SURVEY & STATUS REPORT FOR RARE GYPSOPHILIC PLANTS IN THE OJITO/WHITE MESA AREA OF SANDOVAL COUNTY, NEW MEXICO

DANIELA ROTH[1]
ROBERT SIVINSKI[2]
for
BUREAU OF LAND MANAGEMENT
RIO PUERCO FIELD OFFICE
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INTRODUCTION

The Ojito/White Mesa area, including the Ojito Area of Critical Environmental Concern (ACEC) and the Ojito Wilderness Area, is located in a geological diverse region of mostly Jurassic-age sedimentary strata about 5 miles southwest of San Ysidro in Sandoval County, New Mexico. This area is well known as habitat for rare plant species endemic to gypseous substrates. Although the draft management plan for the Rio Puerco Resource Management Area (BLM 2012) identifies *Sclerocactus papyracanthus* (gramagrass cactus) and *Astragalus knightii* (Knight's milkvetch) as the only plant species of concern in the Ojito ACEC, this short list is not comprehensive and probably inaccurate. Although gramagrass cactus does occur in the White Mesa area, there are no published records or herbarium specimens of Knight's milkvetch in this ACEC or the adjacent Ojito Wilderness Area. In fact, it is the unique gypsum soils and its associated flora that make the Ojito/White Mesa area so special. This region contains gypsophilic plant species endemic to north-central New Mexico including *Townsendia gypsophila* (gypsum Townsend aster), *Abronia bigelovii* (tufted sand verbena), *Phacelia sivinskii* (Sivinski's scorpionweed) and *Mentzelia todiltoensis* (Todilto stickleaf). Both *T. gypsophila* and *A. bigelovii* are BLM Sensitive plant species (BLM 2011). The purpose of this study was to document these four rare gypsophilic plant species in the in the Ojito/White Mesa area and assesses their current status on BLM managed lands.

STUDY AREA

BLM lands in the Ojito/White Mesa area were initially given Special Management Area (SMA) designation until a large portion (11,183 acres) was formally declared a Wilderness Area in 2005. The Ojito ACEC is located between the wilderness on the west and White Mesa on the east and north. The Ojito ACEC currently encompasses 13,657 acres and includes large portions of the Ojito Wilderness. The BLM draft Resource Management plan proposes to reduce the size of the Ojito ACEC to exclude the wilderness area. Much of White Mesa is owned and managed by Zia Pueblo and State of New Mexico.

The most prominent geologic feature of the Ojito ACEC is the dramatically tilted and eroded southern end of the Tierra Amarilla Anticline (a.k.a. San Ysidro Anticline), which exposes a thick stratum of gray and tan gypsum in the Tonque Member of the Jurassic–age Todilto Formation. A thin stratum of sandy gypsum or gyseous sandstone at the base of the Jurassic-age Summerville Formation overlays the Todilto gypsum and also provides habitat for the gypsophilic plants of this region. The Todilto and Summerville gypsum strata have previously been placed in the Jurassic-age Morrison Formation by some researchers, but are no longer recognized as Morrison strata and are now separated as distinct formations by geologists (Lucas and Heckert 2003). The

[1] NM Energy, Minerals and Natural Resources Department-Forestry Division, Santa Fe
[2] RCS Southwest, Santa Fe, NM

Morrison Formation of the Ojito/White Mesa region is entirely above the Todilto and Summerville formations and does not contain any gypseous strata (Lucas and Heckert 2003). The Ojito Wilderness Area is mostly mudstone and sandstone strata of the Morrison Formation, with only a relatively small area of Summerville and Todilto gypsum in the northeastern corner of the wilderness (Soulliere and Long 1987). This area and the other gypsum outcrops in the ACEC were the focus of this field survey for rare gypsophilic plants (Figure 1).

Elevations range from 6,040-5,570 feet (1,840-1,700 m) and soil substrates grade from almost pure gypsum with gypsite/lichen crust to gypseous sandy loam. Vegetation cover is usually very sparse with scattered *Juniperus monosperma* (one-seed juniper), *Pinus edulis* (piñon pine), *Quercus* x *undulata* (waveyleaf oak), *Ephedra torreyana* (Torrey jointfir), *Yucca baileyi* (Bailey's yucca), and several common and widespread gypsophilic species including *Sporobolus nealleyi* (gyp dropseed), *Tiquilia hispidissima* (hairy crinklemat), *Oenothera hartwegii* subsp. *filifolia* (Hartweg's sundrops), *Tetradymia filifolia* (threadleaf horsebrush) and *Ascleisanthes lanceolata* (lanceleaf moonpod).

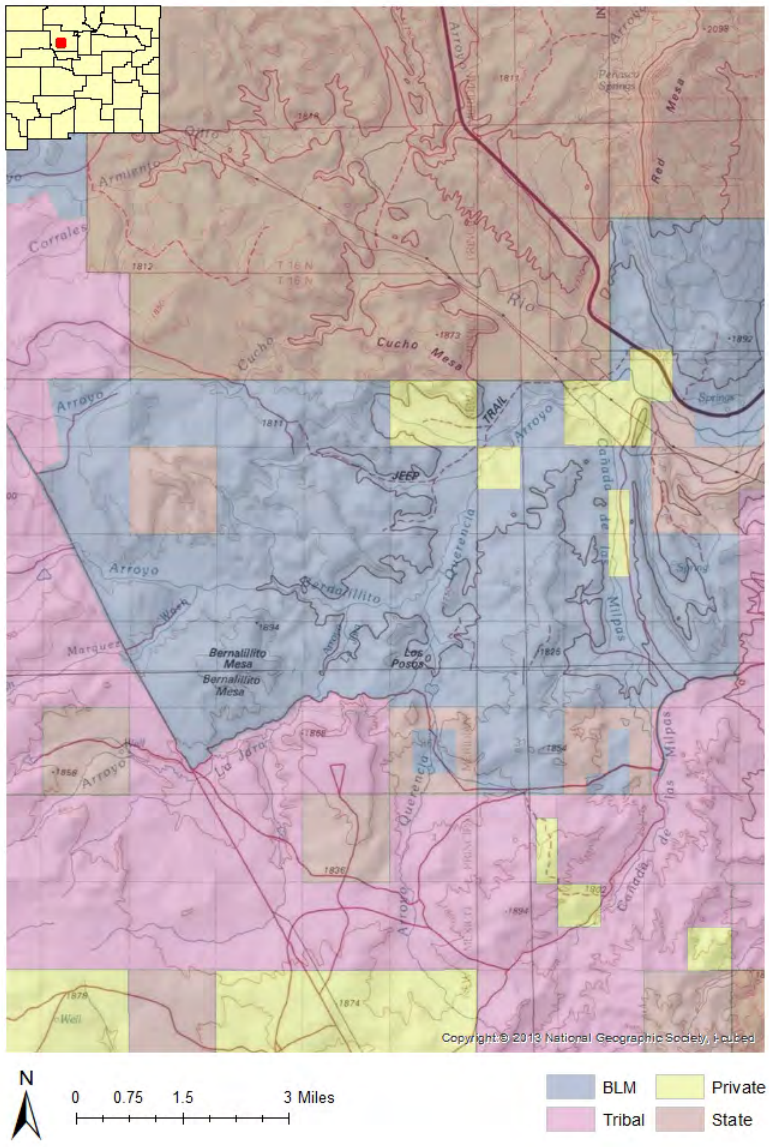

Figure 1. 2014-2015 Study Area boundaries within the BLM Ojito ACEC and Wilderness Area, Sandoval County, NM.

