STATUS REPORT
AZTEC GILIA (*ALICIELLA FORMOSA*)
SAN JUAN COUNTY, NEW MEXICO

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for
U.S. FISH AND WILDLIFE SERVICE
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INTRODUCTION

Aliciella formosa (Aztec gilia, aka beautiful gilia) is a rare plant endemic to San Juan County in New Mexico. It is a perennial herb with a branching basal caudex, entire leaves and tubular pink flowers that bloom from late April to early June (Porter 1998). Plants germinate and establish between early April and early June, depending on moisture availability (Floyd-Hanna 1994). Plants flower at 2 – 3 years of age and may live for 10 years or more.

Aliciella formosa is listed Endangered in the state of New Mexico (NMAC 19.21.2). It is also a Bureau of Land Management (BLM) Sensitive Species and a candidate for listing as endangered on the Navajo Nation (BLM 2008; NESL 2008). The New Mexico Rare Plant Conservation Strategy considers the species under conserved due to its limited range, current and potential threats, and lack of protection from these threats (EMNRD-Forestry Division 2017). NatureServe ranks the species globally and state imperiled (G2/S2). The U.S. Fish and Wildlife Service (USFWS) evaluated the status of *A. formosa* in 2012 in response to a petition to list the species and determined that the petition did not provide substantial information indicating that a listing may be warranted (77FR 24908). However, the information used for the 90-day finding was largely derived from decades old surveys, dating to the mid-1990s, or older. Field observations have noted the disappearance or decline in plant numbers since 2000.

The total worldwide distribution of this species is limited to an area of approximately 50 miles x 35 miles. Based on past surveys, there are 42 known populations (Element Occurrences) within that area. Only about 10% of known sites have been documented since 1995. No repeat surveys have been done to determine the current status of these populations since the 1990s and clearance surveys for oil & gas development projects have largely been negative. Sensitive plant surveys throughout the Nacimiento Formation in 2015 have documented this species from only a handful locations, all within the previously known distribution range (Muldavin et al. 2016). The largest site contained 16 plants. No new populations were located in suitable habitat outside the known distribution. All of the known occurrences are on BLM active leased lands for oil and gas development. There are no protected sites for this BLM sensitive and state listed plant. An Area of Critical Environmental Concern set aside to protect the species was rescinded by the BLM in 2003 and turned into an ORV recreation site.

The status of this rare plant has not been assessed for the past two decades. The goal of this survey and status report was to determine the current status of the species to help analyze the degree of endangerment this species faces and to inform any additional management directives needed to protect the species.

DISTRIBUTION AND GENERAL HABITAT

Aliciella formosa occurs predominantly on BLM land, but is also present on New Mexico State Trust Land, Navajo Nation and private lands. It is endemic to San Juan County in New Mexico, with a range extending from about 3 miles south of the Colorado border just west of the Animas River, then west to the vicinity of La Plata, then southeast to the Angel Peak badlands (upper Kutz Canyon), then east to Largo Canyon, then north to the vicinity of Cedar Hill on the Animas River (Figure 1). There is one anomalous collection of this rare plant, from the Los Pinos River valley above Navajo Lake and 1 mile south of the Colorado border (M.J. Porter 1015 SJC)(SEINet 2017). This record is not mapped because the specimen label location coordinates are for a point west of the Animas River, contradicting the location description. The specimen was not seen by the authors of this report for verification of identification.

In general, *A. formosa* occurs on eroding clayey sand soils on soft shaley sandstone strata in the northern badland regions of the Nacimiento Formation. The Nacimiento is well known for its Paleocene mammal fossils (Williamson and Lucas 1992), but very little is published about the surface outcrops of its geologic strata. It is not a marine deposit, but its badlands are extensive, barren depositional shale, mudstone and soft sandstone. Occasional selenite crystals and gypsum crusts are found on the clayey sand soils. These gypseous substrates are most common north of the San Juan River and are classified as gypsum soils in the San Juan County soil survey (USDA-SCS 1980). Habitat elevations range from 1,680 m to 1,940 m (5,500 – 6,360 ft).

Vegetation cover in the badland habitats of *A. formosa* is sparse, but vascular plant species composition is fairly diverse. The plant community consists of widely scattered Utah juniper (*Juniperus osteosperma*), piñon pine (*Pinus edulis*); shrub species such as bitterbrush (*Purshia tridentata*), Utah serviceberry (*Amelanchier utahensis*), mountain mahogany (*Cercocarpus montanus*), rabbitbrush (*Ericameria nauseosa*), crispleaf buckwheat (*Eriogonum corymbosum*), Mormon tea (*Ephedra viridis*), Bailey's yucca (*Yucca baileyi*), brownspine pricklypear (*Opuntia phaeacantha*) and Clover's hardwall cactus (*Sclerocactus cloverae*). The most frequent herbaceous species are needle and thread grass (*Hesperostipa comata*), galleta (*Pleuraphis jamesii*), Indian ricegrass (*Achnatherum hymenoides*), hoary Townsend aster (*Townsendia incana*), yellow catseye (*Oreocarya flava*), sleepdaisy (*Xanthisma grindelioides*), Ives' fournerved daisy (*Tetraneuris ivesiana*), fineleaf hymenopappus (*Hymenopappus filifolius*), sand verbena (*Abronia elliptica*) and Shockley's buckwheat (*Eriogonum shockleyi*), just to name a few. Surprisingly, habitats with apparently gypseous soil lack any of the common gypsophilic species found on other gypsum strata in New Mexico and southwestern Colorado.

LEGACY DATA

We compiled all known locations and associated data for *Aliciella formosa* from museum records and observations in the New Mexico Natural Heritage Program (NMNHP) Biotics database along with survey and monitoring reports provided to us by the BLM. A total of 42 Element Occurrences, containing 173 *A. formosa* locations were assembled (Figure 1; Appendices B, C and D). Thirty-three of these locations were on State or private lands (19%). Most of these locations were mapped pre-GPS technology and had therefore been georeferenced from report maps, narrative descriptions, or TRS conversions. Several locations were especially vague and could not be located during the 2017 field survey (Appendices C & D).

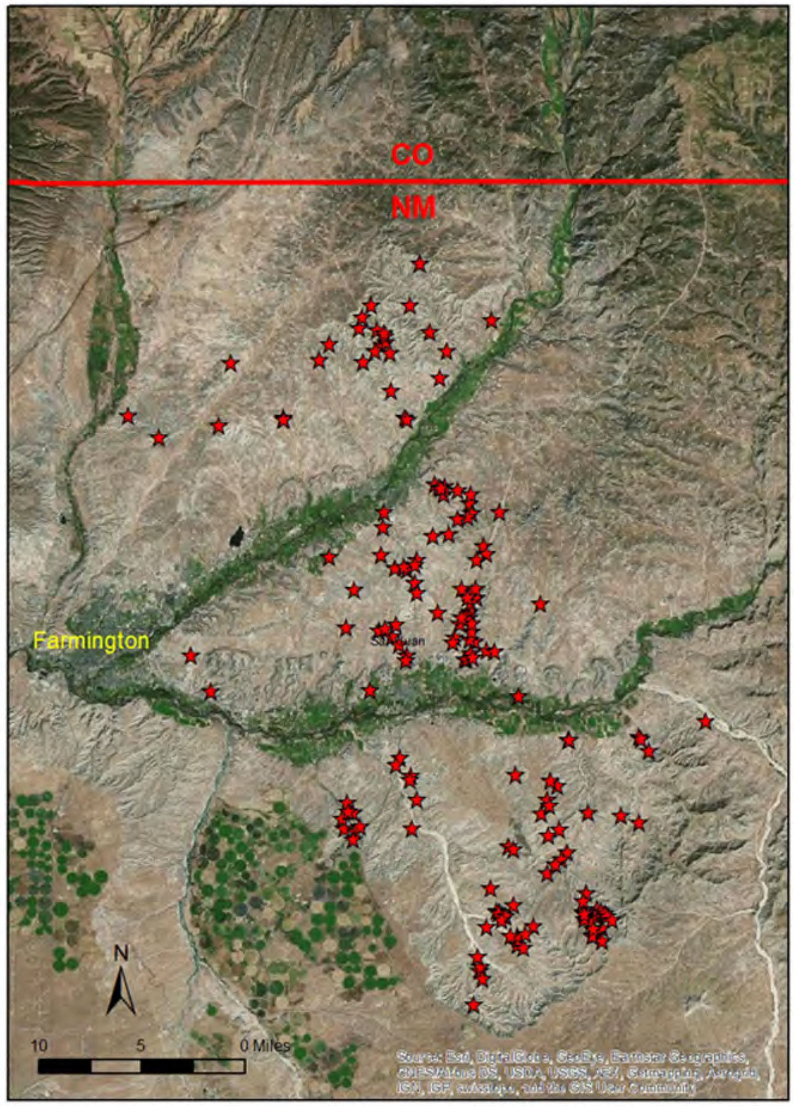

Figure 1. *Aliciella formosa* locations in NHNM NMBiotics database

Two previous inventories have been conducted to define the distribution and habitats of *A. formosa*. The first was by botanists from the New Mexico Department of Natural Resources (Knight and Cully 1986) and second was by the New Mexico Natural Heritage Program (DeBruin 1991). Most locations discovered after 1991 were by consultants performing biological assessments for proposed roads, pipelines and well pads associated with oil and gas development in the region. The 1991 NMNHP effort also included establishing 26 monitoring plots within occupied habitats. An additional 4 monitoring plots were established in 1992 and all 30 plots were monitored in 1992, 1993 and 1995 (DeBruin 1995). Relocating and monitoring these plots was a priority for the 2017 status survey. Five additional monitoring plots were established in 1991 by the Lisa Floyd-Hanna within pipeline right-of-ways as a mitigation measure and annually monitored until 1994 (Floyd-Hanna 1994). We also tried to locate these plots in 2017.

