

**Wildfire Impacts
on Species of Concern Plants in the
Gila National Forest, New Mexico**



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INTRODUCTION

Although wildfires are a natural driver shaping southwest forest ecosystems, frequent large scale mega fires are a recent phenomenon in the Southwest, associated with decades of grazing and fire suppression activities as well as prolonged droughts caused by climate change. In 2012 and 2013, the Whitewater-Baldy, Little Bear, and Silver wildfires burned nearly half a million (472,750) acres of forested lands in New Mexico. As many as 15 state and federal Species of Concern may have had significant portions of their range burned by these fires (Roth 2016). Between 2000 and 2013 over 1 million acres have burned on the Gila National Forest in Catron, Grant, and Sierra counties of New Mexico (1, 034,350 acres). In 2012 the Whitewater–Baldy Fire burned approximately 290,000 acres of forest land, followed in 2013 by the Silver Fire, which burned an additional 138,698 acres.

The Gila National Forest lists 21 plant species a Forest Sensitive, which have been documented from 158 sites (Figure 1). Thirty-one percent of these 158 known rare plant sites occur within the Whitewater–Baldy fire perimeter, including a significant portion of the known range of several highly endemic plant species (Figure 1). In addition, a significant portion of the known range of several rare plant species burned in the 2013 Silver Fire and the 2006 Bear Fire, resulting in the burning of 68% of all 158 known sites of Forest Sensitive plants since 2006. For some of these species, it is estimated that their entire known range might have burned, potentially putting them at risk of extinction and therefore possibly requiring protection under the federal Endangered Species Act. Although it is generally assumed that native plant species are adapted to natural fire cycles and will therefore experience a natural recovery, the response of these sensitive species to wildfire and potential associated habitat alterations has not been studied.

All 22 species are also listed as Species of Concern (SOC) with the State of New Mexico and the U.S. Fish & Wildlife Service (USFWS) and include one NM State Listed Endangered plant, Goodding’s onion (*Allium gooddingii*) (NMRPTC 1999). From these, 8 target species were identified for the post-fire impact study, primarily based on rarity and occurrences within the fire perimeters:

1. Goodding’s Onion (*Allium gooddingii*)
2. Mogollon death camas (*Anticlea mogollonensis*)
3. Gila thistle (*Cirsium gilense*)
4. Heartleaf groundsel (*Packera cardamine*)
5. Hess’ fleabane (*Erigeron hessii*)
6. Mogollon hawkweed (*Hieracium brevopilum*)
7. Metcalfe’s penstemon (*Penstemon metcalfei*)
8. Mimbres figwort (*Scrophularia macrantha*)

The primary objectives of this study were to collect baseline information on the initial response of rare plant species to wildfires at varying levels of fire severity, collect baseline information on the impacts of altered fire regimes (increased severity and frequency) to the habitats rare plants, including the invasion of nonnative plants, and to collect baseline information on how habitats will be altered by vegetation community changes brought on by the synergistic effects of wildfires, continued drought, and the invasion of nonnative species.

Expected Results or Benefits:

- Provide recommendations for SOC plant species management before, after, and during wildfires.
- Provide updates on the current, post-fire status of SOC plants to the USFWS and land management agencies.
- Provide a framework for addressing SOC plant species management in response to increased wildfire severity and frequency.