METHODS

Field surveys on the Ojito ACEC and the Ojito Wilderness occurred during summer and autumn of 2014 and 2015. Gypsum outcrops on BLM land that were previously surveyed for *Townsendia gypsophila* by Lowrey and Knight (1994) were all revisited during this survey. No formal surveys had previously been conducted to document the occurrences and distribution of *Abronia bigelovii, Mentzelia todiltoensis*, and *Phacelia sivinskii*. Limited existing occurrence documentation was provided by the New Mexico Natural Heritage Program. All the gypsum outcrops on BLM lands in Sections 7, 17, 18, 20, 21, 28, and 29, Township 15N, Range 1E were included in this survey (Figure 1). Additional gypsum outcrops in the study area were identified with satellite imagery on GoogleEarth and visited to confirm the presence of gypsum soils and rare gypsophilic plants. Areas evaluated and surveyed included Sections 15, 21, 22, 23, 24, 25 and 26, Township 15N, Range 1W in the Ojito Wilderness Area.

Two different methods of GPS mapping were employed for this field survey. Both *Townsendia gypsophila* and *Abronia bigelovii* occur in small scattered patches of plants and were not usually suited for walking polygons around occupied habitat. These two species were marked with GPS waypoints (sites) when encountered, then an estimated 15-meter (ca 50-foot) radius around the point was thoroughly searched and the number of plants recorded. Only a few small GPS polygons of densely populated habitat were delineated for these two species. *Mentzelia todiltoensis* and *Phacelia sivinskii* were far more abundant and often continuously distributed across large gypsum outcrops so could not be easily recorded with waypoints. Occupied habitats for these species are generally mapped as polygons that were roughly delineated in the field with a GPS unit and later expanded to include appropriate habitat boundaries. A few waypoints are included for these two species when isolated patches of plants were encountered. Population density counts of individuals were not usually attempted within the polygons for these two locally abundant species and were visually estimated. Plant populations are separated based on the 2004 NatureServe Habitat Based Strategy for Delimiting Plant Element Occurrences, which separates locations if they are more than 1 km apart within suitable habitat.

RESULTS

All of the gypsum strata and gypseous soils surveyed were habitats for at least one, and occasionally all, of the four gypsophilic plants endemic to north-central New Mexico (Figure 2). Except for plants found in Sections 7 and 18, all 4 sensitive plant species are restricted within the proposed new boundaries for the Ojito ACEC (preferred alternative). Sections 7 and 18 are located within the boundaries of the Ojito Wilderness. None of the areas surveyed in the Ojito Wilderness Area sections 15, 21, 22, 23, 24, 25 and 26 (Township 15N, Range 1W) contained suitable habitat for the 4 gypsum endemics and none were found.

No invasive species were documented in the habitat of the four sensitive species throughout the survey area. Documented disturbances include a natural gas storage facility and associated infrastructure, livestock trampling, dirt roads and off-road vehicle use, and recreational biking. The primary and most pervasive disturbance in the habitat of all four species is recreational activity in the form of designated bike trails, as well as an abundant number of non-designated “wildcat” bike trails (Figures 13 & 14). Plants and habitat for all 4 species along the Tierra Amarilla Anticline in Sections 28, 21, 20 (in part), and 17 are impacted by disturbances associated with recreational biking.

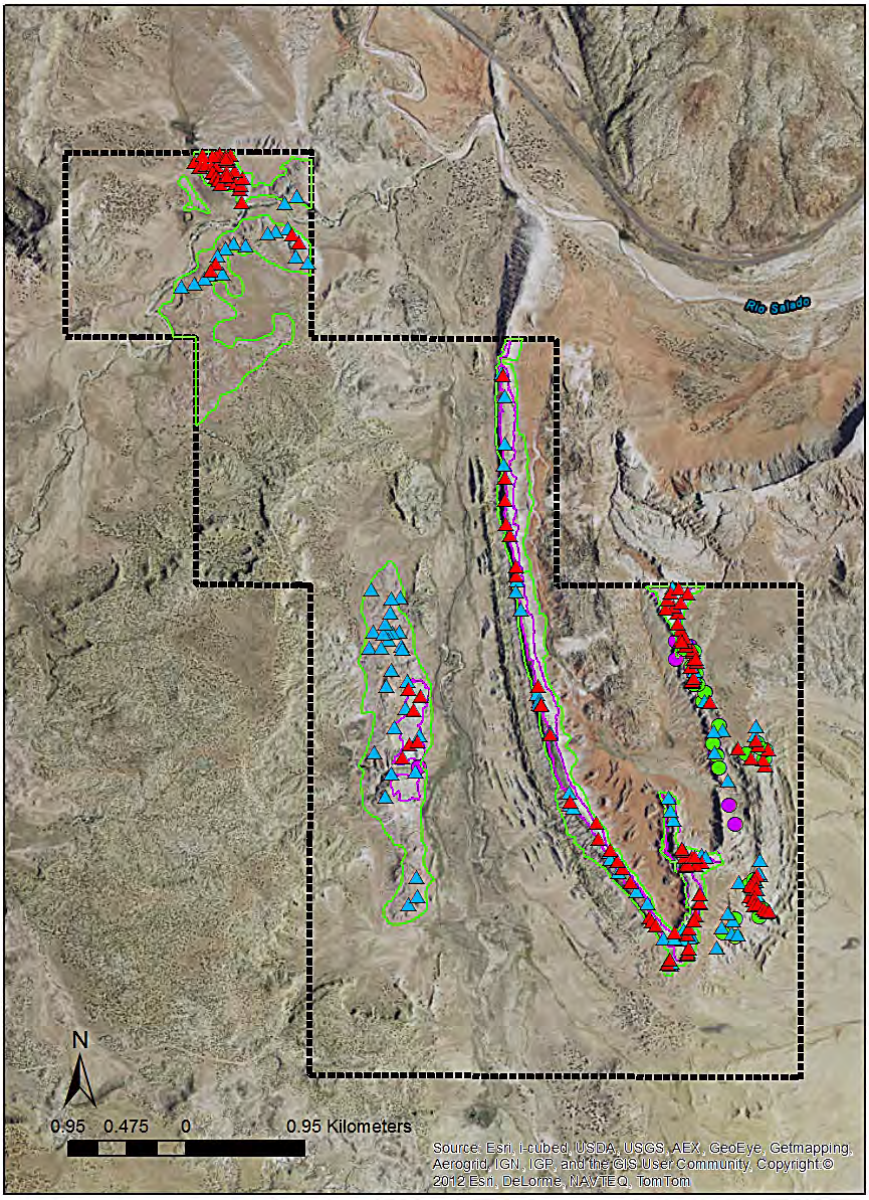

Figure 2. Locations of gypsophilic plant in the BLM Ojito ACEC and Wilderness Area. Red triangles: *Townsendia gyposophila*; Blue triangles: *Abronia bigelovii*; Violet circles and polygons: *Phacelia sivinskii*; Green circles and polygons: *Mentzelia todiltoensis*.