METHODS

In 2017, general field surveys to locate the previous observations focused on searching suitable habitats in the vicinity of the reported 140 mapped locations on BLM lands. *Aliciella formosa* occurs in small scattered patches of plants that are not suited for walking polygons around occupied habitat. Plant patches were marked with GPS waypoints when encountered, then an estimated 30-meter (ca 125-foot) radius around the point was thoroughly searched and the number of plants recorded. When more plants in adjacent habitat were encountered, additional waypoints and counts were made until no more plants were found in the vicinity. Therefore, a grouping of waypoints indicates the extent of the local population. Any apparent land use impacts, including the presence of invasive plants and livestock, through the occupied habitat and adjacent area were noted. Potential disturbances associated with oil wells, roads, ORV trails, oil & gas pipelines, were analyzed by using ArcMap GIS spatial proximity analysis tools to determine the distance to the nearest disturbance, including a 30-meter buffer area around all waypoints recorded to contain plants.
Monitoring plots established in 1991 and 1992 were located using original maps and monitoring reports in combination with photos provided in the initial monitoring report (DeBruin 1991). Plot dimensions were 10x10 m or 5x20 m and the corners were marked with metal rebar or wooden stakes. Whenever plots were found, the boundaries were delineated with metric tape measures, photographed, and mapped using a GPS. All *Aliciella formosa* plants in the plots were counted using three age classes – seedlings (recently germinated), juveniles (small non-flowering), and adult (large and small flowering or large non-flowering). Any apparent land use impacts to the plot or adjacent areas were noted. Areas were surveyed between May 1 and June 14 (1-3 people).

RESULTS

FIELD SURVEYS FOR PREVIOUS OBSERVATIONS

Much of the 2017 field work was devoted to locating the 140 previous observations of *Aliciella formosa* on BLM lands. Thirty-three of the 140 previous records from BLM lands could not be found (Appendix C). Limited data was available on the number of plants for each previously documented site and could not be used for comparisons because we have limited knowledge of the exact location or previous survey extent. In 2017, plants were found at 107 of the previously documented 140 sites on BLM lands (Figure 2, Appendix B). In addition to plants located within the 22 monitoring plots, a total of 13,674 plants were documented from 448 waypoints, ranging from 1 to 375 plants per waypoint. The majority of waypoints had fewer than 50 plants (Appendix B). Five new locations were discovered during the surveys (19 waypoints). The majority of plants were located N/NW of Aztec, west of the Animas River (Figure 2). Significantly fewer plants were found south of the San Juan River. The fewest plants were documented north of the San Juan River and south of Aztec.

Thirty-three of the 140 previous records from BLM lands could not be found. The primary reason for not locating these previously documented sites was due to vague or inaccurate location coordinates or descriptions. These were often obvious because the mapped locations did not have suitable habitats for this rare plant. Two of our targeted points were inaccessible because of locked gates. Seven of the previous record locations where we failed to find *A. formosa* may have originally been misidentifications. Fairly accurate directions occasionally led to sites with marginally suitable *A. formosa* habitats that did have populations of *Aliciella haydenii* (Hayden's gilia), which occurs in similar habitats. This closely related species also has pink flowers and might have been misidentified and reported as *A. formosa* by poorly trained biological consultants. Some previous records that could not be located again in the field despite good directions and good habitat may have had small patches of plants that were missed in the field search, or *A. formosa* had died-out from those areas.

Most of the 2017 field searches of BLM land found patches of *A. formosa* at, or near, the recorded locations of previous observations. Except for the monitoring plots found intact in 2017, most of the original observations were not detailed enough to make comparisons of numbers of plants with the counts performed in 2017. We have little information on the number of plants originally documented, the survey effort, or extend of the surveys, making comparisons unsuitable. A notable exception is the eastern-most occurrence of this species near Largo Canyon. The biological consultant who discovered this site adjacent to a proposed road R-O-W counted 22 *A. formosa* in 2012 and the BLM enclosed the 15x15 m area of habitat with a fence. The 2017 site visit found 55 plants both inside (51) and just outside the fence, indicating an increase over that 5-year period.

However, general observations from the 107 locations surveyed support the declining trend data observed in the monitoring plots. Several of the revisited locations had very sparse patches of plants with many having fewer than 5 plants remaining (Appendix B). Thirty-four of the 173 locations reported originally contained over 100 plants per site (up to many thousands of plants). These locations were scattered over the entire range of the species. In 2017, few sites had several hundred plants (31 of 469 waypoints, including monitoring sites). The majority of plants and the majority of larger sites were located north and northwest of the Animas River.

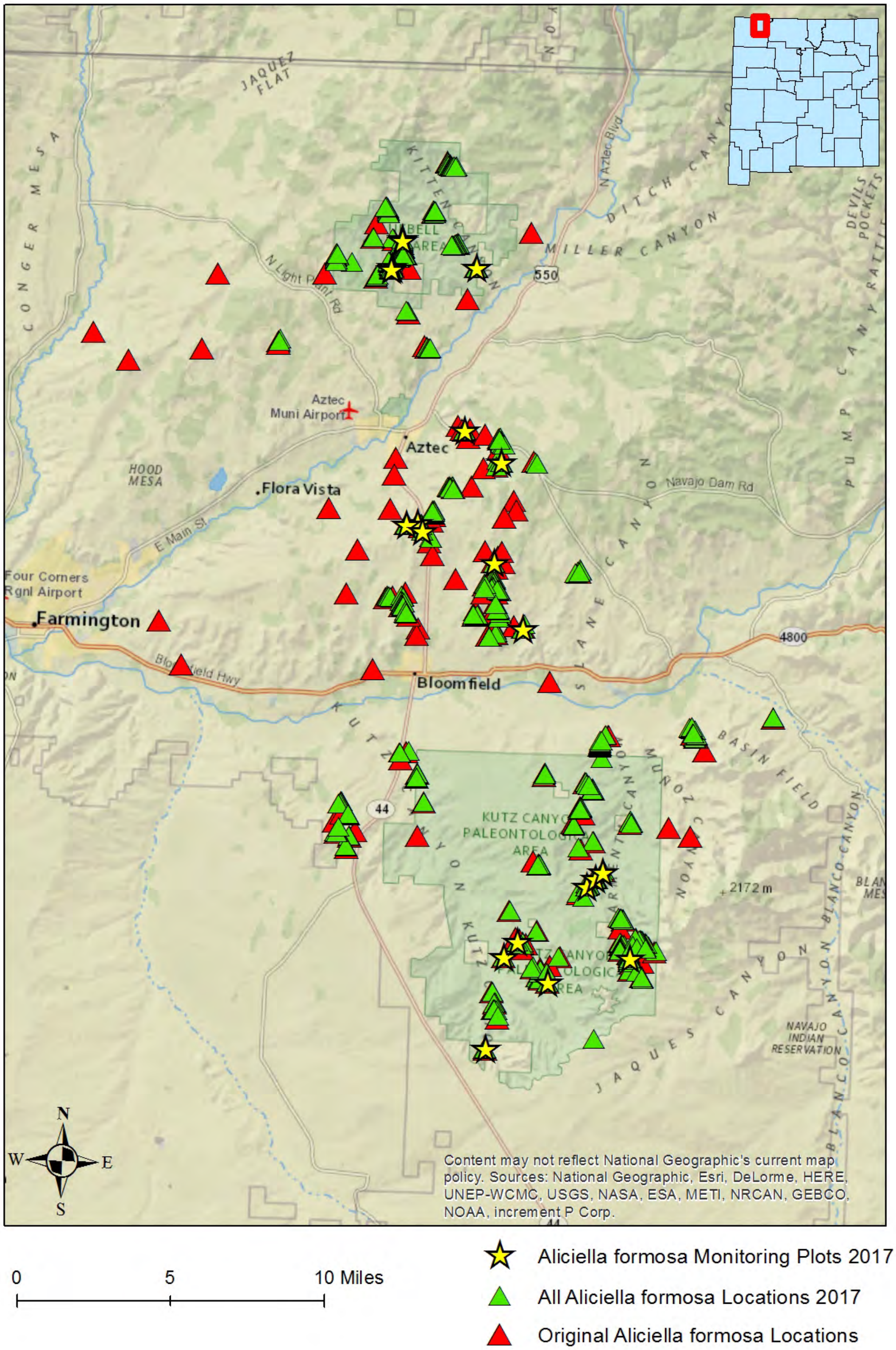

Figure 2. Distribution of *Aliciella formosa* in San Juan County, NM.

MONITORING PLOTS

The permanent *Aliciella formosa* monitoring plots established by the NMNHP and Lisa Floyd-Hanna in 1991 and 1992 had not been revisited since 1995 and offered the best opportunity to assess long-term population trends. Overall, there appeared to be a significant decline in the total number of plants recorded in the 22 monitoring plots that could be located in 2017 (Figure 3; Tables 1 & 2).

Twenty of the original 30 NMNHP plots were found in 2017. The other 10 plots could not be located during the field search, or evidence of vandalism was found (Appendix D). For instance, Plots 13, 14, 15 and 28 were clustered in a small area, but their rebar stakes had been pulled-up and piled nearby.

The total number of plants present in the 20 individual NHNM plots varied widely between years ranging from 0 to 61 in 2017, and from 1 to 689 in 1995 (Table 1). The highest number of plants was found in 1995, when a total of 3,312 plants were found in the monitoring plots (Figure 3). The lowest number of plants was found in 2017, when only 488 plants were found. This represents a decline of 52% over initial counts in 1992 and even larger declines from 1993 (59%) and 1995 (85%) values. The average number of plants found in the 20 monitoring plots was consistently between 50 and 60 plants between 1991 and 1993 (Table 1). This number rose dramatically during the 1995 monitoring season, when an average of 165 plants were found in the 20 monitoring plots. In 2017, the average number of plants in the monitoring plots had declined to only 24 plants. The majority of plants are consistently classified as adults, during all monitoring years, with significantly fewer plant classified as juveniles or seedlings (Figure 3). No age class data was available for 1991.

