows (Fig. 16) and managed pastures (Fig. 17). The combination of these features provides a set of environments that supply resources to elements of the regional biodiversity that no longer exist between Lake Mead and Ash Meadows, a distance of 135 km. The patchy and diverse nature of these resources, as well as their isolation, has fostered a hotbed of biodiversity and rare and endemic species.

Figure 15. Four-wing saltbush (*Atriplex canescens*) tall shrublands (gray foreground) and Fremont cottonwood (*Populus fremontii*) Goodding willow (*Salix gooddingii*) – velvet ash (*Fraxinus velutina*) riparian gallery in Pahranagat Valley, Lincoln County, Nevada. Creosote bush (*Larrea tridentata*) in the foreground, Badger Mountain of the Pahranagat Range in the background. Photograph by the author.

Figure 16. Wet meadows in Pahranagat Valley, Lincoln County, Nevada. East Pahranagat Range in background. Photograph by the author.

Figure 17. Pastures in Pahranagat Valley, Lincoln County, Nevada. Mount Irish in background. Photograph by the author.

Current Status of the Valleys' Ecosystems

Ecosystems of both valley systems, like most valleys in Nevada, are stressed (Brussard et al. 1999). Overgrazing, particularly during the late 1800s (Young and Sparks 1985, Charlet 2007), water diversions, and groundwater pumping have weakened the native plant communities.

The weakened state makes them susceptible to invasion by alien invasive weeds, especially cheatgrass (*Bromus tectorum*) in neutral soils and halogeton (*Halogeton glomeratus*) in more saline soils.

Existing water diversions have no doubt stressed the native plant communities of all the valleys in question. Ironically, in spite of the stress, the ecosystems of Cave, Delamar, and Dry Lake Valley are in better ecological condition than most Nevada valleys because the lack of flowing water in these basins lowered the impact of grazing and other human activities. The waters of the Pahranagat, Pahroc, and White River watersheds have supported not only human agriculture and attendant settlements, but also local wildlife and are critical to birds from all over the Western Hemisphere who use the wetlands as they traverse the continent twice a year on the Pacific Flyway (Brussard et al. 1999). At least 240 bird species are known from the Pahranagat National Wildlife Refuge alone (US Fish and Wildlife Service 1988), even though no formal survey has ever been conducted there. Nevertheless, in spite of our ignorance, all migratory bird species that move through the area are protected by the Migratory Bird Conservation Act (16 U.S.C. §§ 715-715r, February 18, 1929, as amended 1935, 1961, 1962, 1966-1968, 1970, 1973, 1976, 1978, 1983, 1984, 1986, 1988 and 1989)(US Fish and Wildlife Service 2007c).

Wildlife

The complexity and diversity of the entire suite of vegetation communities in both valley systems provides valuable cover and forage for pronghorn (Tanner et al. 2003) (Figure 16). Spending three days this autumn visiting each valley, the author counted more than 70 pronghorn in a single day (Fig. 18). In addition to pronghorn, Mule deer (*Odocoileus hemionus*) use all the valleys for winter range, as do wild horses (*Equus ferus*) (Fig. 19). During this time I also saw badgers and a pair of immature Golden Eagles (*Aquila chrysaetos*) feeding in Cave Valley. As we pointed out (Charlet and Rust 1991), the feeding range of Golden Eagles depends on the availability of springs fitting a narrow range of specifications in order to meet their water requirements.

Sensitive Species in the Terrestrial Ecosystems

Forty-seven species in these terrestrial ecosystems are sensitive according to the Nevada Natural Heritage Program (Appendix I; Nevada Natural Heritage Program 2007, written communication). Of these, 13 are vertebrates (2 reptiles, 7 birds, 6 mammals), 3 invertebrates (all butterflies), and 29 plant taxa. Of the plants, 8 are endemic to Nevada (Kartesz 1988), while 24 are endemic to the Great Basin and/or Mojave Desert (USDA Natural Resource Conservation Service 2007). Most of the plants (25) are upland taxa whose lives will be impacted only indirectly by the groundwater withdrawal project. However, the remaining 4 species will be put at risk directly by the groundwater pumping in the proposed project, as will 14 animal species. These species will all be indirectly affected by the project going forward.