Townsendia gypsophila (Gypsum Townsend aster)

Townsendia gypsophila is a low-growing, caespitose perennial aster with white flowers and short strigose-pubescent leaves and white ray flowers (Figures 3, 4, 5). It is entirely endemic to the Todilto and Summerville gypsum strata in Ojito/White Mesa region. The entire world-wide range is less than 20 miles (ca 30 km) of discontinuous gypsum outcrops in Sandoval County (Lowrey and Knight 1994a).

This localized endemic has a NatureServe rank of G2/S2 (imperiled) because of its limited range and known threats. The New Mexico Rare Plant Technical Council R-E-D Code (R = Rarity, E = Endangerment, D = Distribution) for this rare plant is 2-2-3, meaning it is confined to several populations or one extended population; is endangered in a portion of its range; and is endemic to New Mexico (NMRPTC 1999).

Figure 3. Large *Townsendia gypsophila* in the BLM Ojito ACEC.

Figure 4. *Townsendia gypsophila* (foreground) on gypseous sandstone of the lower Summerville Fma near contact with barren Tonque Member of Todilto Fma gypsum (background).

Townsendia gypsophila still occurs at all of the previously documented locations on the major gypsum outcrops on BLM lands in the White Mesa area (Figure 6). This rare plant usually occurs as scattered patches of a few individuals on ridge tops, rolling hills and caprock rims. It can occur on all topographic exposures and does not usually occupy steep slopes. In 2014 & 2015, just over 1,000 individual plants were documented from 127 sites and 2 small polygons (Section 7) within the study area (Table 1). The majority of sites contained small groupings of plants ranging from 1 to 10 individuals. Few sites contained more than 10 individuals (18%). The highest concentrations of plants were found in sections 7 and 21 (Figure 6; Table 1). Based on the NatureServe Habitat Based Strategy for Delimiting Plant Element Occurrences (2004), the total number of Element Occurrences on BLM lands is 3. The spring and summer of 2015 were relatively wet with abundant rainfall. *Townsendia gypsophila* flowered summer to autumn and a few new seedlings were observed at all the population locations visited that year.

Townsendia gypsophila is more often found on a sandy gypsum layer of the lower Summerville Formation than on the underlying barren Tonque Member of the Todilto Formation, which is more pure gypsum (Figure 4). A dark, thin crust of cyanobacteria is often evident on the sandy gypsum and the many of the gypsum substrates are covered with a pinnacled crust of several lichen species (Figure 5). Disturbed areas are devoid of this plant.

Figure 5. Biological soil crusts in *Townsendia gypsophila* habitats. **Left Photo:** A bicycle trail (light surface) has eliminated the cryptogamic soil crust (dark surface) on Summerville sandy gypsum. Three *T. gypsophila* plants are on left edge of trail in foreground. **Right Photo:** Pinnacled soil crust on Todilto gypsum with at least five lichen species visible in photo.

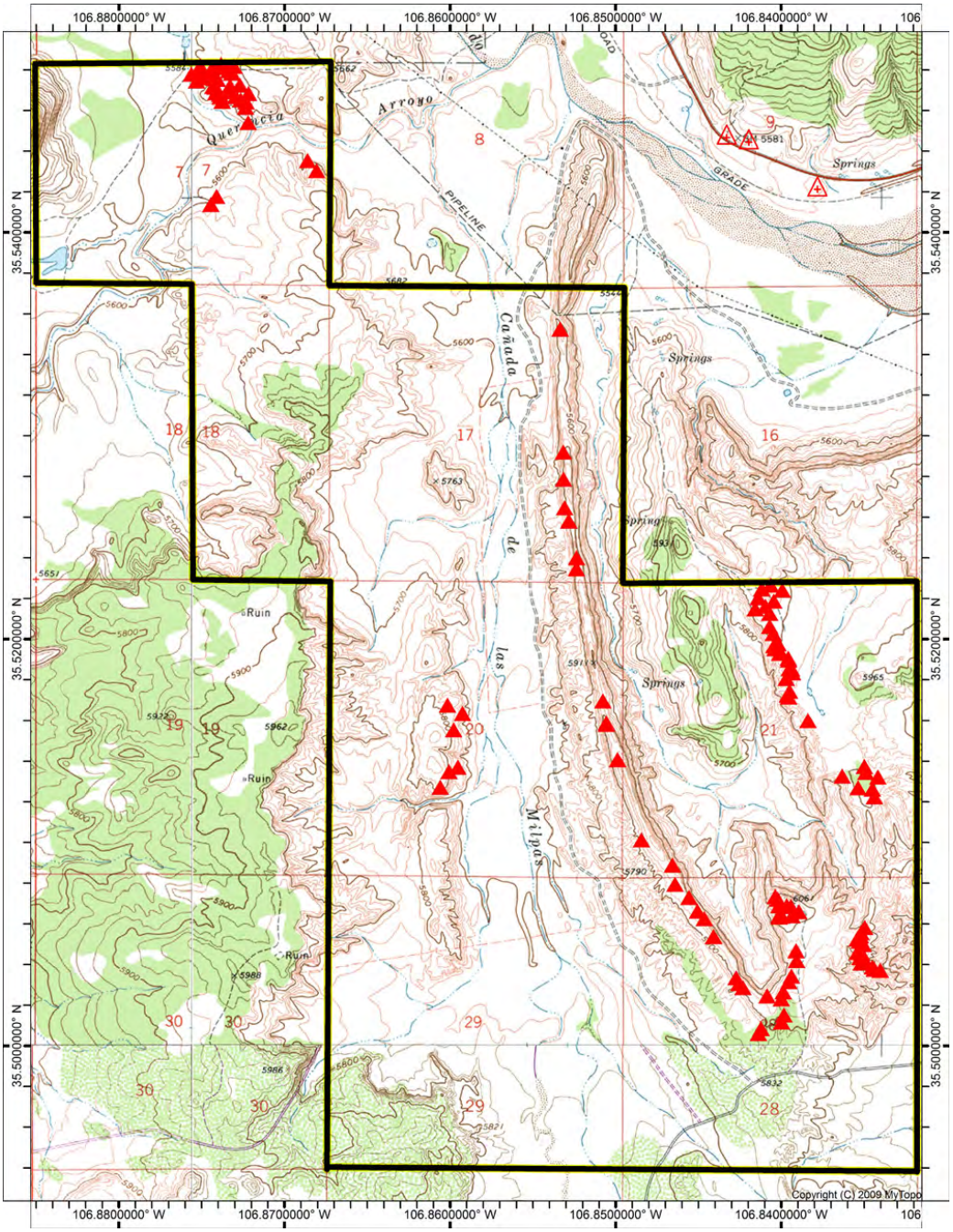

Figure 6. 2014-2015 *Townsendia gypsophila* distribution in the Ojito ACEC and Wilderness Area.

Table 1. Number of *Townsendia gypsophila* plants documented in 2014 and 2015 in the Ojito/White Mesa Study area.