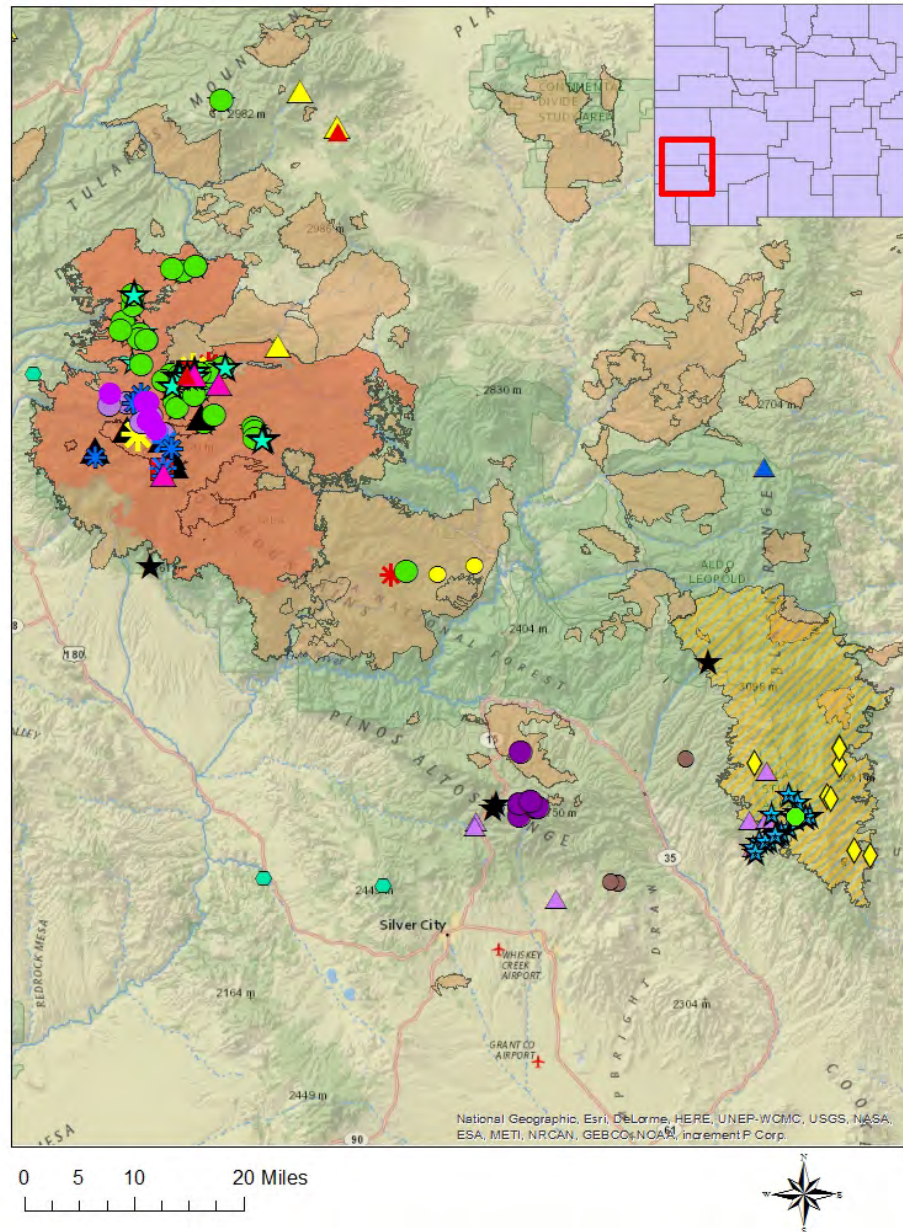


Figure 1. Documented rare plant locations in the Gila National Forest prior to 2013. Shaded polygons represent historic fire perimeters since 2000. Orange polygon: Whitewater-Baldy Fire perimeter. Yellow polygon: Silver Fire. Individual symbols represent individual rare plant species sites.

METHODS

Eight Species of Concern were selected for study based on their known occurrences within the 2012 Whitewater-Baldy and 2013 Silver Fire perimeters and overall rarity. Targeted were areas of documented occupation within fire perimeters. Initial location data was provided by the Gila National Forest and the Natural Heritage Program of New Mexico (NHNM). Additional locational information was obtained online through the Southwest Environmental Information Network (SEINet) (<http://swbiodiversity.org/seinet/index.php>). Status surveys were performed during the optimum survey period for detection and proper identification during flowering and fruiting season. All documented sites within the mapped fire perimeters and their periphery were attempted to be located during the summers of 2013, 2014, and 2015. Plants were documented with waypoints using a handheld Garmin Montana GPS and mapped using ArcMap 10.1. Each waypoint represents an occupied location or site where 1 to many plants were documented within approximately 100 ft radius of the waypoint. Documented were the estimated number of plants, associated species, fire severity, observed disturbances, and the presence of invasive species. Because fires burn in patches and sensitive plant species often occur in small microhabitat sites, burn severity was determined on site where plants were located during the survey, or where plants were mapped prior to the fire. An area of occupied habitat was determined severely burned if the tree canopy over a site or in the immediate vicinity of a site was at least 80% dead. A moderate burn was considered if the canopy was 30 - 80% dead, and a light burn contained up to 30% dead trees. Specimens collected for verification of identification and documentation purposes were deposited at the University of New Mexico Herbarium in Albuquerque.