Figure 18. Pronghorn (*Antilocarpa americana*) in temporarily flooded greasewood (*Sarcobatus vermiculatus*) shrubland at the Malheur National Wildlife Refuge, Oregon, May 2003. Photograph by Phil Myers, Museum of Zoology, University of Michigan and downloaded from Animal Diversity Web, Museum of Zoology, University of Michigan.

Figure 19. Wild horses (*Equus ferus*) in Dry Lake Valley, Lincoln County, Nevada. Black Cliff of the Seaman Range in the distance. Photograph by the author.

Indirect Effects to Upland Taxa

Disturbance to the eastern valley system will come with the building of wells and the construction of the pipeline (Fig. 20). These operations clear local areas of vegetation, providing opportunities for invasive exotic weeds to colonize (D'Antonio and Vitousek 1992). The pipeline will create a corridor that promotes the opportunities for the weeds, as well as a corridor bisecting all the affected valleys that will further promote the opportunities for these weeds to invade the surrounding landscape. With the introduction of heavy machinery and a much greater human presence, we also introduce the greater likelihood of ignition and increase the possibility of catastrophic fire.

Figure 20. Well-drilling operation in Cave Valley, Nevada, 2 November 2007. Photograph by the author.

Ecosystems process and move enormous quantities of material. For instance, California wildfires in September 2006 produced about half of the estimated total monthly emissions of CO_2 from fossil fuel burning for the entire state (Wiedinmyer and Neff 2007). The preliminary estimates of CO_2 release during the devastating wildfires in southern California during the week of 19-26 October 2007 was about 7.9 million metric tons, equivalent to roughly a quarter of the monthly CO_2 emissions from fossil fuel burning for the entire state (National Science Foundation 2007).

Another example of how powerful ecosystems are and how much material is moved through them are the phreatophytic shrublands in Spring Valley, Nevada. These shrublands move so much water during their short growing season (ca. 213, 948 acre-feet in 173 days)(Devitt et al. 2006), that it captured the interest of a major utility (SNWA) to harvest some of this water (BLM 2004) to continue to feed the growth of one of the most rapidly growing urban areas in the United States (Deacon et al. 2007). It is interesting that to do their job, the plants in Spring Valley in 173 days move through their collective bodies more than 70% of the total amount of water withdrawn from Lake Mead in a year to support the people and their activities in the Las Vegas Valley.

Primary productivity involves the stripping of atmospheric CO_2 and putting it into the bodies of plants, rearranging the carbon and oxygen and assembling it into high-energy organic compounds such as glucose. Primary productivity can be measured as either an increase in biomass (dry weight of living organisms) or in the amount of chemical bond energy these living organisms have accumulated over a year. Either way we measure it, primary productivity is a result of plants conducting photosynthesis. Primary productivity involves plants not only pulling CO_2 from the atmosphere and "fixing" it in their bodies in the form of high-energy organic compounds, but the process depends on plants pulling water through their bodies for the purpose of incorporating some water (as a source of hydrogen) into glucose as well as to cool the plants during the process. Without water, plants cannot conduct photosynthesis, and reductions in water reduce plant productivity.

When a resource that limits productivity is removed from an ecosystem, the ecosystem must adjust accordingly. It is well known that the main resource that limits primary productivity in desert ecosystems is water. Therefore, when large amounts of water are withdrawn from desert ecosystems, the effects of this withdrawal are felt throughout all trophic, or feeding, layers of the system, and this effect can spill over into neighboring ecosystems. With lower primary productivity comes less growth and lower seed-set in plants. As plants fail to produce, the animals that depend on them, either directly (to herbivores through feeding on the plants) or indirectly (to carnivores feeding on the herbivores), are also negatively impacted. Individuals struggle to find enough feed and compete with one another, both between individuals of the same species (intraspecific competition) and between individuals of different species (interspecific competition), to the detriment of both competitors. As the competition for food progresses, the condition of the competitors continues to decline, and this in turn limits their fitness, or reproductive success.