TRS	Number of Plants
T 15N R1E Section 7	314 - 339
T 15N R1E Section 17	25
T 15N R1E Section 20	81
T 15N R1E Section 21	399
T 15N R1E Section 28	184
Total	**1003-1028**

Almost all of the locations documented by Lowrey and Knight in 1994 still had extant patches of plants observed in the 2014-2015 survey. The densities of plants found in this later survey, however, were low and generally significantly lower than the 1994 population assessment. For instance, Lowrey and Knight (1994b) found a very dense population of *T. gypsophila* in Section 7 (now within the Ojito Wilderness) and estimated a total density of 200,000 plants north of Querencia Arroyo in that section on Summerville gypsum between the northern boundary fence and Querencia Arroyo. The subsequent survey of this location in 2014 counted only between 314 and 339 plants in that same area, which is only about 0.17% of the 1994 estimate. In addition, Section 7 was the only surveyed area were livestock impacts were notable, likely due to the presence of a livestock watering tank in the vicinity of the *T. gypsophila* population north of Querencia Arroyo. A dirt road bisects this population and the habitat near the northern BLM boundary fence was impacted by off-road traffic.

Lowrey and Knight also found two populations of several hundred plants each on Todilto gypsum in the NW¼ of Section 20 in 1994. These could not be precisely relocated in the 2014-2015 surveys of that section and a much smaller population of only 53 plants was found a little further to south in the west-central part of Section 20 (Figure 6). This population was possibly misplaced on the 1994 survey map, yet the later survey shows a greatly diminished population from many hundreds in 1994 to only 53 plants 21 years later. The top of the ridge has been considerably disturbed by the establishment of a natural gas storage facility, including waste piles, roads, and storage tanks. It is unknown whether this disturbance primarily occurred after the 1994 surveys. A few *T. gypsophila* plants were found recolonizing some of the disturbed areas.

The 1994 survey map indicated a population of *T. gypsophila* in the NW¼ of Section 29, but this location is not discussed in the written report (Lowrey and Knight 1994b). The 2015 field survey of the location found little or no gypsum substrate and no *T. gypsophila*. The delineation of occupied habitat in Section 29 is most likely an error on the 1994 map.

The west rim of the anticline strikes north for approximately 2.5 miles from the old quarry near the center of Section 28 to the north edge of Section 17. It is a narrow ridge capped with Todilto gypsum and occasionally Summerville gypsum. *Townsendia gypsophila* was found along the top of most of this rim in 2014-2015 except for three unoccupied gaps of a quarter mile or more (Figure 6). Waypoints were marked for patches of plants ranging from 1 to 17 individuals, but most were small (5 or fewer). No population estimate was given in the 1994 survey report of this rim and simply reports that *T. gypsophila* was found along the entire traverse of the rim for approximately 13,000 feet (Lowrey and Knight 1994b), which, except for a few gaps, is still the case. Sections 17 and 28 are significantly impacted by recreational biking.

The east rim of the anticline from the quarry in Section 28 to the north line of Section 21 is more broken into small ridges and drainages. Todilto gypsum outcrops in a few interior locations, but the Summerville Formation is the dominant gypsum stratum along the southern and eastern edge. The 1994 survey reported scattered individuals of *T. gypsophila* on Todilto gypsum along the edge of the anticline from near the quarry to the "bench mark" (north center?) of Section 28. This scattering of plants was still the case for the 2014-2015 survey, which marked 17 small patches of plants along this half-mile of rim that totaled only 64 individuals. An additional location on Summerville gypsum was found during the 2014-2015 survey of the NE¼ that is also sparsely populated with only 81 total plants. The central portion of Section 28 (into Sections 17 & parts of Section 21) is the area most significantly impacted by bike trails.

There is significant discrepancy between the map locations and written descriptions for Section 21 locations of *T. gypsophila* in the survey report by Lowrey and Knight (1994b). The map shows only one small area of occupied habitat, but the report describes an extensive population on and below the rim of the anticline through Section 28. For instance, Lowrey and Knight describe *T. gypsophila* as growing "in profusion" on the Morrison (now called the Summerville) gypsum from just north of the center of Section 21 to the south boundary with Section 28. The 2014-2015 survey found only one small area of occupied habitat in that region, which consists of a few scattered plants totaling 45 individuals in the SE¼. Either this later survey failed to relocate the population found in 1994 or there has been dramatic decline of population density at this location. Lowrey and Knight (1994b) also describe, but do not map, a scattering of individuals

totaling about 100 “southeast of the North ¼-corner of the section”. The 2014-2015 survey did locate a relatively scattered, but occasionally dense patch of *T. gypsophila* starting just above the center of Section 21 then north to the center of the boundary with Section 16 (Figure 6). This habitat is a zone of contact between the Todilto and Summerville gypsum strata. A total of 349 plants were counted at this BLM location and the population continues north into the adjacent section of NM State Trust Land (Lowrey and Hafler 2014). Although just a few hundred plants, this is the most densely occupied habitat located during the 2014-2015 survey (Table 1).

Abronia bigelovii (Tufted sand verbena)

Abronia bigelovii is a low-growing, caespitose perennial with an umbel inflorescence of tubular white flowers and nearly linear semi-succulent leaves (Figure 7). It is entirely endemic to the northern outcrops of Todilto and Summerville gypsum strata in Rio Arriba, Sandoval County and Santa Fe counties (NMRPTC 1999). Typical habitats for *A. bigelovii* are gypseous sandy loams on the eroding breaks of hillsides and ridges. It occurs on all topographic exposures and can often occupy very steep eroding slopes and can recolonize lightly disturbed areas.

This localized endemic has a NatureServe rank of G3/S3 (vulnerable) because of its highly restricted range and habitat, the number of occurrences and documented threats in its habitat. The New Mexico Rare Plant Technical Council R-E-D Code for this rare plant is 1-1-3, meaning it is rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low for the foreseeable future; is not endangered; and is endemic to New Mexico (NMRPTC 1999).

Abronia bigelovii occurs on almost all of the same gypsum outcrops in the Ojito ACEC as does *Townsendia gypsophila* (Figures 2 and 8) and on the Ojito Wilderness Area gypsum outcrops in Section 7. These two gypsophilic plants can occasionally be found growing side by side. *Abronia*, however, is somewhat more abundant and widespread than the *Townsendia*. Although it may be a little more abundant, it still occurs in scattered patches and does not form dense populations. In 2014 & 2015, *Abronia bigelovii* was documented from 118 sites and one polygon, containing a total of 1,525-1,550 plants. The majority of plants occurred in small grouping of 1 to 20 individuals. Only a few documented sites contained more than 20 individuals (14%). One polygon documented 125-150 plants (Section 28). The highest concentration of plants were found in sections 7 and 28 (Figure 8). Based on the NatureServe Habitat Based Strategy for Delimiting Plant Element Occurrences (2004), the total number of Element Occurrences on BLM lands is 3. Observed disturbances to plants and their habitat are the same as those recorded for *Townsendia gypsophila,* with the primary disturbance being recreational biking in sections 17, 20, 21, and 28.

Figure 7. *Abronia bigelovii* in the BLM Ojito ACEC.