Whitewater-Baldy Fire

The Whitewater-Baldy fire burned approximately 290,000 acres of forested lands in the Mogollon Mountain in 2012 (USFS 2012). Six of the eight targeted Species of Concern were known to occur within the Whitewater-Baldy Fire perimeter (Figure 2). Two of these six Species of Concern had their entire known range burned, including (Hess fleabane (*Erigeron hessii*) and Mogollon death camas (*Anticlea mogollonensis*)). Goodding’s onion (*Allium gooddingii*), Gila thistle (*Cirsium gilense*), heartleaf groundsel (*Packera cardamine*), and Mogollon hawkweed (*Hieracium brevipilum*) had a significant portion of their known distribution burned by the fire.

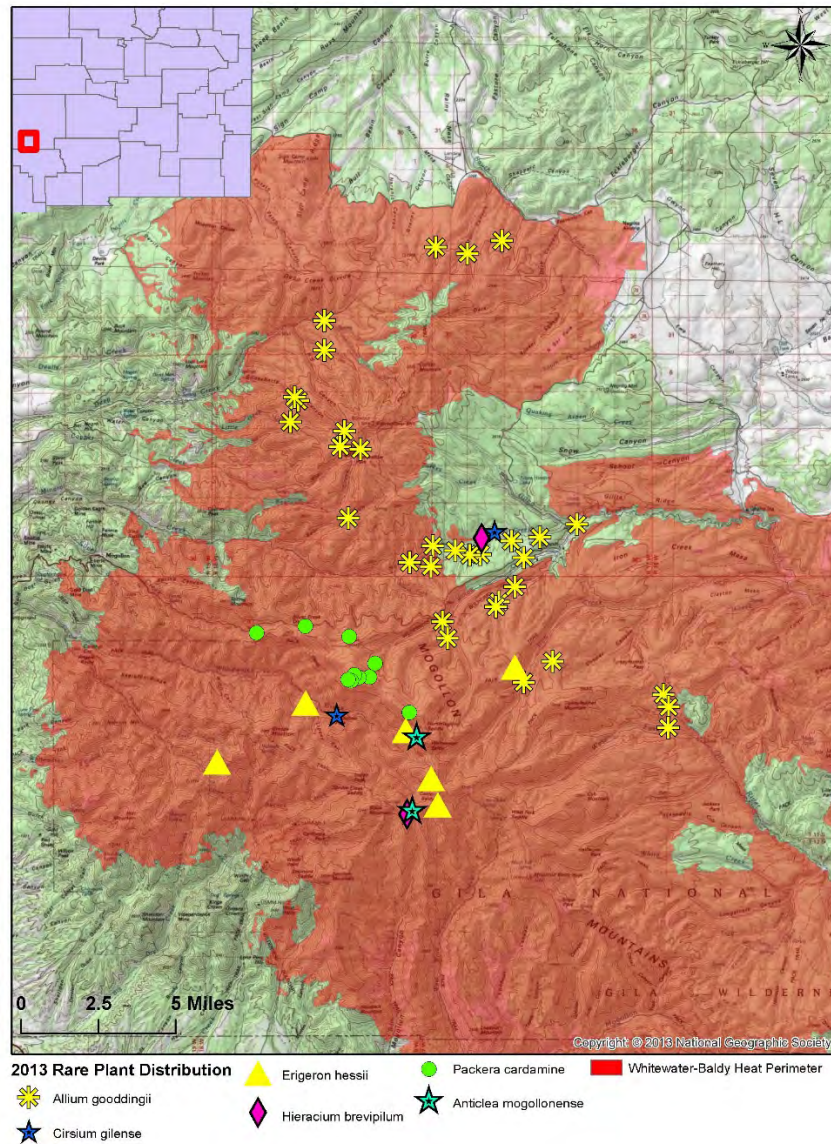


Figure 2. Documented rare plant locations within the Whitewater-Baldy fire perimeter, prior to 2013 (Gila NF 2013).