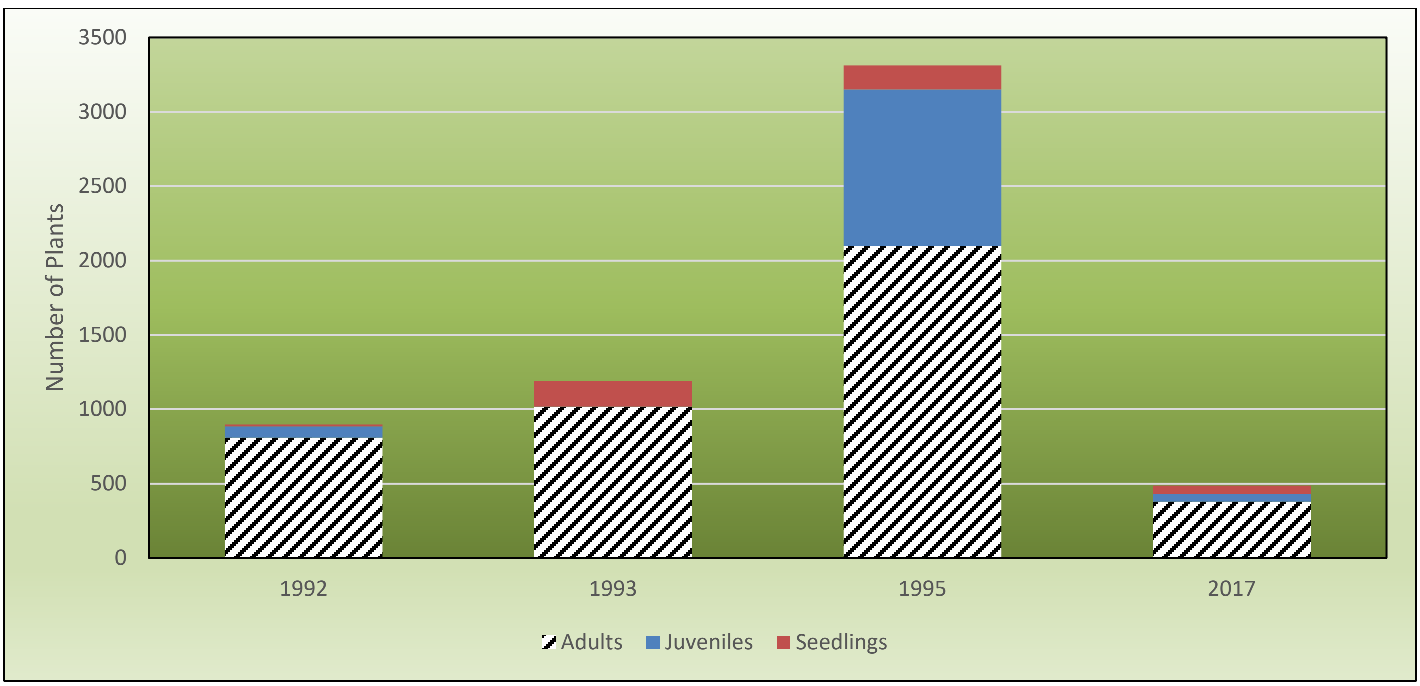

Figure 3. Total number of *Aliciella formosa* plants and their respective life stages between 1992 and 2017 in 20 monitoring plots on BLM lands.

Table 1. Total number of *Aliciella formosa* plants in 20 monitoring plots between 1991 and 2017. *No data was available for plots 27, 29, and 30 in 1991.

Plot	Location	1991	1992	1993	1995	2017
1	N Side	48	49	53	57	49
2	N Side	32	29	69	159	48
3	N Side	23	29	74	309	16
8	N Side	14	18	32	120	3
9	N Side	1	1	1	1	0
10	N Side	32	42	86	242	57
26	N Side	49	36	55	100	11
4	S Aztec	92	139	135	356	38
5	S Aztec	51	34	28	133	15
19	S Aztec	115	106	104	219	5
20	S Aztec	214	193	203	369	6
21	S Aztec	66	52	47	82	11
23	S Aztec	48	37	35	84	15
25	S Aztec	42	126	127	689	55
29	S Aztec	N/A	37	35	159	52
11	S San Juan	34	25	30	44	61
12	S San Juan	26	22	17	34	10
6	S San Juan	19	19	26	95	22
27	S San Juan	N/A	9	17	27	4
30	S San Juan	N/A	10	17	33	10
Average		**53.29**	**50.65**	**59.55**	**165.60**	**24.40**
Total		***906**	**1013**	**1191**	**3312**	**488**

Only two of the five monitoring plots established by Lisa Floyd-Hanna could be located in 2017(Floyd-Hanna 1994). The Floyd-Hanna Northwest Pipeline plot location originally had seven plots with combined data, but only three of those were found in 2017 and could not be used for comparison (Appendix D). The El Paso monitoring site could not be located in 2017. No location reference was given for the control site.

The 2 Floyd-Hanna monitoring plots are presented separately because they were originally monitored multiple times a year, in March, for pre-germination/winter mortality counts, in May/June, for germination counts, and again, during September, for summer mortality counts. The 2017 surveys occurred in early June, which may have influenced the number of seedlings and juveniles counted in the monitoring plots. Only juveniles were recorded in June of 2017, no seedlings. Overall, the 2 monitoring plots that could be located in 2017, contained significantly fewer plants than during the previous years (Table 2). Only 45 plants, including 7 juveniles, were found in the two monitoring plots in 2017, which represents a decline of 68% over the initial 1991 counts.

Table 2. Total number of *Aliciella formosa* plants through time, including seedlings in two 10 x 10 m monitoring plots. Seedlings/juveniles in parentheses. No information available on seedlings/juveniles for the initial 1991 counts.

Plot	1991	1992	1993	1994	2017
2 (Meridian)	66	73 (26)	64 (7)	131 (85)	37 (5)
3 (Manzanares)	72	66 (2)	61 (2)	88 (37)	8 (2)

STATUS ASSESSMENT

The prevailing and most destructive land use in the habitats of *Aliciella formosa* is exploration and development of oil and natural gas, including oil & gas wells and associated infrastructure such as access roads, storage sites, and pipelines (Figure 4). San Juan is the second largest natural gas-producing and third largest oil producing county in New Mexico (NMEMNRD 2016). Natural gas wells have long been producing from the Nacimiento Formation and the formations directly below the Nacimiento are reservoirs for oil (Engler et al. 2001). The natural gas well fields currently impacting *A. formosa* habitats are relatively old, but new methods such as horizontal drilling and hydraulic fracturing of shale strata are expected to open new opportunities to develop additional wells in areas already highly impacted by single vertical wells. A recent assessment of reasonably foreseeable shale oil well production (Engler et al. 2014) predicts approximately 2,000 additional wells to make natural gas available from the Mancos shale – mostly from the central part of the formation near the Colorado border. This could continue to impact the Bloomfield/Aztec region, which is an area already densely developed by more traditional vertical wells (Engler et al. 2014).

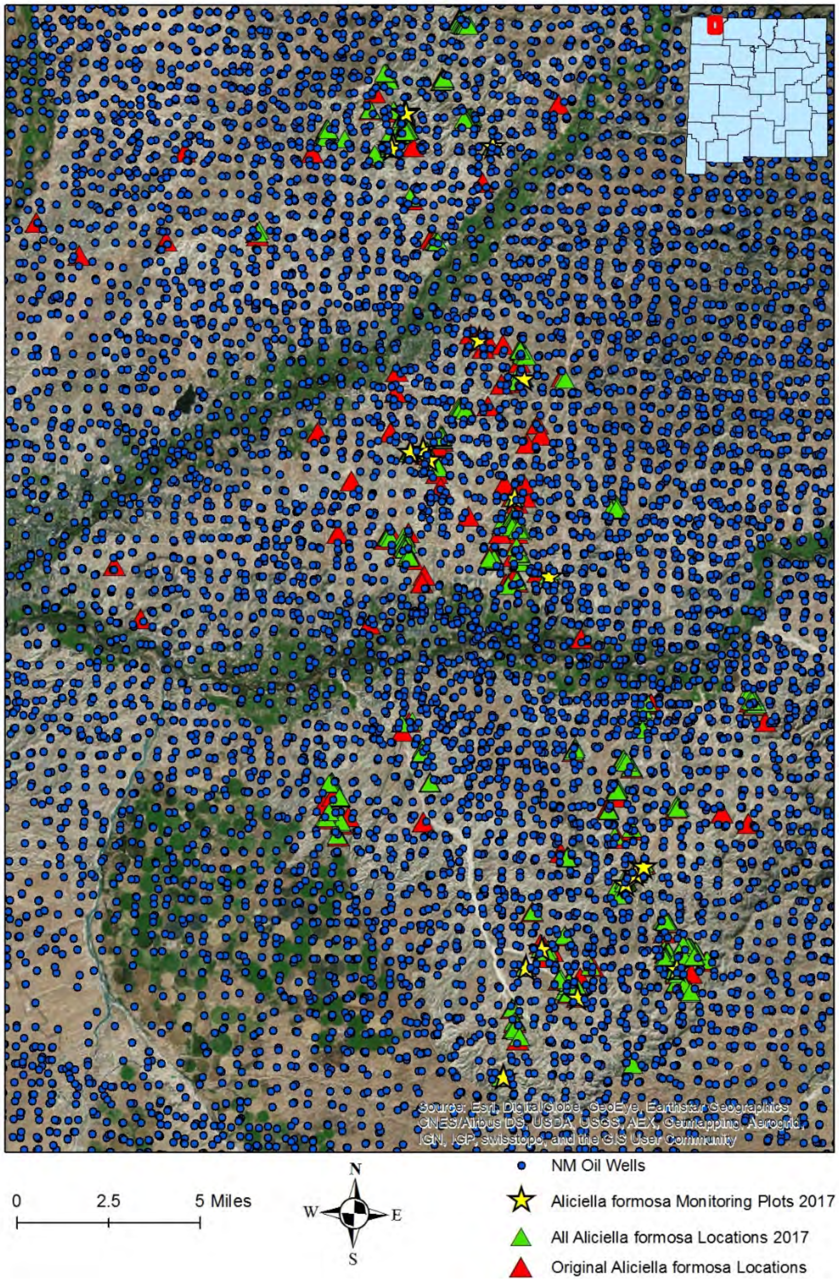

Figure 4. Density of oil & gas wells in the habitat of *Aliciella formosa*.