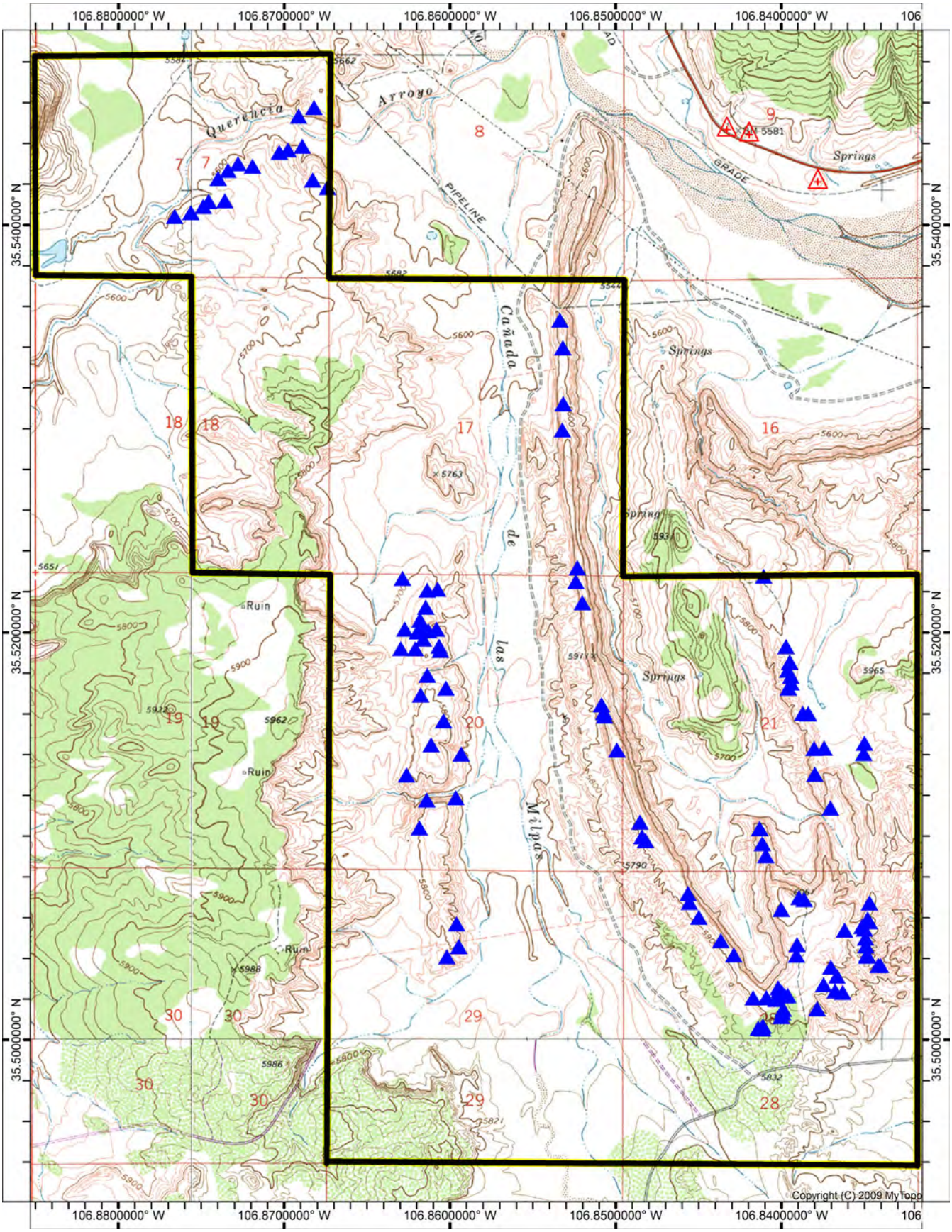

Figure 8. 2014-2015 *Abronia bigelovii* distribution in the Ojito ACEC and Wilderness Area.

Mentzelia todiltoensis (Todilto stickleaf)

Mentzelia todiltoensis is a stout, mostly perennial herb branching from the base with entire or pinnatisect leaves and sulphur yellow or cream flowers (Figure 9). It is one of the most recently described gypsophilic plant species from outcrops of Todilto Formation gypsum in north-central New Mexico (Atwood and Welsh 2005). This species was originally described for two widely separated populations – one near Tohajiilee in Cibola County and the other near Galisteo Dam in southern Santa Fe County. In the strict sense, this species is a strong perennial with entire, linear leaves and pale yellow flowers. However, the intervening Todilto gypsum outcrops near San Felipe and San Ysidro have extensive populations of mostly biennial plants with pinnatisect leaves (Figure 9) that will soon be placed within a broader circumscription of *M. todiltoensis* for the Flora of North America treatment of the genus (John Schenk and Larry Hufford, unpublished manuscript reviewed by Sivinski). Although they look quite different and distinct, the Ojito/White Mesa plants do have floral, fruit and seed morphologies similar to the type for *M. todiltoensis*. This broader circumscription of the species extends its distribution to all the large Todilto gypsum outcrops in Bernalillo, Cibola, Sandoval and Santa Fe counties, where it can be locally common. Therefore, the 2007 New Mexico Rare Plant Technical Council R-E-D Code for this species is not currently relevant since the NM Rare Plants website report has not been updated with new information (NMRPTC 1999). This species has not yet been given a relevant NatureServe G or S rank and it is not a BLM Sensitive Species.

The Ojito/White Mesa population of *M. todiltoensis* occurs on all the gypsum outcrops within the survey area. This plant does not occur in dense populations, but is fairly continuously distributed and therefore was primarily delineated by habitat polygons (Figure 10). It is frequently found growing together with *Phacelia sivinskii,* but has a broader distribution and is less abundant. A few scattered locations were marked with waypoints. *Mentzelia todiltoensis* occurs on both the Todilto and Summerville gypsum strata. It is most frequently found along steep slopes and on eroded bedrock and crumbling blocky colluvium at the bases of slopes. It can occupy all topographic exposures and will also tolerate some soil disturbance. A few plants were observed growing on pushed-up soil at the edges of old roads and well pads. An abundance of new seedlings were observed germinating on Ojito gyspeous soils in September 2015 after the rainy summer season. This plant is frequently found on the gypsum outcrops in the Ojito ACEC and on Ojito Wilderness Area gypsum in sections 7 and 18. Plants occur in small groupings distributed throughout the mapped polygons, numbering from several hundred to thousands of individuals. The largest concentration of plants was found along the Tierra Amarilla anticline in sections 17, 20, 21, and 28, where it occurs in the thousands. Based on the NatureServe Habitat Based Strategy for Delimiting Plant Element Occurrences (2004), the total number of Element Occurrences on BLM lands is 3. Observed disturbances to plants and their habitat are the same as those recorded for *Townsendia gypsophila,* with the primary disturbance being recreational biking in sections 17, 20, 21, and 28.

Figure 9. *Mentzelia todiltoensis* and habitat in the BLM Ojito ACEC.