RESULTS

Summary

Except for a few areas which were difficult to reach due post-fire habitat conditions, this survey attempted to relocate the majority of sites for the 6 target species known to occur within the Whitewater-Baldy Fire perimeter. Most of the locational information was derived from the specimen record, largely documenting plants prior to the the advent of Global Positioning Devices (i.e. prior to 1995). Therefore mapped locations provided were often very general or possibly inaccurate. Except for Goodding's onion (*Allium gooddingii*), no inventory to document the abundance and distribution had been completed prior to the fire for the majority of the 6 target species. But even for Goodding's onion the last pre-fire surveys were performed before 1997 and little data on abundance was available prior to the 2012 fire. The majority of known locations for these rare plants came from the specimen record, providing incidental locational information, but no data on abundance or actual distribution of the species within the Gila National Forest. In the absence of baseline information it is not possible to determine whether there are fewer or possibly more plants after the fire than there had been prior to the fire.

With the exception of habitats burned in the 2006 Bear Fire, all six target species within the Whitewater-Baldy Fire perimeter still occupied the general areas and habitat from where they were documented prior to the 2012 fire (Figure 3). Therefore it can be assumed that these rare plants generally survive the direct impacts of fires, irregardless of fire severity. However, long term impacts of radical habitat alteration caused by severe fires may ultimately cause the decline or even disappearance of several species from their current occupied habitats. These include species adapted to growing under the canopy of mixed conifer forests, along N-facing slopes, in shady canyon bottoms, and without competition from more aggressive sun loving plants. It is assumed that sensitive species such as Goodding's onion (*Allium gooddingii*), Mogollon death camas (*Anticlea mogollonensis*), and heartleaf groundsel (*Packera cardamine*) may disappear over time, as indicated by survey results for Goodding's onion in the Indian Creek drainage, which severely burned in the 2006 Bear Fire. Surveys in areas severely burned in the Bear Fire documented the complete absence of this species, likely due to habitat and plant community changes over time, caused by the complete removal of the forest canopy overstory.

Three of the 6 target species within the Whitewater-Baldy Fire perimeter are not likely impacted or possibly even positively impacted by the fire and are experiencing few, if any, alterations to their habitats from direct impacts of the fire or post-fire impacts. These include Hess fleabane (*Erigeron hessii*), Mogollon hawkweed (*Hieracium brevipilum*), and Gila thistle (*Cirsium gilense*).

The presence and density of invasive species, native as well as introduced, changed from one year to the next, apparently depending on rainfall and to some degree elevation. In general, invasive species were documented in low numbers, typically in patchy stands, throughout the burned area. The most commonly documented invasive species included horseweed (*Conyza canadensis*), mullein (*Verbascum thapsus*), and bull thistle (*Cirsium vulgare*). Mullein and bull thistle are considered nonnative. There were significantly fewer invasive species and at lower densities at higher elevations, above 8,000ft. Horseweed was especially ubiquitous during the 2015 surveys at the lower elevations of B.S. Canyon, where it was the dominant species. All three species are annual or biennials and densities are therefore expected to

vary between years, depending on rainfall amounts and timing. Other invasives documented included broadleaf plantain (*Plantago major*), dandelion (*Taraxacum officinale*), and white goosefoot (*Chenopodium album*). Competition from the aggressive regeneration of native aspen stands and other native woody deciduous species may also impact some extant sites and habitats of Goodding’s onion, Moggollon death camas, and heartleaf groundsel.