Gas and oil wells and their associated road and pipeline infrastructure are already established or actively developing throughout all *A. formosa* habitats, regardless of surface ownership. Direct impacts of gas and oil development are mostly associated with the surface activities of creating well pads and connecting them with broad and extensive networks of pipelines and roads. *Aliciella formosa* has occasionally been observed recolonizing well field ground disturbance, if the original surface soils are used for construction (Figure 5). Significant earth movement such as cut and fill for well pads and roads tends to eliminate this species from that part of the habitat (Figure 6).

Figure 5. *Aliciella formosa* (arrow) recolonizing a well pad berm.

Figure 6. *Aliciella formosa* (arrow) grows on an undisturbed edge of this well pad but not on the upper fill slope or pad.

Plants not directly impacted by energy exploration and development can suffer indirect impacts when in close proximity to roads and pipelines including impacts of dust, chemicals, air pollution, invasive species, and impacts on pollinators (FWS 2014). Fugitive dust from vehicles traveling unpaved roads will settle on nearby plants and can reduce photosynthesis and decrease water-use efficiency (Sharifi et al. 1997; Padgett et al. 2007). Dust can interfere with pollination and pollination success, potentially reducing seed set (Waser et al. 2017).

In 2017, 99% of 470 waypoints, including monitoring plots, were located within 1000 ft of a road, primarily dirt roads providing access to oil wells (Tables 3 & 4). 26% of all waypoints were located within 100 ft of a road. 92% of the 470 waypoints were within 1000 ft of an oil well or well pad. ORV trails and pipelines were generally further from waypoints and monitoring sites (>1000ft). ORV trails were largely observed north of the San Juan River.

Table 3. Distance of 470 *Aliciella formosa* waypoints to potential sources of disturbances, including monitoring plots, 2017.

Distance (ft)	Road	Oil Well	ORV Trail	Pipeline
0	53	3	23	3
1 - 100	71	25	11	5
101 - 150	35	25	5	1
151 - 200	39	28	3	0
201 - 300	68	43	4	2
301 -500	85	91	5	4
501 - 1000	113	216	7	20
>1000	6	39	412	435

Table 4. Distance of 22 *Aliciella formosa* monitoring plots to potential sources of disturbances, 2017.

Distance (ft)	Road	Oil Well	ORV Trail	Pipeline
0	6	0	1	2
1 - 100	3	0	0	2
101 - 150	2	1	1	0
151 - 200	3	1	0	0
201 - 300	5	1	0	0
301 -500	2	4	0	0
501 - 1000	1	14	0	0
>1000	0	1	20	18

Roads and pipelines also fragment habitats into smaller pieces and that potentially creates smaller patches of *A. formosa* from fewer larger patches. Distribution of *A. formosa* is naturally very patchy with distances between patches often exceeding 100 m and some patches containing only a few isolated individuals. Gene flow between patches may be almost entirely mediated by flying insects carrying pollen. Habitat fragmentation by 10 m-wide roads is unlikely to inhibit pollinator movement and gene flow. However, dust deposition may negatively impact pollination and pollination success. Seed dispersal for this species appears to be generally localized around maternal plants, but occasional longer distance dispersal by animal vectors and cyclonic whirlwinds likely occurs. These habitat fragments may, or may not, be as stable as the larger undisturbed patches, but the long-term impacts of habitat fragmentation in well fields have not been studied for plants or their pollinators.

Off-road vehicle (ORV) traffic is an ongoing threat to some patches of *A. formosa* because ORVs run over them and indirectly impact habitat by destruction of fragile soil crusts that may aid germination and establishment, cause soil compaction, contribute to dust deposition, leave deep tracks and ruts that alter drainage patterns and cause erosion. The 2017 survey found significant amounts of soil disturbance from bicycle and motorized ORV traffic on most BLM lands north of the San Juan River in the regions around Bloomfield, Aztec and La Plata, especially along ridges. ORV impacts to habitats in that region were not as severe as the disturbances caused by roads and infrastructure supporting energy development, but were quite noticeable in the northern part of the survey area. Many of these trails are marked by BLM for public use. These trails and associated off-trail diversions only add to the general surface disturbance of oil and gas well fields in this highly impacted region (Figure 7).

Figure 7. ORV tracks meeting pipeline and pipeline access road in the habitat of *Aliciella formosa* (in the foreground).

Figure 8. Cattle track on *A. formosa.*

Land use within the *Aliciella formosa* habitat has historically been livestock grazing and all sites are located within active grazing allotments. Livestock impacts were observed in the vicinity of 58% of the reported waypoints (Figure 8). The majority of livestock impacts were observed in the southern portion of the survey area, south of the San Juan River, portions of which are grazed year-round. Although *A. formosa* may not be palatable to livestock, individuals are easily trampled, which may result in direct death or injury of the plant which in turn will influence the reproductive potential of the population over time. Indirect impacts include dust deposition, increased erosion, soil compaction, and the introduction of invasive species.
Invasive species including cheatgrass (*Bromus tectorum)* and Russian thistle (*Salsola kali)* were documented throughout the survey area, especially in the vicinity of disturbed areas, such as roads and well pads. A few sites documented halogeton (*Halogeton glomeratus*), an aggressive invasive plant which has invaded much of the Mancos shale habitats throughout the BLM Farmington District.

DISCUSSION

Aliciella formosa is a rare plant endemic to San Juan County in New Mexico. Although the number of plants in the monitoring plots has fluctuated widely between years over most of its range on BLM lands, the populations appear to have experienced a significant decline throughout its range over early mid-1990s levels. The cause of this decline is unclear. There are no protected sites for this species and it continues to be primarily impacted by oil and gas development, but also ORV recreation activities, livestock, and potentially invasive species throughout its limited range. Despite a few recent years with good rainfall amounts, impacts of prolonged drought and climate change may have already impacted this species, contributing to the overall observed decline. A moth larva may be contributing significantly to the mortality of plants and the observed decline. More likely than not, the decline is a long-term trend caused by the combination of these stressors on the species.

Recruitment is generally associated with good rainfall amounts during the winter and spring months (Floyd-Hanna 1994). Monitoring data documented significant recruitment between 1993 and 1995 (Figure 3, Tables 1 & 2). This increase was largely associated with adult and juvenile plants recorded in 1995 in NMNHP study plots, indicating a likely recruitment event in 1994 (no data available). Floyd-Hanna did report an unprecedented recruitment event during the 1994 monitoring season. However, the increases are not well correlated with local rainfall data collected in nearby Aztec and Bloomfield (WRCC 2017). Annual precipitation for 1994 and 1995 was only average or below average for those years of greatest recruitment (Appendix A). In fact, winter precipitation (November to April 1993/1994) was the lowest of all winters on record since monitoring began. Since 2015 and through the spring of 2017, rainfall amounts in the Aztec and Bloomfield areas were at or above the average rainfall amounts, yet 2017 had the lowest numbers of plants on record. Winter precipitation (2016/2017) was similar (Aztec) or well above (Bloomfield) the amounts received during all other monitoring years, but no large recruitment event was documented (seedlings). It is possible that low population numbers are the results of drought impacts experienced in the early 2000s, and the population is currently recovering from even lower numbers. However, it is likely that factors other than climate and rainfall amounts are contributing to the observed decline of the species.

A study on dust deposition of 4 endangered plant species in California concluded that plants growing within 400 m of disturbed limestone landscape are in degraded habitats, impacting plant productivity (Padgett et al. 2007). Dust particles and pollen grains are similar in size. Therefore, dust can interfere with pollination and pollination success, potentially reducing seed set (Waser et al. 2017). In addition, pollinators may avoid dusty flowers. Dust impacts on plant productivity and pollination success of *Aliciella formosa* have not been studied. However, considering the proximity of less than 400 m of all extant sites to active dirt roads is likely having an impact on the viability of the species and should be further studied.

The propensity of disturbance throughout the range of the species, especially oil wells, roads and pipelines provide seedbeds and travel routes for invasives throughout the range of the species. Although the observed density of invasives was relatively low in 2017, the density of annual invaders can change annually with rainfall amounts which may negatively impact the germination and establishment of *A. formosa*.

The distribution and habitat of *A. formosa* is fairly well understood, but its ecology and life history are not well known. Hawk moths and bee flies have been observed as the primary pollinators of *A. formosa* (Floyd-Hanna 1994). Our 2017 field observations found that when *A. formosa* co-occurs with yellow catseye (*Oreocarya* *flava),* which is often, a native bee fly (*Bombilius* sp.) is the principal pollinator of both species. The impacts of habitat fragmentation on these pollinators and pollination success have not been studied.

Porter and Floyd (1993) observed predation by a microlepidopteran moth larvae (Gelechiidae), which bores into the lower woody caudex region of *A. formosa*. The moth larvae caused mortality of at least one entire population of plants over the course of one summer and contributed significantly to the mortality of monitored adult plants over a 4 year period (Floyd-Hanna 1994). In addition to drought related mortalities, this tiny moth may be partly or entirely responsible for the severe decline of *A. formosa* in many of the permanent monitoring plots. No significant numbers of dead adult *A. formosa* were observed in the 2017 field survey, but we were there in the spring and not the heat of summer. Microlepidoptern moth predation may be causing a high level of *A. formosa* mortality that is currently going undocumented. The southwestern climate is predicted to warm, so future droughts will be coincident with higher temperatures (Woodhouse et al. 2010). Warmer winters could increase moth survival and longer summers potentially add another generation to the life cycle of this particular moth species. Increases in moth larvae predation may have contributed to the decline of the species already and should be studied further.