As water is withdrawn from Cave, Delamar and Dry Lake Valleys, the hydrogeologic effect spills over into the neighboring, downstream watersheds of Pahranagat, Pahroc and the White River (Myers 2007). Plants that depend on this water suffer, and the animals that depend on the plants also suffer, and this effect works its way up through all the trophic layers until it impacts the large creatures that we have grown to know and love in these systems such as pronghorn, Golden Eagles, Snowy Egrets, Great Blue Herons, and many others, by reducing the size and productivity of their habitat, and their effective feeding range.

Direct Effects on Ecosystems and Their Species

An example of the ripple effect that will course through the ecosystems of this area can be seen with the butterflies. Several species of rare resident butterflies as well as migrants such as the Monarch butterfly (*Danaus plexippus*) depend on the late season productivity of the meadows, wetlands, and riparian forests in the western valley system considered here. Continued reproductive success of butterflies depends on a food source for their developing larvae. In the valleys in question, *Speyeria nokomis* feeds on violets (*Viola* spp.), *Limenitis archippus* ssp. depend on willows (*Salix* spp.) and cottonwoods (*Populus* spp.), *Phyciodes* spp. rely on thistles (*Cirsium* spp.) and saltgrass (*Distichlis spicata*) and other plants of wet meadows. Other rare butterflies in the area include *Cercyonis pegala pluvialis*, *Hesperia uncas grandiose, Polites sabuleti nigrescens* (Bruce Boyd, Lepidopterist, Nevada State Museum, written communication 2007).

The direct effect of groundwater pumping will also be seen in animals who are less visible but nevertheless remarkable in their ability to make a living in the desert. Some of these animals are rare, such as the Pahranagat Valley Montane Vole (*Microtus montanus* ssp. *fucosus*), which occurs in tall grasses tightly associated with springs in the Pahranagat Valley and nowhere else in the world. In the study area there are three bat species identified as of conservation concern by the Nevada Natural Heritage Program and The Revised Nevada Bat Conservation Plan (Bradley et al. 2006): the western small-footed myotis (*Myotis ciliolabrum*), pallid bat (*Antrozous pallidus*), and the silver-haired bat (*Lasionycteris noctivagans*). While very little is known about their ecological requirements, we do know that they are all rare in Nevada and all utilize the wetlands to prey upon flying insects there (Bradley et al. 2006).

The Rare Parish Phacelia

A rare occurrence in White River Valley is Parish phacelia (*Phacelia parishii*). *Phacelia parishii* is locally abundant either by itself or with Fremont phacelia (*Phacelia fremontii*) in open spaces between *Atriplex* shrubs on the margins of dry lakebeds. The species sprouts once the ephemeral waters of the lake evaporate and the playa mud begin to dry and separate in mid-spring (Figure 21). *Phacelia parishii* populations are naturally isolated from one another given their dependence on dry lakebeds. The playas in which it occurs are necessarily separated from one another. Weak connections exist between the playas via low passes between mountains. Dispersal between valleys, and subsequent gene flow between individuals in these locales, probably depends on occasional long-distance wind dispersal of its small seeds. Parish phacelia was included on Nevada's watch list by Mozingo and Williams (1980) and is covered in the Clark County Multiple Species Habitat Conservation Plan (MSHCP) (The Nature Conservancy 2007). Conservation Status reports for *Phacelia parishii* were prepared for its range in California (Constance 1979), and the Nevada Test Site (Blomquist et al. 1995). Smith (1996) prepared a comprehensive report for the species throughout its distribution, with particular focus on its Nevada populations. The Nevada Natural Heritage Program has the species on its watch list, and has a fact sheet and general map available to the public (Morefield 2001). It is globally imperiled, and critically imperiled in Arizona and California. However, *Phacelia parishii* is not threatened, endangered, or a candidate for listing under the ESA. Similarly, the species has no protection from the State of Nevada (Morefield 2001).