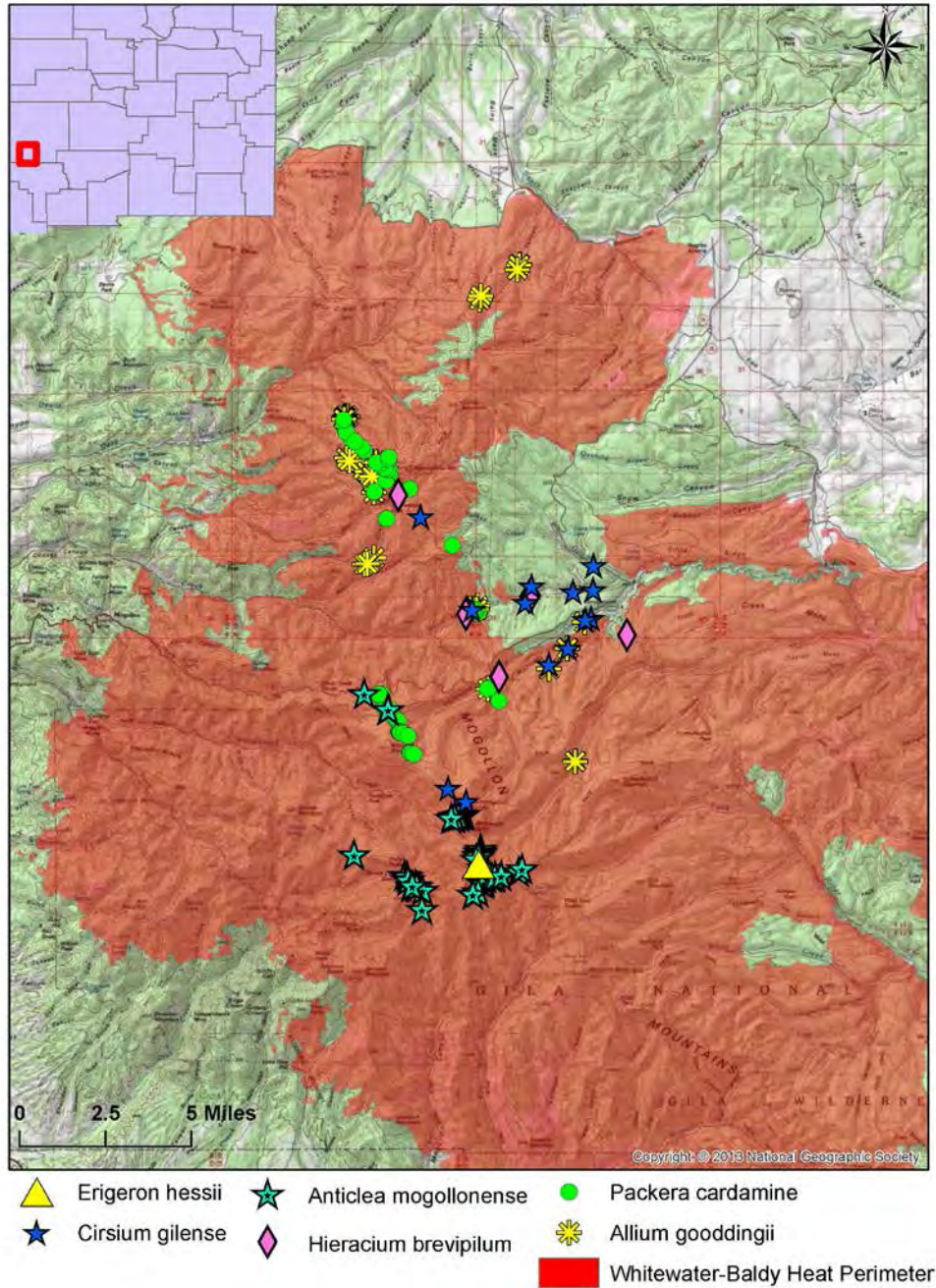
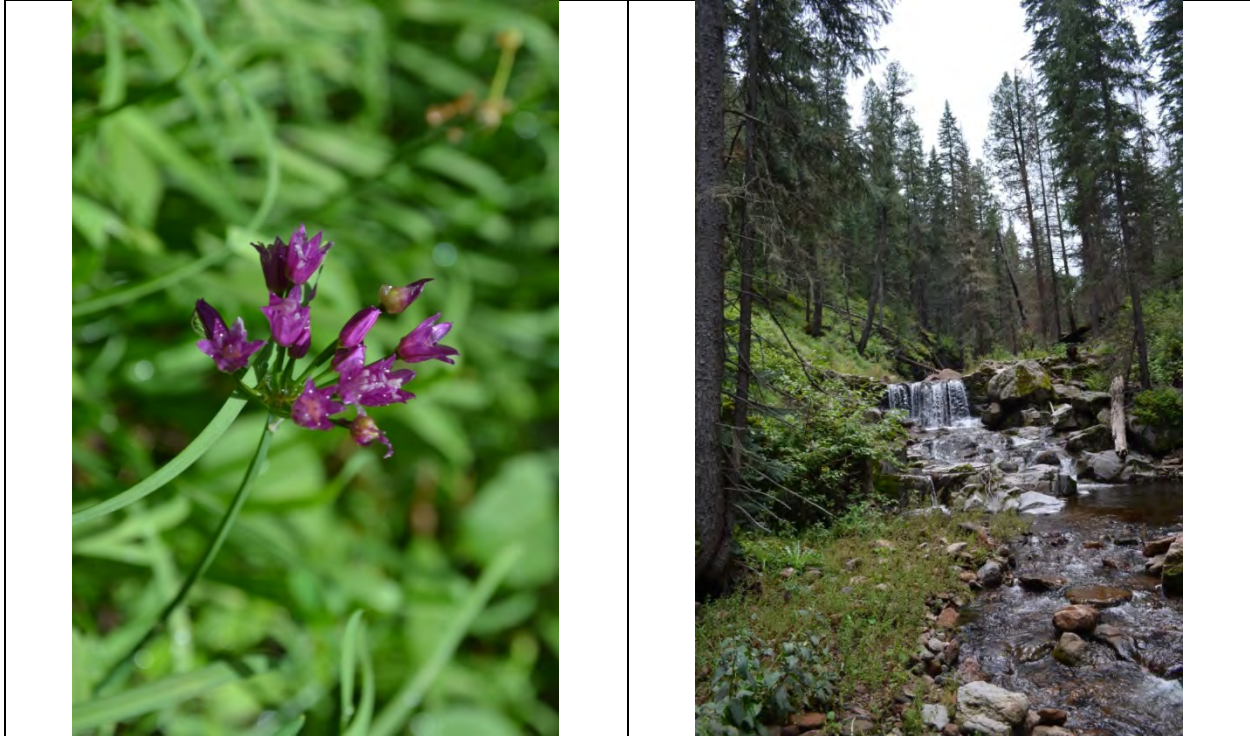