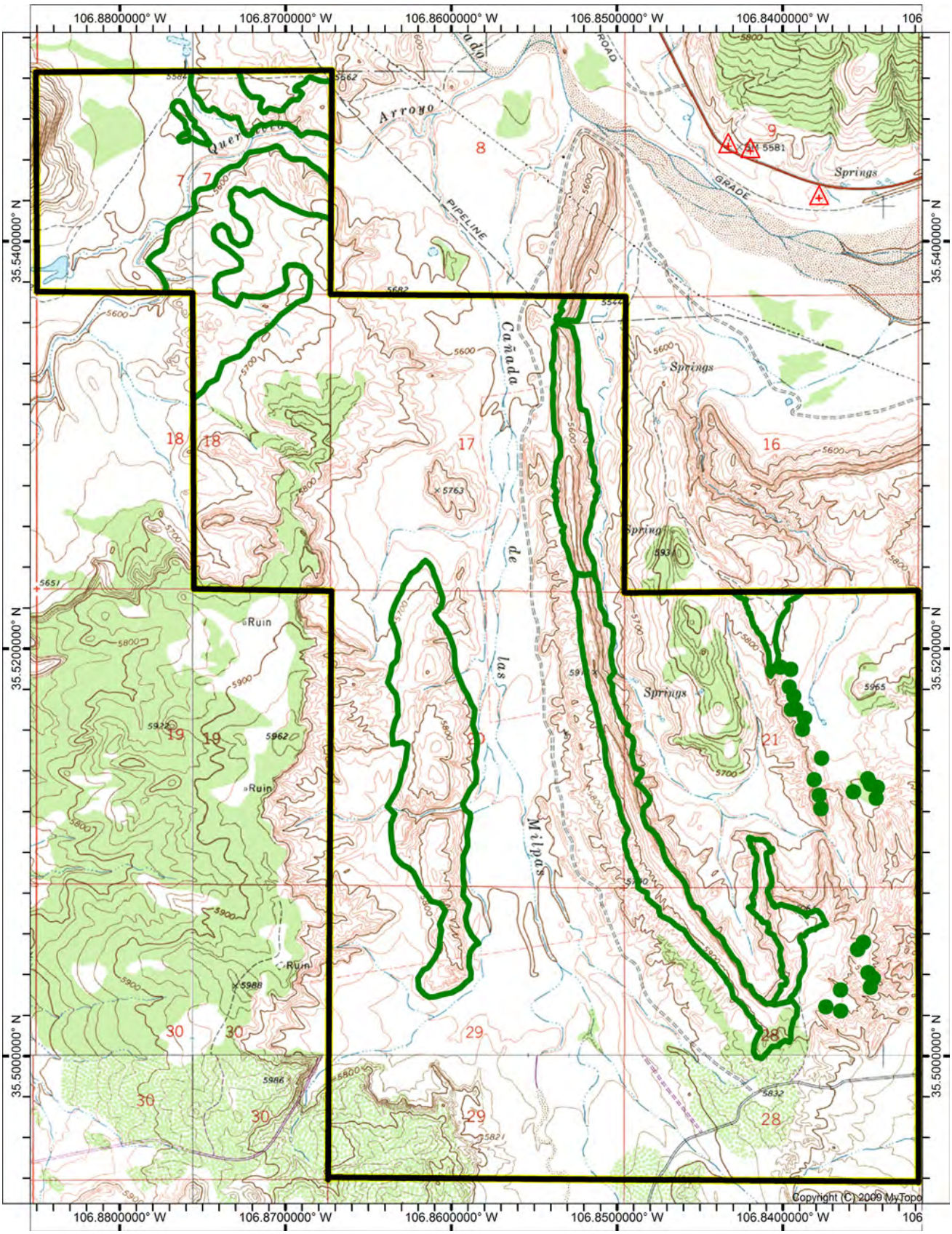

Figure 10. 2014-2015 *Mentzelia todiltoensis* distribution in the Ojito ACEC and Wilderness Area.

Phacelia sivinskii (Sivinski's scorpion weed)

Phacelia sivinskii was also described fairly recently from the Todilto gypsum of north-central New Mexico (Atwood and Welsh 2005). It co-occurs with *Mentzelia todiltoensis* and has the same Todilto Formation range as that species, but also extends somewhat further south onto gypsum outcrops of the Permian-age Yeso Formation in Valencia and Socorro counties. The New Mexico Rare Plant Technical Council gives *Phacelia sivinskii* a R-E-D Code of 1-1-3, meaning it is rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low for the foreseeable future; is not endangered; and is endemic to New Mexico (NMRPTC 1999). This species has not yet been given a NatureServe G or S rank and it is not a BLM Sensitive Species.

Phacelia sivinskii is an erect, leafy biennial with crenate-dentate leaves and sticky glandular hairs on the stems and leaves. Its small violet flowers are in coiled cymes at the ends of branches and there are numerous floriferous branches at the leaf axils from the top of the plant down to its base (Figure 11). It is fairly common and can be locally abundant in the Ojito/White Mesa region where it is almost entirely confined to the nearly barren outcrops of Todilto gypsum (Figure 11). It was rarely observed on Summerville sandy gypsum and then only near the contact with the underlying Todilto gypsum. It is most frequently found along steep slopes and can occupy all topographic exposures. On BLM managed lands *Phacelia sivinskii* is confined to the proposed boundaries of the Ojito ACEC (Figure 12). It does not occur on the gypsum hills in the Ojito Wilderness Area Sections 7 and 18 where there is very little outcrop of Todilto gypsum.

Plants occur in small groupings distributed throughout the mapped polygons, numbering from several hundred to thousands of individuals. The largest concentration of plants was found along the Tierra Amarilla Anticline in sections 17, 20, 21, and 28, where it occurs in the thousands, especially along steep slopes. Local abundance of *P. sivinskii* can vary dramatically from year to year in response to the amount and timing of precipitation. Adult flowering was abundant in the autumn of 2014 when large patches of plants on gypsum hillsides and benches numbered in the thousands along the Tierra Amarilla Anticline. Adult plant density was much lower in 2015 with no plants or a few scattered individuals in the same places where they were abundant during the previous year. Some areas in the Ojito ACEC were beginning to show good germination of seedlings by September 2015. Based on the NatureServe Habitat Based Strategy for Delimiting Plant Element Occurrences (2004), the total number of Element Occurrences on BLM lands is 2.

Observed disturbances to plants and their habitat are the same as those recorded for *Townsendia gypsophila,* with the primary disturbance being recreational biking in sections 17, 20, 21, and 28. However, this rare species prefers growing on steep, largely inaccessible slopes and can tolerate severe soil disturbance. It was observed growing within the pit and sidewalls of the old gypsum quarry near the center of Section 28 and on an old road and well pad near the center of Section 20.

Figure 11. *Phacelia sivinskii* and habitat in the BLM Ojito ACEC.