The species is nearly endemic to Nevada, with only two locations known outside the state, one small population in California and another small one in Arizona. In Nevada, it is known historically from Stewart Valley (Nye County), White River Valley (Nye County), Lake Valley (Lincoln County), Three Lakes Valley (Nye County), Indian Springs Valley (Nye and Clark Counties), and at four locations in Spring Valley. *Phacelia parishii* status in Indian Springs and Three Lakes Valleys (in the Nevada Range Complex) is uncertain (Frank Smith, personal communication 2004, The Nature Conservancy 2007). Groundwater withdrawal from Spring Valley by the SNWA approved by the State Engineer may imperil the populations of this species in that valley (Charlet 2006). That leaves only the Stewart, White River, and Lake Valley populations that are more or less secure at this time, but even these are receiving increasing pressure (The Nature Conservancy 2007).

Figure 21. *Phacelia parishii*, blooming in the drying playa mud of Stewart Valley, Nye County, Nevada. Photograph by the author.

The species requires either spring discharge or winter to early spring precipitation in sufficient quantities to form ephemeral lakes in the playas where it occurs. Exactly how much water is needed is unknown, as are few of the biological or geophysical factors necessary for its survival and reproductive success (The Nature Conservancy 2007). *Phacelia parishii* has a tiny, tubular flower that is insect-pollinated, almost certainly a solitary bee that nests in the clays of the playa where the larvae develop and pupate during the non-growing season (Rich Rust, University of Nevada Biology Professor, personal communication 2004).

Southwestern Willow Flycatcher

The fourth largest population of Southwestern Willow Flycatcher (*Empidonax traillii* ssp. *extimus*) occurs in the Pahranagat Valley, from the Key-Pittman WMA south through Maynard Lake in the Pahranagat NWR (US Fish and Wildlife Service 2002: Table 9). The life history and continued reproductive success of the Southwestern Willow Flycatcher requires dense riparian systems (US Fish and Wildlife Service 2002). Breeding habitats are near open water, marshes, or muddy and saturated soils, with individual territories established only rarely more than 50 m from these features (US Fish and Wildlife Service 2005).

Riparian stands at Pahranagat NWR are tightly associated with open water and saturated soils. Reduction in water will reduce the productivity of these forest stands, hence knocking out the insects that depend on the vegetation. Those insects are the food base of the flycatcher. In addition, flycatchers nest in dense riparian systems to conceal themselves from predators. The reduced ability for the flycatchers to conceal their nests in thick vegetation will also compromise their recovery. Standing water under the nest sites may have the additional benefit of reducing the ability of terrestrial predators to access the trees in which the flycatchers are nesting The sequence of events following groundwater withdrawal is simple, predictable, and inevitable in the case if the Southwestern Willow Flycatcher in the Pahranagat NWR and Key-Pittman WMA. Groundwater drawdown leads to decline of the vegetation; this leads to the decline of the insects and available cover; these factors lead to the demise of the flycatcher's reproductive success in these systems.

Field studies followed by Population Viability Analysis have determined that the Southwestern Willow Flycatcher will be promoted with more breeding territories in more areas, and with breeding sites dispersed over a large geographic area (Lamberson et al. 2000). According to the Recovery Plan for the species, in order for the flycatcher to be removed from the endangered list and go to the threatened list, annual breeding territories in the Pahranagat Management Unit (including both the Pahranagat NWR and the Key-Pittman WMA) need to rise from 34 to 50 (US Fish and Wildlife Service 2002). The SNWA groundwater withdrawal plan would work against the Recovery Plan for the species by reducing important habitat for the species in an area felt to be relatively secure, the Pahranagat Management Unit. Reductions in spring flow necessarily lead to reduction in habitat, imperiling this species that is afforded the maximum level of protection the law allows by virtue of its status as Listed Endangered.

Effects of Proposed Action on the Valleys' Ecosystems

The groundwater development proposed by the SNWA for the eastern valley system (Cave, Dry Lake, and Delamar Valleys) will severely compromise the meadows and wetlands of the western valley system (White River, Pahroc, and Pahranagat watersheds) due to the eventual drawdown of spring discharge in these basins (Myers 2007).