Figure 3. Post-fire rare plant sites documented from 2013 to 2015.

Goodding's Onion

(*Allium gooddingii*)



Goodding's onion is perennial herb in the lily family (Liliaceae). It is endemic to New Mexico and Arizona where it generally occurs under the canopy of mature mixed conifer and spruce forests, along north-trending drainage bottoms associated with perennial and intermittent stream courses at elevations between 7,000 and 11,300 ft (NMRPTC 1999). In New Mexico the species is known from the Gila and Lincoln National Forests. The White Mountain population in the Sierra Blanca region of the Lincoln National Forest in New Mexico is unique because plants occur in open meadows, avalanche chutes and ski slopes surrounded by subalpine forests above 10,200 ft (NMRPTC 1999).

Goodding's onion was a Candidate for Federal listing under the Endangered Species Act until a Candidate Conservation Agreement (CCA) was signed between the U.S. Forest Service (USFS) and the USFWS, providing management guidance to ensure the protection of the species in the absence of listing (USFS & USFWS 1997). The majority of sites known prior to this study were last documented well before the 1997 CCA was established. No additional inventories or monitoring took place after the CCA was finalized (Laurenzi & Anderson 2011). Goodding's onion continues to be a Forest Sensitive Species and a Species of Concern for the USFWS. It is also listed endangered with the State of New Mexico. NatureServe gives Goodding's onion an updated conservation rank of S2 (imperiled) for New Mexico (2016). It is estimated that 94 % of all documented sites in AZ and NM burned in 3 different fires between 2011 and 2012.