Previous studies found that mortality of plants in undisturbed control plots was significantly lower than mortality recorded in 4 study sites that were immediately adjacent to pipeline right-of-ways (Floyd-Hanna 1994). In the disturbed plots size class distribution was skewed towards smaller plants, with fewer flowers than larger plants, therefore producing fewer seeds. Large size plants can produce up to 40 inflorescences and appear to be largely found in undisturbed sites (Floyd-Hanna 1994). Ongoing disturbances in the habitat of *A. formosa* may skew the life stage distribution of populations towards smaller plants, thereby reducing seedbanks and the reproductive potential over time.

Despite the longevity of this perennial species, population are documented to fluctuate widely from one year to the next and between monitoring plots. Overall the species appears to be in decline for unclear reasons. Additional studies are essential in determining the degree to which this species is endangered and to identify what management actions are needed to keep it from extinction. Continued monitoring is essential in determining population trends. Additional research is needed on potential stressors to the species continued existence, especially reproductive success and recruitment, the impacts of dust deposition on pollination success, and the impacts of moth larval infestation on mortality. Seeds should be collected for ex-situ conservation purposes. Protection of existing populations through the creation of Best Management Practices and designating protected areas for the few areas still containing large healthy populations should be considered by the BLM and added to resource management plans. In addition, it is highly recommended to perform biological clearance surveys for all ground disturbing activities during the appropriate time of year, when plants can be properly identified during the flowering period.

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LITERATURE CITED

Bureau of Land Management (BLM). 2008. Special Status Species Management Manual for the Bureau of Land Management. Manual 6840, Release 6-125.

DeBruin, E.A. 1991. *Gilia formosa* inventory and monitoring project. New Mexico Natural Heritage Program, The Nature Conservancy, University of New Mexico, Albuquerque. Prepared for the BLM Farmington Resource Area, Farmington, NM.

DeBruin, E.A. 1993. Monitoring the status of *Gilia formosa* in the San Juan Basin, New Mexico. In: Southwestern Rare and Endangered Plants: Proceedings of the 1992 Southwestern Rare and Endangered Plant Conference, R. Sivinski and K. Lightfoot eds., NM Forestry and Resources Conservation Division, Misc. Publ. No. 2.

DeBruin, E.A. 1995. *Gilia formosa* monitoring project. Final Report. New Mexico Natural Heritage Program, University of New Mexico, Albuquerque. Prepared for the BLM Farmington Resource Area, Farmington, NM.

Engler, T.W., B.S. Brister, H-Y. Chen, and L.W. Teufel. 2001. Oil and Gas Resource Development for San Juan Basin, New Mexico: A 20-year, Reasonable Foreseeable Development (RFD) Scenario Supporting the Resource Management Plan for the Farmington Field Office, BLM.

Engler, T.W., S. Kelley and M. Cather. 2014. Reasonable foreseeable development (RFD) for northern New Mexico. New Mexico Institute of Mining and Technology for Farmington Field Office, U.S. Department of the Interior, Bureau of Land Management.

Floyd-Hanna, L. 1994. *Gilia formosa* population monitoring study. Unpublished report prepared for BLM Farmington Resource Area.

Knight, P.J. and A. Cully. 1986. A study of *Gilia formosa, Erigeron rhizomatus* and *Pediocactus papyracanthus* in the BLM Farmington Resource Area. Unpublished report by New Mexico Natural Resources Department, Santa Fe.

Muldavin, E., R. Sivinski, M. East, Y. Chauvin, and M. Horner. 2016. Brack's hardwall cactus distribution, habitat, and status survey 2015. Natural Heritage New Mexico, Museum of Southwestern Biology and Department of Biology University of New Mexico, Albuquerque.

Navajo Nation, Division of Natural Resources, Department of Fish and Wildlife. 2008. Navajo Endangered Species List. Resources Committee Resolution No. RCS-41-08. Available: http://www.nndfw.org/nnhp/nnhp_nesl.pdf.

New Mexico Energy, Minerals & Natural Resources Department, 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.

New Mexico Energy, Minerals & Natural Resources Department. 2016, EMNRD Annual Report. Available: http://www.emnrd.state.nm.us/ADMIN/documents/Final_2016_EMNRD_AnnualReport.pdf.

New Mexico Natural Heritage Program. 2017. Database records for *Aliciella formosa*.

Padgett P.E., W.M. Dobrowolski, M.J. Arbaugh, and S.A. Eliason. 2007. Patterns of carbonate dust deposition: Implications for four federally endangered plant species. Madroño 54(4):275-285.

Porter, J.M. 1998. *Aliciella*, a recircumscribed genus of Polemoniaceae. *Aliso* 17: 23–46.

Porter, J.M. and M. Lisa Floyd. 1993. A phylogenetic approach to natural historical and demographic explanations of the rarity of *Gilia formosa*. In: Southwestern Rare and Endangered Plants: Proceedings of the 1992 Southwestern Rare and Endangered Plant Conference, R. Sivinski and K. Lightfoot eds., NM Forestry and Resources Conservation Division, Misc. Publ. No. 2.

Roth, D. 2008. Species Account for *Aliciella formosa*. Navajo Nation Endangered Species List Species Accounts. Window Rock, AZ: Navajo Natural Heritage Program. August. pp. 89-90.

Sharifi, M.R., A.C. Gibson, P.W. Rundel. 1997. Surface dust impacts on gas exchange in Mojave Desert shrubs. Journal of Applied Ecology 34: 837-846.

Southwest Environmental Information Network, SEINet. 2017. http://swbiodiversity.org/seinet/index.php.

USDA, SCS. 1980. Soil Survey of San Juan County, New Mexico, Eastern Part. Available: http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/new_mexico/NM618/0/sanjuan.pdf

U.S. Fish and Wildlife Service. 2014. Ecological Effects of Ground Disturbance and Roads on Plants and Recommended Buffer Distances, with Emphasis on the Uinta Basin, Utah. Utah Ecological Services Field Office, US Fish and Wildlife Service (Final Draft).

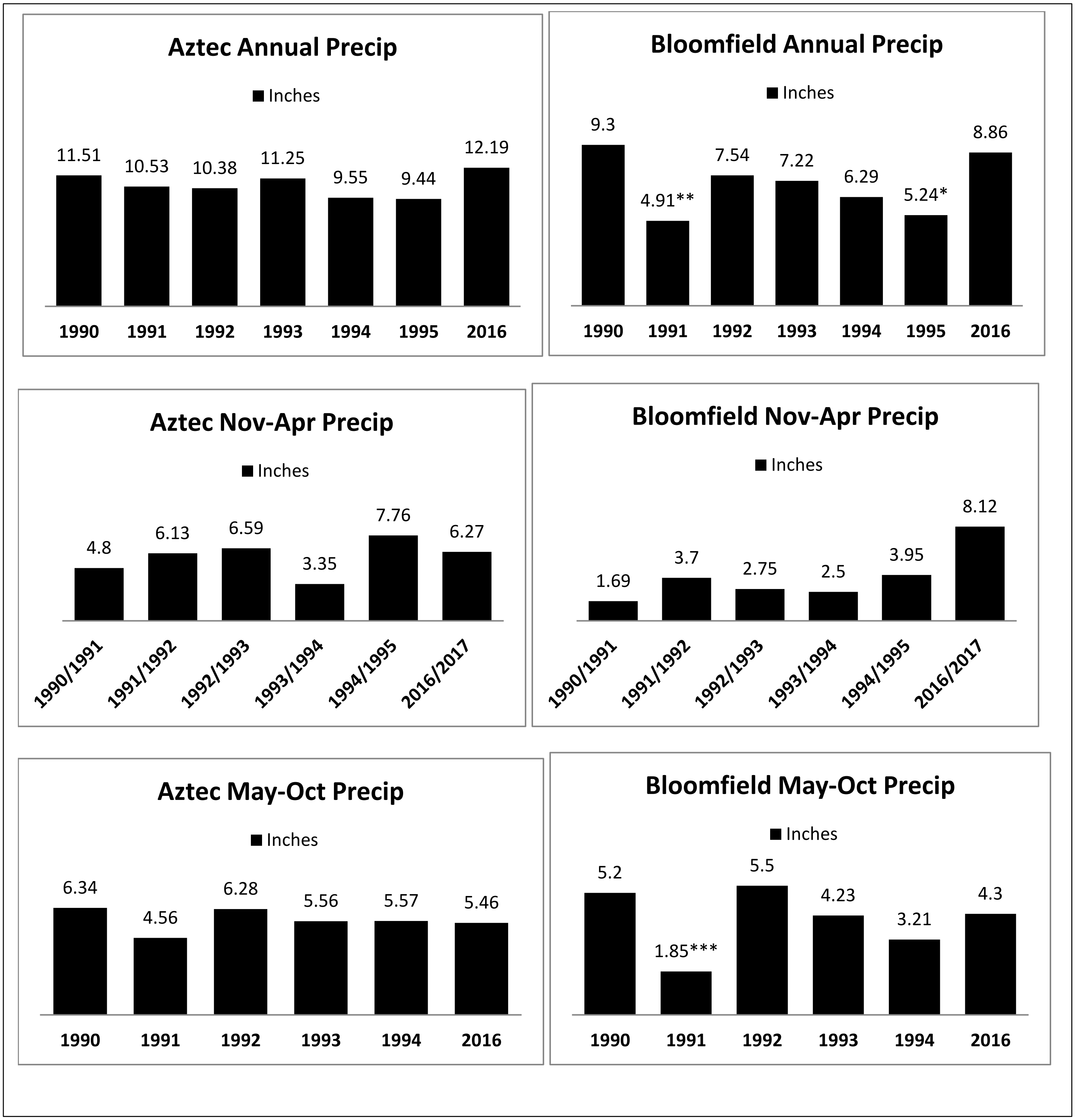
Western Regional Climate Center. 2017. Total monthly precipitation for Aztec and Bloomfield, NM. Accessed online at https://wrcc.dri.edu/summary/Climsmnm.html

Waser, N.M., M.V. Price, G. Casco, M. Diaz, A.L. Morales, and J. Solverson. 2017. Effects of road dust on the pollination and reproduction of wildflowers. Int. J. Plant Sci. 178(2)

Williamson, T.E. and S.G. Lucas. 1992. Stratigraphy and mammalian biostratigraphy of the Paleocene Nacimiento Formation, southern San Juan Basin, New Mexico. New Mexico Geological Society Guidebook, 43rd Field Conference, San Juan Basin IV. Available: http://nmgs.nmt.edu/publications/guidebooks/downloads/43/43_p0265_p0296.pdf.