The proposed interbasin water transfer may affect the White River Valley population of *Phacelia parishii* insofar as they will reduce surface water flow from spring discharge, and so not moisten as much of the playa margins as is presently the case. The State Engineer has already approved a limited withdrawal of groundwater from Spring Valley, where another *Phacelia parishii* population resides, and I proposed at the hearing that this action may not only affect the Spring Valley population, but may impact the hydrographically connected Lake Valley population, these sustained by seasonal flooding of the playa in Lake Valley. If so, this leaves only the Stewart Valley populations without imminent threats on their event horizons. Moreover, the proposed action may have negative effects on the populations of the unknown pollinator of *Phacelia parishii*. It is necessary for the females of the pollinator species (probably a ground-nesting, solitary bee) to have wet mud in order to build their nests (Richard Rust, Emeritus Professor of Biology, University of Nevada personal communication 2004).

The general trend of the ecosystems during the proposed action will be to simplify the vertical structure of the vegetation, reduce the biodiversity of the communities, transform wetlands into xeric sites, and dramatically reduce the amount of palatable forage in the western valley system.

Predicted Successional Series During 2000 years of Pumping

The successional series of communities that will replace them will likely be rather simple. Cheatgrass invasion in the suite of xeric shrublands and woodlands in both valley systems, will be facilitated by the large-scale disturbance that will occur in the valleys in question, and the condition of these systems will be degraded and stressed. Should there be fire events during this transition, the communities can easily become pure stands of cheatgrass. Some of these communities may potentially be converted to shadscale shrublands. An additional factor here that could come into play is the alien, saline-tolerant weed halogeton that will increase in these shrublands. A danger in this is a massive and inexplicable die-off in winterfat with the increase in halogeton, something that has been observed at the USDA Forest Service Desert Experimental Range Station in Pine Valley, Utah (Stan Kitchen, Desert Experimental Range Station Director, 2006, personal communication). Hopefully, the native shrub shadscale (*Atriplex confertifolia*) will ultimately dominate the area, representing a greatly simplified and far less valuable rangeland with poor wildlife value compared to the four-wing, mixed, and winterfat shrublands they replace, but far better than the *Halogeton* alternative.

The building of the pipeline through the valleys will provide establishment opportunities and migration corridors for the already resident alien weeds, and connecting this valley to more southerly valleys will provide a new corridor of migration for another alien grass wreaking havoc with ecosystems in the Mojave Desert, red brome (*Bromus madritensis*), further destabilizing the ecosystems of the valleys. The one-time disturbance of building a pipeline in the desert takes from 100-300 years for the reestablishment of the dominant woody vegetation (Lathrop and Archbold 1980).

There are precedents for these kinds of vegetation conversions (D'Antonio and Vitousek 1992). Simplification of vegetation structure is devastating to semi-arid ecosystems and has occurred in similar systems in Iran (Charlet 2007). In the western US, the interaction between cheatgrass and increased frequency of fire is well documented in sagebrush shrublands (Whisenant 1990), as it has been more recently for the cheatgrass relative, red brome (Bromus madritensis) in shrublands of the Mojave Desert (Brooks et al. 2004). To date, we have no effective restoration technique to combat the invasion of either of these species in native ecosystems (Brooks et al. 2004).

There is also danger of desertification in both valley systems, particularly in Pahranagat Valley, where a drawdown in spring flow may eventually result in the drying of all the Pahranagat lakes. A similar situation occurred in Owens Valley, California, after the Los Angeles Department of Water and Power drained the sources of the Owens River. In 1930, after the Los Angeles Aqueduct was only operating for 17 years, Owens Lake was dry. Now the Los Angeles Department of Water and Power is irrigating the lakebed in a $415 million project designed to reduce the toxic particulates that the lake has been releasing in the past 70 years (Biland and Fasano 2007). I anticipate the consequences to wildlife and people that inhabit Pahranagat Valley will be severe and similar to those seen in Owens Valley. The diverse combination of multi-layered shrublands, woodlands, and riparian forests magnifies the wildlife value of these ecosystems, especially to the resident and migratory birds.