Prior to this study 30 sites had been documented from the Gila National Forest for Goodding’s onion (NHNM 2013). Twenty-eight of these 30 known locations on the Gila National Forest burned since 2006, including 21 sites during the 2012 Whitewater-Baldy Fire. This study attempted to relocate 18 of the 21 documented locations within the Whitewater-Baldy fire perimeter. In addition, five locations that were burned in 2006 were visited for reference purposes to determine the possible long-term impacts of habitat alteration.

Twenty of the 30 known locations were also visited by another researcher in 2012, including 9 sites burned in 2012, 6 sites burned in 2006, and 5 unburned sites (Crosley 2012) (Table 1). Pre-fire population estimates were largely not available, but the number of plants estimated for these 9 sites several months post-fire were significantly lower in 2013 through 2015 over 2012 estimates (Table 1). No plants were found in 2012 nor 2015 in 5 sites burned in 2006 in the Indian Creek drainage. Only one site was found to contain Goodding’s onion in 2012 in a burned area of the Indian Creek drainage (Indian Creek 24). A total of 75 plants were found in small patches under unburned canopy and open areas. This site reported 1,000 plants in 1991 and was one of the largest sites documented prior to the fires (NHNM 2013).

Table 1. Comparison of 20 Goodding’s onion sites visited in 2012 (Crosley 2012) and during the 2013-2015 study (highlighted). The number of plants detected in parentheses. N/A = Not attempted

Forest Service Site Name	Fire	Detected 2012	Detected 2013 - 2015
Bearwallow Creek 16	2012	Y (2500)	Y (400)
BS Canyon 18	2012	Y (750)	Y (400)
Copper Creek 33	2012	N	N
Little Turkey Creek 20	2012	Y (440)	Y (100-150)
Little Turkey Creek 22	2012	N	N
Little Turkey Creek 23	2012	Y (350)	Y (50 – 75)
Rainy Mesa Canyon 11	2012	Y (3400)	Y (175)
Rainy Mesa-Water Canyon 10	2012	Y (50)	Y (50 – 75)
Rainy Mesa-Hail Canyon 14	2012	N	N/A
Gilita Creek 6	2006	N	N
Indian Creek 8	2006	N	N
Indian Creek 12	2006	N	N
Indian Creek 15	2006	N	N
Indian Creek 23	2006	N	N
Indian Creek 24	2006	Y (75)	N/A
Indian Creek 26	None	Y	N/A
Indian Creek 13	None	Y	N/A
Willow Creek 25	None	N	Y
Frieborn Canyon 20	None	Y	N/A
Long Canyon 9	None	Y	N/A

During the 2013 – 2015 surveys Goodding’s onion was reported from 60 waypoints in 12 locations (Table 2). Approximately 6,000 plants were found in all 12 locations (Figure 4, Table 2). Plants were found in light to severely burned forests and unburned patches, except for areas that had burned in the 2006 fire. Plants were primarily vegetative with only about 5- 10% flowering in 2013. The percentage of flowering plants appeared higher in 2015.

In addition to fire severity impacts and canopy removal, much of the habitat of Goodding’s onion was significantly impacted by post-fire erosion along stream banks, including stream bank scouring and incision, debris flows and large volumes of debris deposition (Figure 4). Based on the observations of the complete absence of Goodding’s onion from areas severely burned in the 2006 Bear Fire, and the radical habitat alterations in the majority of sites documented within the Whitewater-Baldy perimeter, it is likely that Goodding’s onion will disappear from many previously recorded sites on the Gila National Forest (Figure 5). Persistence of this species should be closely monitored. Seed banking should be considered to maintain an ex-situ collection, in the event that reintroduction will become necessary in the future.