Woodhouse, C.A., D.M. Meko, G.M. MacDonald, D.W. Stahle, and E.R. Cook. 2010. A 1,200-year perspective of 21st century drought in southwestern North America. Proceedings of the National Academy of Sciences 107(50):21283-21288. Available: http://www.pnas.org/content/107/50/21283.full

Appendix A. Rainfall data from https://wrcc.dri.edu/. *23 days missing, **34 days missing, ***Month of July missing



Appendix B. Number of *Aliciella formosa* plants at each waypoint in 2017.

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
AF1	New	4088595.123	230108.6	70
AF2	57267	4089012.257	229312.7392	28
AF2B	57267	4088963.388	229308.9513	10
AF2C	57267	4088946.213	229366.8358	22
AF2D	57267	4088931.447	229404.9037	35
AF2E	57267	4088943.061	229281.0053	48
AF2F	57267	4088965.468	229257.6332	18
AF2G	57267	4088918.303	229245.692	13
AF2H	57267	4088871.114	229258.9072	112
AF2I	57267	4088848.207	229245.6875	88
AF2J	57267	4088783.969	229229.1873	50
AF2K	57267	4088746.108	229263.3972	110
AF2L	57267	4088718.132	229297.6548	15
AF2M	57267	4088674.137	229280.3728	7
AF2N	57267	4089051.654	229265.1981	33
AF2O	57267	4089076.087	229293.2746	28
AF2P	57267	4089065.796	229323.3665	46
AF2Q	57267	4089011.793	229358.6667	28
AF3	57268	4087808.146	231367.996	60
AF3B	57268	4087857.33	231386.4134	16
AF3C	57268	4087938.834	231426.1048	14
AF4	10135	4088850.584	232585.5395	75
AF4B	10135	4088865.691	232631.421	23
AF4C	10135	4088925.993	232628.4132	1
AF4D	10135	4088912.485	232549.3979	22
AF4E	10135	4088941.531	232508.9214	28
AF4F	10135	4088967.877	232476.567	13
AF4G	10135	4088802.094	232552.0767	25
AF5	10138	4089852.5	232249.2476	17
AF6	10139	4089907.969	231186.4412	110
AF6B	10139	4089899.813	231223.0213	8
AF7	19137	4091418.492	231977.5073	50
AF7B	19137	4091377.667	231993.3405	1
AF7C	19137	4091290.07	232002.3458	42
AF7D	19137	4091255.313	231994.9162	29
AE7E	19137	4091203.289	232010.1286	26
AF7F	19137	4091181.441	232033.6071	7
AF7G	19137	4091467.687	231977.991	33
AF7H	19137	4091491.053	231941.6305	77
AF7I	19137	4091524.509	231898.8114	13
AF7J	19137	4091507.414	231856.2678	5

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
AF8	10240	4091341.144	234391.4669	120
AF8B	10240	4091301.752	234400.757	54
AF8C	10240	4091248.596	234416.8398	175
AF8D	10240	4091215.226	234428.9047	45
AF8E	10240	4091170.196	234359.2731	165
AF8F	10240	4091148.571	234319.0895	40
AF8G	10240	4091126.783	234337.3135	6
AF8H	10240	4091158.608	234406.5323	55
AF8I	10240	4091161.886	234447.3009	85
AF8J	10240	4091166.685	234471.4403	33
AF8K	10240	4091266.08	234504.1577	80
AF8L	10240	4091291.903	234470.5428	175
AF9	10241	4089580.546	235724.4277	13
AF9B	10241	4089554.506	235629.6058	17
AF9C	10241	4089565.035	235576.8627	125
AF9D	10241	4089549.932	235533.9354	68
AF9E	10241	4089546.639	235493.4274	45
AF9F	10241	4089508.08	235436.8357	50
AF9G	10241	4089469.655	235450.8018	155
AF9H	10241	4089482.96	235387.4412	130
AF9I	10241	4089474.272	235341.8588	10
AF10B	10245	4088352.466	236621.0952	33
AF10C	10245	4088273.498	236620.7876	63
AF11	10244	4089754.052	232761.3433	130
AF11B	10244	4089687.626	232757.7361	15
AE11C	10244	4089639.037	232759.1502	230
AF11D	10244	4089610.616	232751.5658	145
AF11D	10244	4089618.42	232658.9564	4
AF11E	10244	4089553.13	232675.7215	140
AF11F	10244	4089514.683	232640.7938	96
AF12	10242 10243	4089360.208	232801.7536	55
AF12C	10242 10243	4089299.586	232825.5359	27
AF12D	10242 10243	4089280.925	232793.7283	240
AF12E	10242 10243	4089211.574	232791.2784	4
AF12F	10242 10243	4089171.582	232780.7429	35
AF12G	10242 10243	4089088.516	232783.4811	8
AF12H	10242 10243	4089067.921	232820.2093	5
AF12I	10242 10243	4089050.383	232855.0714	98
AF12J	10242 10243	4088993.661	232917.3357	68
AF12K	10242 10243	4088956.516	232844.5361	53
AF12L	10242 10243	4088955.965	232773.7795	2
AF13	10226	4084133.792	234050.7236	53
AF13B	10226	4084094.858	234116.4467	21

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
AF13C	10226	4084059.602	234149.7967	19
AE13D	10226	4084088.823	234195.7832	17
AF14	10145	4086010.241	233017.8004	33
AF14B	10145	4086039.278	232959.8174	13
AF15	10141	4088185.902	232122.2025	220
AF15B	10141	4088222.934	232117.393	250
AF15C	10141	4088298.429	232115.224	375
AF15D	10141	4088371.522	232111.7305	225
AF15E	10141	4088408.427	232110.9318	4
AF15F	10141	4088421.161	232168.6069	1
AF15G	10141	4088400.603	232214.6162	365
AF15H	10141	4088366.436	232237.8046	26
AF15I	10141	4088299.625	232246.4039	23
AF15J	10141	4088263.417	232260.3395	34
AF15K	10141	4088473.984	232184.3679	26
AF15L	10141	4088447.065	232086.9037	18
AF15M	10141	4088462.541	232113.9766	220
AF15N	10141	4088529.543	232106.366	35
AF15O	10141	4088613.049	232093.2098	175
AF15P	10141	4088551.469	232031.0508	50
AF15Q	10141	4088611.118	232052.2911	140
AF15R	10141	4088673.32	232027.8477	15
AF16	52803 52804	4093853.07	235144.0953	90
AF16B	52803 52804	4093806.026	235163.6654	2
AF16C	52803 52804	4093783.283	235258.7926	35
AF16D	52803 52804	4093711.984	235272.5246	90
AF16E	52803 52804	4093675.73	235248.9263	85
AF16F	52803 52804	4093673.679	235182.9787	70
AF16G	52803 52804	4093636.642	235255.6404	32
AF16H	52803 52804	4093633.051	235303.0467	155
AF16I	52803 52804	4093650.002	235347.1715	112
AF16J	52803 52804	4093589.252	235353.9232	80
AF16K	52803 52804	4093594.518	235398.7532	33
AF16L	52803 52804	4093630.234	235460.9373	129
AF16M	52803 52804	4093650.701	235573.9968	230
AF16N	52803 52804	4093581.865	235558.6555	200
AF17	10162 10163	4084584.292	226327.9447	9
AF17B	10162 10163	4084448.681	226275.202	1
AF18B	10233	4079810.994	236002.5953	23
AF18C	10233	4079755.007	235984.7866	40
AF19B	10229	4078106.581	237889.1184	25
AF19C	10229	4078124.072	237847.68	11
AF19D	10229	4078147.318	237814.1887	10

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
AF19E	10229	4078216.291	237803.5393	4
AF19F	10229	4078234.922	237725.0727	9
AF20	10232	4077910.12	237667.8296	41
AF21	10230	4079328.741	237774.0106	31
AF21B	10230	4079356.753	237820.2366	21
AF21C	10230	4079399.848	237878.0888	60
AF21D	10230	4079250.873	237893.2401	67
AF21E	10230	4079233.932	237916.7406	3
AF21F	10230	4079187.837	237920.3233	22
AF21G	10230	4079143.888	237933.5274	19
AF21H	10230	4079107.89	237951.8877	70
AF21I	10230	4079040.992	238032.3449	115
AF21J	10230	4079029.96	238098.5356	3
AF21K	10230	4079288.114	237834.466	31
AF22	10223	4078085.95	239740.1653	25
AF22B	10223	4078001.949	239799.3136	20
AF23	10231	4072489.118	242069.9165	12
AF23B	10231	4072395.564	242100.4238	25
AF23C	10231	4072360.639	241940.2963	31
AF23D	10231	4072247.195	241890.2175	9
AF23E	10231	4072279.833	241817.297	8
AF23F	10231	4072312.454	242053.5874	1
AF24	52797	4076832.766	235361.1288	36
AF24B	52797	4076807.245	235306.5609	21
AF24C	52797	4076850.524	235222.0603	12
AF24D	52797	4076811.55	235185.8331	4
AF24E	52797	4076814.531	235129.2021	3
AF24F	52797	4076772.068	235151.6444	10
AF24G	52797	4076767.564	235207.2458	13
AF24H	52797	4076750.143	235249.5828	6
AF24I	52797	4076665.925	235404.099	3
AF25B	10253	4074898.65	233502.5027	10
AF25C	10253	4074941.912	233582.6608	30
AF25D	10253	4074910.215	233623.0402	13
AF26	10235	4074811.065	233735.4756	11
AF26B	10235	4074881.184	233727.478	1
AF27B	10236	4074791.301	232942.6649	28
AF27C	10236	4074866.183	233020.3322	20
AF28	10129	4071107.445	231938.3112	4
AF28B	10129	4071044.549	231946.1706	2
AF28C	10129	4071086.677	232026.6941	3
AF28D	10129	4071014.986	232109.547	23
AF29	10193 10206	4071065.644	232786.7591	3