The perennial yield (PY) of water in a hydrographic basin is essentially determined by the groundwater evapotranspiration (GW ET) of that basin. We operate as if the entire PY of a basin is there for us to harvest and move to promote urbanization in distant basins. However, these transfers remove it from basins where animals depend on plants doing their job and putting biologically available chemical energy into the ecosystems. If we persist in this, we will continue to see a rapid degradation of Great Basin and Mojave Desert ecosystems, eventually imperiling our economic well-being and negatively affecting our quality of life.

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Appendix I. Sensitive terrestrial species in the Pahroc, Pahranagat, White River, Dry Lake, Cave Valley, and Delamar Valley Watersheds, Lincoln, Nye, and White Pine Counties, Nevada. Agency categories and endemism to either Nevada (NV) or Great Basin / Mojave Desert regions (GB) indicated. Key to codes appears at the end of the appendix.

Binomial	USFWS	BLM	USFS	State	Srank	Grank	NV endemic	GB endemic
Plants: 29 species	.	.	.	.	.	.	.	.
Agave utahensis var. *eborispina*	.	.	.	.	S3	G4T3Q	.	1
Arabis shockleyi	.	.	C;I	.	S3	G3	.	1
Asclepias eastwoodiana	xC2	N	S	.	S2	G2Q	.	.
Astragalus calycosus var. *monophyllidius*	.	.	.	.	S2	G5T2Q	.	1
Astragalus convallarius var. *finitimus*	.	.	.	.	S3	G5T3	.	1
Astragalus jejunus var. *jejunus*	.	.	.	.	S2?	G3T3	.	.
Astragalus oophorus var. *lonchocalyx*	xC2	N	.	.	S2	G4T2	.	1
Astragalus uncialis	.	N	S	.	S1	G2	.	1
Coryphantha vivipara var. *rosea*	.	.	.	CY	S3	G5T3	.	1
Cryptantha welshii	xC2	N	.	.	S3	G3	1	1
Ericameria watsonii	.	.	.	.	S3	G3G4	.	.
Erigeron ovinus	.	N	.	.	S2	G2	1	1
Erigeron uncialis var. *uncialis*	.	.	S;I	.	S2?	G3G4T2?	.	1
Eriogonum darrovii	.	.	.	.	S2	G2	.	.
Frasera gypsicola	xC2	S	.	CE	S1	G1	.	1
Ivesia arizonica var. *saxosa*	.	N	.	.	S1	G3G4T1	.	1
Jamesia tetrapetala	.	N	S	.	S2	G2	.	1
Lesquerella hitchcockii	.	.	.	.	S3	G3	.	1
Machaeranthera grindelioides var. depressa	.	.	.	.	S3	G5T3T4	.	.
Mentzelia tiehmii	.	N	.	.	S1S2	G1G2	1	1
Penstemon leiophyllus var. *francisci-pennellii*	.	.	.	.	S2	G3T2	1	1
Penstemon moriahensis	.	.	S	.	S1S2	G1G2	1	1
Perityle intricata	.	.	.	.	S3	G3	.	1
Phacelia parishii	.	N;C	.	.	S2S3	G2G3	.	1
Silene nachlingerae	.	N	S	.	S2	G2	1	1
Sisyrinchium radicatum	.	.	.	.	S1S2	G2?Q	.	1
Townsendia jonesii var. *tumulosa*	.	N	S	.	S3	G4T3	1	1
Trifolium andinum var. *podocephalum*	.	N	S	.	S1	G3T1	1	1
Viola lithion	xC2	N	S	.	S1	G1G2	.	1
Reptiles: 2 species	.	.	.	.	.	.	.	.
Gopherus agassizii	LT	S	T	YES	S2S3	G4	.	.
Heloderma suspectum cinctum	xC2NL	N;C	.	YES	S2	G4T4	.	.
Mammals: 6 species	.	.	.	.	.	.	.	.
Microtus montanus fucosus	xC2	N	.	YES	S2	G5T2	.	.
Microdipodops megacephalus albiventer	xC2	N	.	YES	S2	G4T2	.	.
Myotis ciliolabrum	.	N;C	.	.	S3	G5	.	.
Antrozous pallidus	.	N;C	I	YES	S3	G5	.	.
Brachylagus idahoensis	.	N	.	YES	S3	G4	.	.
Lasionycteris noctivagans	.	N	.	.	S3	G5	.	.
Birds: 5; 7 total species	.	.	.	.	.	.	.	.
Coccyzus americanus occidentalis	C	S	I	YES	S1B	G5T3Q	.	.
Empidonax traillii extimus	LE	S	E	YES	S1B	G5T1T2	.	.