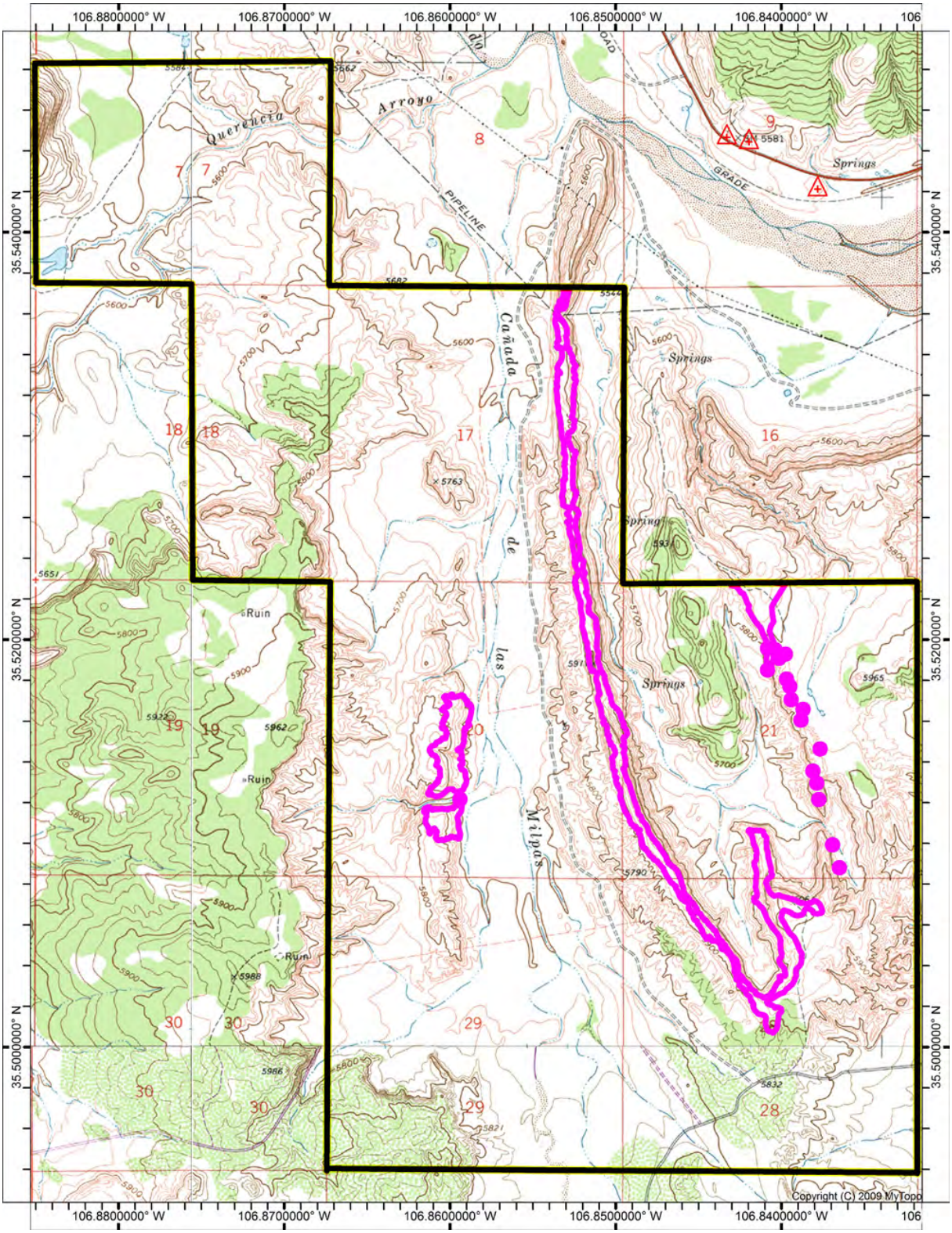

Figure 12. 2014-2015 *Phacelia sivinskii* distribution in the Ojito ACEC.

CONSERVATION STATUS

All four rare gypsophilic plants occupy suitable gypsum outcrop habitats on BLM lands in the Ojito/White Mesa region and are all represented by healthy reproductive individuals. No infestations of disease, predators, or exotic weeds were found during this survey of gypsum habitats in the Ojito ACEC Sections 17, 20, 21, 28 and 29 or in the Ojito Wilderness Area Sections 7 and 18. Livestock use and trampling was only documented in Section 7, within the Wilderness area. No livestock impacts were documented within the Ojito ACEC on gypsum outcrops during the 2014-2015 surveys. Access road and associated off-road vehicle use were notable in Section 7, 17, and 20. Several areas contained historic disturbances, including an old gravel pit and an abandoned gas storage facility as well as associated roads and infrastructure. The most prevalent direct impact on all four species and their habitat was caused by bicycle trails along the Tierra Amarilla Anticline (Sections 17, 20, 21, 28)(Figures 13 & 14).

No previously collected population data was available for the three of the four rare plant species and therefore it is not possible to assess population trends for *Mentzelia todiltoensis, Phacelia sivinskii,* or *Abronia bigelovii*.

Townsendia gypsophila population density during the 2014-2015 survey was low when compared to 1994 observations in some of the same habitats. Plant numbers were found to be significantly lower in at least two places (Sections 7 and 21) and seemed generally sparse throughout all the habitats surveyed in 2014-2015. Declines were likely caused by a combination of direct impacts to plants and their habitat in the form of recreational activities (biking), livestock trampling, and various infrastructure development projects (pipelines, gas storage facilities, access roads, etc.), as well as prolonged drought and other impacts associated with climate change.

It is interesting to note that the population density of *T. gypsophila* on the adjacent State Trust Land Section 16 was found to have only a 12% lower density (723 plants) in 2014 than in 1994 (821 plants) (Lowrey and Hafler 2014). However, survey effort appears to have been significantly larger for the 2014 survey and may therefore not accurately reflect a population trend. Nonetheless, the most densely populated habitat on BLM land in 2014 & 2015 was on the same gypsum outcrop that extends into that State Trust Land Section. In addition, known populations on Zia reservation lands were resurveyed in 2015 and results are currently being analyzed. Preliminary results also indicate a decline in the number of plants over 1994 survey results (Roth, in prep.). Survey effort is considered similar to 1994 efforts for 2014-2015 surveys on BLM and Zia lands.

Townsendia gypsophila is a relatively long-lived perennial species and therefore is not expected to show much year-to-year variation in population numbers. Hence much of the apparent decline may be a long term trend caused by year to year variations of weather and prolonged drought conditions. The 2014 survey occurred during the fourth consecutive year of moderate to severe drought and documents a dramatic decline in these relatively long-lived perennial plants.

Although the locatable minerals have been withdrawn from the Ojito ACEC and Wilderness Area, the retention of salable and leasable minerals in the ACEC are still a viable alternative in the proposed BLM Resource Management Plan (BLM 2012). Gypsum mining in the ACEC could potentially occur in the future. The White Mesa gypsum mine in the Todilto Formation on adjacent Zia Pueblo land is the largest gypsum mining operation in the state and enabled New Mexico to rank seventh among the 20 gypsum producing U.S. states in the year 2000 (Berglof and McLemore 2003). This mine feeds raw gypsum to the large wall-board manufacturing plant in Bernalillo, 21 miles to the southeast. The wall-board plant has been inactive since 2010 after the collapse of the real estate market, but could reopen and increase gypsum mining when the market recovers and construction activities resume. The Todilto Formation mines also supply small amounts of gypsum for cement and agricultural amendments (Berglof and McLemore 2003). Future mining of the Todilto gypsum in the Ojito/White Mesa region will further diminish habitat for *Townsendia gypsophila* and *Abronia bigelovii*, both of which are intolerant of soil disturbance and will not quickly reoccupy the remnant gypsum deposits in quarried areas. Previous comments in the Lowrey and Knight (1994) survey report that *T. gypsophila* habitats on the gypseous Morrison strata (now called Summerville strata) are not threatened by gypsum mining may be correct. However, the Summerville gypseous sandstone is only thin layer over the more pure and minable Tonque gypsum stratum of the Todilto Formation. The Summerville gypsum habitat layer could be removed and discarded as overburden

in a strip mining operation, if economically supported by gypsum commodity prices. Therefore, neither the Todilto nor Summerville gypsum habitats for rare gypsophilic are protected from mining impacts for the foreseeable future, except in Section 7 of the Ojito Wilderness Area.