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
AF29B	10193 10206	4071110.682	232714.1522	7
AF29C	10193 10206	4071027.687	232767.9615	3
AF29D	10193 10206	4070826.347	232741.5494	3
AF29E	10193 10206	4070823.493	232665.9221	15
AF29F	10193 10206	4070778.348	232756.1388	3
AF29G	10193 10206	4070742.795	232823.8606	18
AF29H	10193 10206	4070668.076	232737.4026	12
AF29I	10193 10206	4070606.902	232690.2544	6
AF29J	10193 10206	4070577.288	232756.2858	67
AF29K	10193 10206	4070516.593	232750.6326	3
AF29L	10193 10206	4070552.465	232786.3513	4
AF30	10203	4070170.301	232851.82	22
AE30B	10203	4070158.27	232892.0317	23
AF30C	10203	4070294.408	232904.1546	19
AF30D	10203	4070199.462	232938.8241	1
AF31	10251	4071719.854	237036.2429	2
AF31B-FH?	10251	4071689.538	237115.3935	30
AF32	10204	4069167.834	237688.8424	28
AF32B	10204	4069119.634	237648.8294	33
AF33	10115	4074180.373	234222.9867	5
AF33B	10115	4074132.168	234233.5487	6
AF34	52795	4075323.554	234306.5744	5
AF34B	52795	4075330.379	234408.4616	9
AF34C	52795	4075385.574	234394.5449	6
AF34D	52795	4075432.624	234349.7297	6
AF34E	52795	4075476.692	234368.5242	48
AF34F	52795	4075602.98	234340.2939	34
AF34G	52795	4075570.351	234400.0305	26
AF34H	52795	4075498.16	234406.8062	85
AF34I	52795	4075515.069	234331.1231	16
AF35	10122 10189	4068931.148	237304.9931	1
AF36	10250	4069414.392	239064.9709	5
AF36B	10250	4069587.381	239150.7117	19
AF37	10123	4070117.939	237881.5966	46
AF37B	10123	4070003.59	237821.7692	45
AE37C	10123	4069950.552	237812.7219	19
AF37D	10123	4069939.335	237787.3466	54
AF37E	10123	4070205.809	237895.7346	12
AF37F	10123	4070324.257	237785.7497	1
AF37G	10123	4070399.809	237795.9349	5
AF37H	10123	4070349.933	237741.7519	2
AF38	10215 10216	4071978.506	237611.8362	26
AF38B	10215 10216	4071954.637	237564.4484	24

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
AF38C	10215 10216	4071992.938	237500.0236	13
AF38D	10215 10216	4072014.475	237482.3636	1
AF38E	10215 10216	4071879.711	237458.0215	1
AF38F	10215 10216	4071775.645	237493.791	2
AF39	10220	4071629.658	237491.27	37
AF39B	10220	4071582.47	237512.3434	12
AF39C	10220	4071540.995	237528.2298	15
AF39D	10220	4071492.79	237445.054	16
AF40	10222	4071339.064	237886.1685	2
AF40B	10222	4071347.443	237776.0385	3
AF40C	10222	4071402.237	237807.4849	35
AF40D	10222	4071415.172	237740.7564	10
AF41	10198	4070654.469	237659.565	21
AF42	10195	4069997.368	236453.3546	15
AF42B	10195	4069975.231	236548.0597	3
AE42C	10195	4070002.998	236591.3798	35
AF42D	10195	4070033.374	236654.5368	37
AF42E	10195	4070068.796	236676.5473	42
AF42F	10195	4070115.787	236658.3282	5
AF42G	10195	4070125.375	236455.4254	1
AF43	55110	4064659.978	252196.4832	55
AF43B	55110	4064717.492	252219.9702	26
AF44	10188	4063693.89	248055.818	30
AF44B	10188	4063652.829	248081.1765	4
AF44C	10188	4063633.087	248117.9859	5
AE44D	10188	4063727.95	248211.8358	2
AF44E	10188	4063798.193	248183.6679	2
AF45	N of 10186	4064016.174	248090.4359	6
AF45B	N of 10186	4064074.35	247996.7985	10
AF45C	N of 10186	4064063.258	247932.1604	27
AF45D	N of 10186	4064097.226	247898.8133	24
AF45E	N of 10186	4064119.211	247861.2675	60
AF45F	N of 10186	4064165.15	247802.3345	1
AF45G	N of 10186	4064220.925	247937.3393	26
AF46	10186	4063885.207	247962.9656	4
AF46B	10186	4063853.587	248022.2334	13
AF47	10142	4059295.615	244710.3668	1
AF47B	10142	4059217.253	244690.0443	3
AF47C	10142	4059163.953	244816.5328	14
AF47D	10142	4059152.126	244773.5785	7
AF47E	10142	4059123.166	244772.627	22
AF48	New	4063153.618	243060.1364	50
AF48B	New	4063096.88	243111.3955	78

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
AF48C	New	4063144.996	243140.214	54
AF48D	New	4063196.549	243091.4833	36
AF48E	New	4063216.938	243152.3019	32
AF48F	New	4063248.751	243124.8077	1
AF48G	New	4063261.981	243079.9377	28
AF48H	New	4063316.444	243108.2306	22
AF48J	New	4063381.265	243128.1564	43
AF48K	New	4063411.342	243110.3618	81
AF48L	New	4063487.004	243142.8683	13
AF48M	New	4063470.929	243197.4027	15
AF49	52823 10185	4063748.753	243381.1555	60
AF49B	52823 10185	4063777.138	243419.8454	50
AF50	New	4062576.546	243203.4174	N/A
alifor-201-17	10155, 10144, 10146	4051416.333	244704.9476	28
alifor-202-17	10155, 10144, 10146	4051483.347	244725.9287	3
alifor-203-17	10155, 10144, 10146	4051421.326	244678.9382	6
alifor-204-17	10157	4051900.375	244647.9303	6
alifor-205-17	10157	4051852.36	244637.9045	3
alifor-207-17	10157	4051838.304	244669.9137	4
alifor-208-17	10157	4051970.341	244692.9154	9
alifor-209-17	10157	4052017.322	244692.8777	7
alifor-210-17	10157	4052030.383	244686.9059	2
alifor-212-17	10131	4052089.371	244693.9429	4
alifor-213-17	10131	4052188.384	244650.933	18
alifor-214-17	10131	4052245.287	244645.9056	5
alifor-215-18	10131	4052275.333	244643.932	7
alifor-216-17	10131	4052290.35	244631.9277	6
alifor-217-17	10131	4052323.307	244632.9069	5
alifor-218-17	10131	4052349.379	244618.9023	45
alifor-211-17	10131	4052260.386	244619.9303	20
alifor-219-17	10131	4052230.335	244610.8863	9
alifor-220-17	10131	4052194.289	244612.9502	2
alifor-221-17	10131	4052172.29	244631.9131	12
alifor-222-17	10131	4052115.346	244615.8894	7
alifor-223-17	10131	4052062.295	244625.8682	6
alifor-224-17	10131	4051987.326	244625.8802	17
alifor-225-17	10154	4052884.388	244162.8761	2
alifor-226-17	48006	4052747.371	244213.881	12
alifor-227-17	48006	4052700.314	244223.9451	9
alifor-228-17	10118	4052686.37	244296.8867	8
alifor-229-17	10118	4052742.36	244344.9489	13
alifor-230-17	10118	4052774.367	244377.8767	4
alifor-231-17	10118	4052784.376	244313.9546	13

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
alifor-233-17	10155, 10144, 10146	4051333.372	245067.8883	6
alifor-234-17	10147	4050961.344	245332.8694	300
alifor-235-17	10147	4051038.287	245314.9023	5
alifor-171-17	10148	4052593	244248	12
alifor-170-17	10148	4052572	244229	8
alifor-169-17	10148	4052516	244216	30
alifor-167-17	10148	4052530	244161	42
alifor-168-17	10148	4052465	244189	1
alifor-060517-2	10235	4074809.353	233736.9412	1
alifor-90-17	New	4047820.332	242783.9402	15
alifor-91-27	10153	4052424.353	246057.9224	6
alifor-92-17	10152	4052629.295	245519.9463	11
alifor-93-17	10151	4052810.367	245559.8809	1
alifor-94-17	10151	4052852.334	245432.866	2
alifor-95-17	10150	4052968.343	245340.9168	10
alifor-96-17	10150	4052977.363	245313.8671	11
alifor-97-17	10150	4052972.291	245263.919	5
alifor-98-17	10150	4053003.386	245177.874	1
alifor-99-17	10149	4053123.321	244979.9141	12
alifor-100-17	10117	4052743.375	244833.9284	8
alifor-101-17	10117	4052601.299	245036.8819	1
alifor-103-17	10152	4052577.326	245500.9415	3
alifor-104-17	10156	4054179.373	244092.8991	15
alifor-105-17	10156	4054140.359	244175.9171	3
alifor-106-17	10156	4054131.373	244197.9483	1
alifor-107-17	10156	4054101.336	244236.9053	7
alifor-108-17	10156	4054097.349	244314.8775	21
alifor-109-17	10156	4054109.364	244332.8772	4
alifor-110-17	10156	4054077.309	244338.9083	9
alifor-111-17	10156	4054146.356	244231.8875	1
alifor-180-17	10208	4060246.366	233869.9249	24
alifor-184-17	10180	4050798.297	240341.9184	3
alifor-185-17	New	4051065.374	239795.8672	11
alifor-146-17	New	4051052.277	239813.9265	7
alifor-147-17	10168	4050979.319	239908.9256	10
alifor-148-17	10168	4050954.34	239926.8947	21
alifor-149-17	10168	4050969.296	239964.8859	4
alifor-149-17	10120	4051300.378	239924.9088	18
alifor-150-17	10169	4051421.375	239996.9238	1
alifor-151-17	10169	4051467.367	239970.9013	21
alifor-152-17	10170	4051631.366	239601.9348	9
alifor-152-17	10170	4051567.301	239527.8776	1
alifor-153-17	New	4051303.31	240301.8935	19