Binomial	USFWS	BLM	USFS	State	Srank	Grank	NV endemic	GB endemic
Phainopepla nitens	.	N	.	YES	S2B	G5	.	.
Charadrius alexandrinus nivosus	.	N	.	YES	S3B	G4T3	.	.
Ixobrychus exilis hesperis	xC2	N	.	YES	S2B	G5T3T4	.	.
Haliaeetus leucocephalus	xLE	.	.	.	.	.	.	.
Falco peregrinus	LE	.	.	.	.	.	.	.
Invertebrates: 3 species	.	.	.	.	.	.	.	.
Cercyonis pegala pluvialis	xC2	N	.	.	S2	G5T2	.	.
Hesperia uncas grandiosa	xC2	N	.	.	S1	G5T1	.	.
Polites sabuleti nigrescens	.	.	.	.	S3	G5T3	.	.

Key to Appendix Codes:

U. S. Fish and Wildlife Service (Usfws) Categories for Listing under the Endangered Species Act:

LE	Listed Endangered - in danger of extinction in all or a significant portion of its range
LT	Listed Threatened - likely to be classified as Endangered in the foreseeable future if present trends continue
C	Candidate
x C2	Former Category 2 Candidate, now species of concern
NL	Not Listed (no status) in a portion of the species' range
SA	Similarity of appearance species
xLE	Former Listed as Endangered

Bureau of Land Management (Blm) Species Classification:

S	Nevada Special Status Species - USFWS listed, proposed or candidate for listing, or protected by Nevada state law
N	Nevada Special Status Species - designated Sensitive by State Office
C	California Special Status Species (see definition S and N)

United States Forest Service (Usfs) Species Classification:

I	Region 5 (Inyo NF) sensitive species
C	Region 5 sensitive species, not yet known from Inyo NF or LTBMU
E	Region 4 and/or Region 5 Endangered species
T	Region 4 and/or Region 5 Threatened species

Nevada State Protected (State) Species Classification:

Fauna:	
YES	Species protected under NRS 501.
Flora:	
CY	Protected as a cactus, yucca, or Christmas tree (NRS 527.060-.120)

Nevada Natural Heritage Program Global (Grank) and State (Srank) Ranks for Threats and/or Vulnerability:

G	Global rank indicator, based on worldwide distribution at the species level
T	Global trinomial rank indicator, based on worldwide distribution at the infraspecific level
S	State rank indicator, based on distribution within Nevada at the lowest taxonomic level
1	Critically imperiled and especially vulnerable to extinction or extirpation due to extreme rarity, imminent threats, or other factors
2	Imperiled due to rarity or other demonstrable factors
3	Vulnerable to decline because rare and local throughout its range, or with very restricted range
4	Long-term concern, though now apparently secure; usually rare in parts of its range, especially at its periphery

5	Demonstrably secure, widespread, and abundant
A	Accidental within Nevada
B	Breeding status within Nevada (excludes resident taxa)
H	Historical; could be rediscovered
N	Non-breeding status within Nevada (excludes resident taxa)
Q	Taxonomic status uncertain
U	Unrankable
Z	Enduring occurrences cannot be defined (usually given to migrant or accidental birds)
?	Assigned rank uncertain

(Signed) David A. Charlet

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12 November 2007