Infrastructure for natural gas development has already impacted the Ojito ACEC to some small extent. A natural gas pipeline crossed and disturbed a small area of gypsum habitat on the east rim of the anticline in the NE¼ of Section 17. A larger area of disturbance impacted the gypsum hill near the center of Section 20 by bulldozing roads and well pads for the Milpas Natural Gas Storage Facility. This facility is no longer operational, but the damaged crest of the hill has not been regraded to its original contour. Previous surveys documented hundreds of *T. gypsophila* plants in the vicinity of the storage facility. Habitat and plants of *T. gypsophila* and *A. bigelovii* were likely lost to this development. Ojito Wilderness gypsum habitats in Section 7 are protected from future energy infrastructure development, but ACEC habitats are not protected.

Recreational bicycling is the most current and widespread land use impacting gypsum habitats in the Ojito ACEC, especially in the upper elevations of the Tierra Amarilla Anticline. The White Mesa Mountain Bike Trail Head begins at BLM parking area at the south end of the anticline and gives bicycle access to the eastern and western rims of the anticline – both of which are capped with gypsum. The official BLM mountain bike trail network is fairly extensive and is multiplied by numerous wildcat trails that significantly increase surface disturbance in the area (Figures 13 & 14).

Although the nearly barren surfaces of gypsum outcrops may seem like suitable places to route trails and roads, they are actually quite fragile and biologically active surfaces. In addition to the rare gypsophilic vascular plant species, gypsum outcrops usually develop biological soil crusts formed by a surprising diversity of lichens and cyanobacteria (photosynthetic blue-green algae). These cryptogamic soil crusts are diverse biotic communities that contribute benefits to the larger ecosystem by controlling erosion, improving water infiltration, and converting inorganic elements such as nitrogen into biologically useful forms (Belnap et al. 2001a). In fact, the U.S. Department of Interior publication on the ecology and management of soil crusts (Belnap et al. 2001a) specifically advocates "Gypsiferous sites are worthy of protection because of their high potential for cover and biological crust diversity." Species diversity of cryptogams in the soil crusts of the Ojito gypsum outcrops is evidently high (Figure 5), but that diversity has never been assessed or considered in land use planning. The extent to which rare gypsophilic vascular plants rely on the ecological services of biological soil crusts is not known, but there is likely some benefit being conferred to these rare plants, including increased seed, water, and macronutrient retention, seed germination and establishment, and overall survival (Belnap et al. 2001b). Recreational bicycling may occasionally directly impact and kill individual plants. However, the indirect impact of this activity on gypsum habitats, from compacting soils and eliminating biological soil crusts to increasing surface erosion, is becoming extensive in the Ojito ACEC and may therefore be the most significant current threat directly impacting rare gypsophilic species.

Management opportunities are limited with respect to buffering impacts of climate change and prolonged drought conditions. However, considering the apparent decline, overall rarity and current threats to *Townsendia gypsophila* and its habitat, it is highly recommended to restrict development in gypsum habitats, restrict or prohibit recreational bicycling and provide regular monitoring to document population trends.

Figure 13. GoogleEarth image (6/25/2014) of recreational bicycle impacts to gypsum habitats in north-center of Section 28, T15N, R1E northeast of the White Mesa Mountain Bike Trail Head in the Ojito ACEC. White surface is disturbed and gray or tan surface is undisturbed.

Figure 14. 2014 Habitat condition in north-center of Section 28, T15N, R1E.

NOTEWORTHY BOTANICAL OBSERVATIONS

Linum subteres (Utah yellow flax) has been known in the State of New Mexico from only a single 1981 collection with a vague locality of tan sandstone west of San Ysidro (Sivinski 2011). This species was relocated in Sections 21 and 28 during 2015 survey of the Ojito ACEC and vouchered for the UNM Herbarium (Sivinski and Roth 8978, UNM). It co-occurs with *Townsendia gypsophila, Abronia bigelovii*, and *Mentzelia todiltoensis* and other more common gypsophilic plants on tan gypseous sandstone of the lower Summerville Formation. Specific localities are 35.502233 -106.835904; 35.505156 -106.83548 and 35.51325 -106.83632 (WGS84). These population locations are relatively small in habitat size and numbers (a few hundred plants).

This Ojito population of *Linum subteres* is noteworthy for two reasons. One is because it is geographically isolated from its nearest known location in northeastern Arizona by about 175 miles. The other reason is that the Ojito population has a flower color that appears to occur only in this New Mexico population. The Arizona and Utah populations have clear, bright yellow petals. The petals of the Ojito plants are also bright yellow, but the interior surfaces are streaked with red from about middle to within 2 mm of the base making a reddish corolla with a bright yellow 'eye' at the position of the ovary (Figure 15). This unique population could be useful to biologists who study speciation by genetic differentiation with geographic isolation.

Figure 15. *Linum subteres* in the Ojito ACEC. Corolla color variant with reddish markings.

The 2015 portion of this survey also spent two days exploring the interior of the Ojito Wilderness Area for any gypseous strata. Almost all of the wilderness area (except parts of Section 7 and 8) are Morrison Formation sandstone and mudstone strata, hence no gypseous substrates were found in the wilderness interior. A single population of a very interesting *Astragalus* was found on silty sandstone near the confluence of Arroyo Querencia and Arroyo Bernalillito (35.514351 -106.891885 WGS84) and collected for the UNM Herbarium (Sivinski 8993 UNM). This population is tentatively identified as *Astragalus cliffordii* (Clifford's milkvetch), which was previously thought to be a rare plant endemic to western McKinley County 100 miles to the west. The Ojito Wilderness plants are similar to *A. cliffordii* by having numerous wiry stems, lax racemes of tiny (<5 mm) flowers with pale lavender corollas and small, laterally compressed, few-seeded pods. The Ojito Wilderness population is strikingly different in its leaves, which lack leaflets and consist of only a slightly expanded rachis (Figure 16). Specimens collected in 1981 and 1982 from another nearby Ojito population 2 miles to the northeast (P.J. Knight 2187, UNM; Spellenberg and Soreng 6480, NMC, NY) do have a few leaflets on their leaves, hence they are even more similar to *A. cliffordii*. These specimens were apparently not seen by Welsh and Atwood before they gave the McKinley County plants the name *A. cliffordii* in 2003. Rupert Barneby (deceased authority on *Astragalus*) did see the Knight and Spellenberg specimens in the 1980s and put them both into *Astragalus wingatanus* – a widespread and morphologically variable species. Welsh (2007) acknowledges the close

relationship of *A. cliffordii* to *A. wingatanus*, but apparently has a different opinion on the degree morphological difference that is worthy of taxonomic recognition. For the time being, the Ojito Wilderness population can be called *A. cliffordii*, which is considered a rare plant by the New Mexico Rare Plant Technical Council (1999). Additional habitats in the Ojito Wilderness Area should be searched for this, and other, rare plant species.

Figure 16. *Astragalus cliffordii* population lacking leaflets in Ojito Wilderness Area.

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