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
alifor-154-17	New	4051284.308	240305.8885	61
alifor-155-17	10166	4052157.353	240929.9289	22
alifor-156-17	10171	4052785.337	239042.933	68
alifor-157-17	10171	4052893.349	239044.8695	8
alifor-158-17	10171	4052769.289	238967.9201	7
alifor-160-17	10172	4053500.316	239770.8738	6
alifor-161-17	10174	4054583.284	238383.8753	4
alifor-165-17	49754	4061777.314	240207.9212	33
alifor-166-17	49754	4061833.324	240239.8632	5
alifor-166-17	49754	4061716.317	240182.8965	21
alifor-167-17	49754	4061682.369	240177.93	9
alifor-168-17	49754	4061640.305	240165.9167	9
alifor-168-17	49754	4061724.324	240233.8742	10
alifor-1_17	10126	4058448.708	229931.9301	3
alifor-2_17	10126	4058465.791	229915.0104	5
alifor-3_17	10126	4058524.712	229934.6812	5
alifor-4-17	10126	4057926.54	229790.0566	17
alifor-5-17	10127	4057938.184	229811.8214	3
alifor-6-17	10127	4057945.971	229783.2375	1
alifor-7-17	10247	4060312.61	229545.6874	1
alifor-8_17	10247	4060291.609	229528.2869	1
alifor-9-17	10247	4060250.146	229518.6545	1
alifor-10-17	10247	4060211.954	229472.2477	2
alifor-11-17	10247	4060177.976	229390.886	5
alifor-12-17	10247	4060202.27	229402.4835	26
alifor-13-17	10248	4059586.327	229877.88	8
alifor-14-17	10248	4059620.454	229877.0753	6
alifor-15-17	10119	4058760.48	229274.0815	11
alifor-16-17	10119	4058714.864	229234.1462	3
alifor-17-17	10119	4058730.508	229224.1658	11
alifor-18-17	10119	4058684.495	229302.39	8
alifor-19-17	10119	4058970.259	229395.4699	11
alifor-20-17	10205	4062954.338	233076.895	1
alifor-21-17	57265	4061739.293	233485.9354	4
alifor-22-17	57265	4061782.36	233536.9403	8
alifor-22_17	57266	4061521.306	233476.9179	2
alifor-23-17	57266	4061542.384	233484.9116	13
alifor-24-17	57266	4061581.358	233513.955	4
alifor-25-17	10255	4062870.283	232580.9014	14
alifor-26-17	10255	4062864.326	232600.9372	23
alifor-27_17	10255	4062841.316	232597.8924	4
alifor-28-17	10183	4056919.313	239889.8723	121
alifor-29-17	10183	4056941.284	239908.8918	28

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
alifor-30-17	10183	4056973.331	239928.9328	4
alifor-31-17	10183	4057000.291	239929.9289	18
alifor-32-17	10183	4056945.373	239916.8943	53
alifor-33-17	10183	4056934.326	239958.907	3
alifor-34-17	10183	4056948.332	239976.8792	12
alifor-35-17	10183	4056982.297	239951.9449	12
alifor-36-17	10183	4056948.331	239877.9491	9
alifor-37-17	10191	4059068.308	241689.9258	4
alifor-37-17	10191	4059037.343	241714.9497	15
alifor-37-17	10191	4059006.339	241722.877	43
alifor-38-17	10191	4059037.389	241731.8676	4
alifor-39-17	10256	4059835.361	242002.9141	8
alifor-39-17	10256	4059975.292	242128.9284	17
alifor-40-17	10256	4059978.355	242100.919	2
alifor-41-17	10256	4059962.313	242109.923	2
alifor-42-17	10256	4060005.369	242114.8875	5
alifor-43-17	10256	4059952.323	242094.9452	7
alifor-44-17	10256	4059879.343	242098.9249	3
alifor-47-17	10257	4060965.287	242714.9474	4
alifor-48-17	10257	4060937.349	242753.9294	43
alifor-49-17	10257	4060928.377	242730.931	9
alifor-50-17	10257	4060908.376	242697.937	18
alifor-51-17	17488	4061284.285	242392.9069	14
alifor-52-17	17488	4061291.358	242371.9124	2
alifor-54-17	17488	4061175.38	242405.9189	1
alifor-55-17	17488	4061127.365	242517.94	8
alifor-56-17	10178	4055477.307	241972.9207	5
alifor-53-17	New	4055289.385	242227.9359	35
alifor-57-17	10179	4055968.359	242452.913	14
alifor-58-17	10179	4056004.354	242448.8894	12
alifor-96-17	10179	4056000.29	242428.8904	12
alifor-59-17	10179	4055936.312	242528.9533	8
alifor-60-17	10179	4055909.363	242523.9367	2
alifor-61-17	10179	4055879.351	242472.8956	5
alifor-62-17	10179	4055851.303	242448.9534	8
alifor-63-17	10179	4055836.303	242426.9247	5
alifor-64-17	10179	4055830.283	242412.8657	5
alifor-64-17	10160	4056324.321	242856.9103	18
alifor-67-17	10160	4056292.304	242857.9208	22
alifor-68-17	10160	4056275.382	242825.8982	18
alifor-69-17	10160	4056262.372	242807.8704	28
alifor-70-17	10160	4056265.29	242780.9188	29
alifor-73-17	10159	4056709.298	243282.8703	3

2017_ident	Original NHNM SF_ID	y_proj	x_proj	Number of Plants
alifor-75-17	10191	4058230.283	242754.869	11
alifor-76_17	10190	4057896.306	241981.9026	3
alifor-78-17	10246	4050298.303	237457.927	18
alifor-79-17	10246	4050314.322	237489.8661	25
alifor-80-17	10175	4049703.368	237633.9462	6
alifor-91-17	10175	4049753.326	237612.889	2
alifor-81-17	10175	4049740.296	237584.8925	15
alifor-82-17	10175	4049723.314	237569.9477	4
alifor-83-17	57264	4049385.38	237509.9043	29
alifor-84-17	57264	4049374.29	237574.8923	2
alifor-85-17	57264	4049358.309	237599.944	15
alifor-86-17	57264	4049324.32	237661.9041	12
alifor-92-17	57264	4049380.324	237551.8671	8
alifor-87-17	48005	4049051.286	237782.8917	8
alifor-90-17	10182	4047334.383	237093.9178	26
alifor-93-17	10182	4047290.359	237058.8712	53
alifor-94-17	10182	4047267.289	237046.8728	3
alifor-95-17	10182	4047267.357	237011.9179	4
alifor-plot_9_17	10244	4089807.465	232744.2934	3
alifor-060617	10251	4071499.36	237032.9395	1

Appendix C. NHNM *Aliciella formosa* sites on BLM lands, not found in 2017.

NHNM SF_ID	Comment
10140	No plants found. No suitable habitat - all shale. A few *Aliciella haydenii*. Perhaps misID.
10142	No plants found. No suitable habitat near point.
10239	No plants found. No suitable habitat near point. Several *Aliciella haydenii*. Perhaps misID.
10164	Locked gate - no access.
10184	Locked gate - no access.
10211	No plants found. Point in valley bottom. No habitat nearby except at 10226
10212	No plants found. Small outcrop of suitable habitat.
10113	Description too vague. Covers two square miles.
10114	No plants found. No suitable habitat near point.
10213	No plants found. No suitable habitat near point. Only E-facing slope on edge of R-O-W is 180m NE.
10130	No plants found. No habitat in area of point.
10212	No plants on BLM - perhaps on adjacent private land.
10201	No plants found. Marginal habitat.
10122	No plants found. No suitable habitat near point.
60797	No plants found. No suitable habitat near point. Collection narrative does not match point location.
10207	No plants found. No suitable habitat within 3 miles of point.
10194	No plants found. Small outcrop of suitable habitat. EO comment accurately describes population at SF_ID 10195.
48007	No plants found. Suitable habitat present. Several stands of *Aliciella haydenii*. Perhaps a misID
10249	No plants found. Large gas pipeline going through mapped location. Also, *Aliciella haydenii* in area. Possible misID or local extirpation caused by pipeline construction.
10128	No plants found. Suitable habitat present. *Aliciella haydenii* present. Perhaps a misID
10205	No plants found. No suitable habitat near point.
60800	No plants found. Marginal habitat.
10167	No plants found. No suitable habitat near point.
10191	No plants found. Site heavily disturbed. Abandoned well.
17487	No plants found. Suitable habitat present. *Aliciella haydenii* present. Perhaps a misID
17488	No plants found. Suitable habitat present. *Aliciella haydenii* present. Perhaps a misID
10146	No plants found. No suitable habitat at mapped location.
10177	No plants found at mapped location or anywhere near it
10176	No plants found at mapped location or anywhere near it
60789	No plants found. No suitable habitat near point.
48008/10116	No plants found. No suitable habitat near point.
60794	No plants found. No suitable habitat near point.
10143	No plants found. Marginal to good habitat.

Appendix D. *Aliciella formosa* monitoring plots not found in 2017.

NHNM SF_ID	Monitoring Plots not found
10251	30PL, 2 of 7 reported plots located. No plants in plots, but just outside plots. Most disturbance at E edge of pipeline. AF31B-FH? alifor-060617. Likely Floyd-Hanna #1 (Northwest Pipeline)
10209	No plants found. No suitable habitat near point. Closest habitat more 700m E on private property. Likely Floyd Hanna #4 (El Paso site)
10127	Plots 13, 14, 15, 28. All 4 plots mapped in the same vicinity. All plots vandalized, rebar stakes pulled and left in a pile. Could not determine original boundaries
10158	Plot 22. On private lands
10183	Plot 24. Not found.
10234	Plots 17 & 18. On private lands
10237	Plot 7. On private lands
10126	Plot 16. Not found