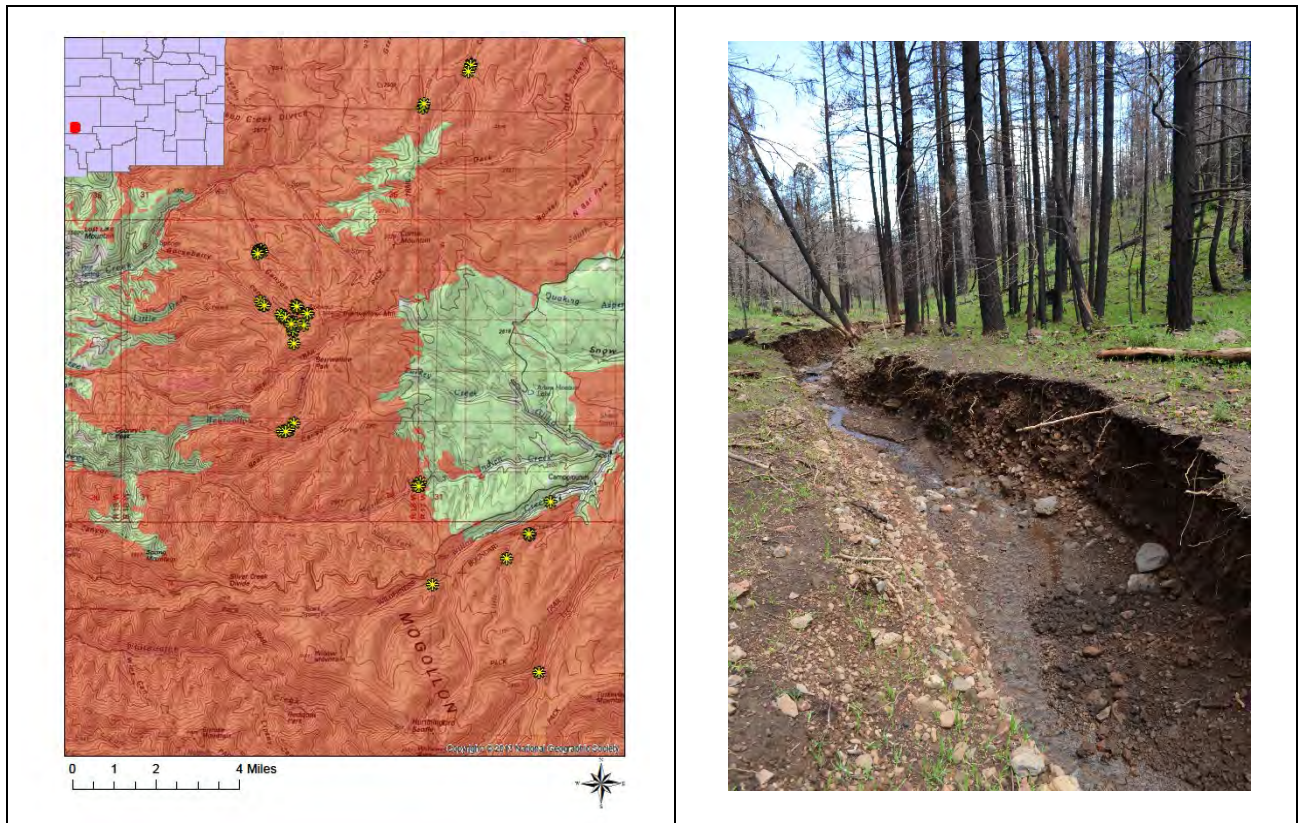


Figure 4. Documented extant sites for Goodding’s onion, 2013-2015, and post-fire habitat conditions.

Table 2. The number of Goodding’s onion plants at each waypoint/site and associated fire severity.

Waypoint/Site Name	Location	Last Observed	2013-2015 No of Plants	Fire Severity
Allgoo-16-1-13	Bearwallow Creek	9/4/13	100 - 150 plants	Light
Allgoo-16-2-13	Bearwallow Creek	9/4/13	100 - 150 plants	Light
Allgoo-16-2b-13	Bearwallow Creek	9/4/13	50-75 plants	Light
Allgoo-16-3-13	Bearwallow Creek	9/4/13	50 plants	Light
Allgoo-16-3b-13	Bearwallow Creek	9/4/13	50 plants	Light
Allgoo-fs5?-13	Mineral Creek	9/4/13	15 - 20 plants	Light
Allgoo-fs5?b-13	Mineral Creek	9/4/13	5 plants	Moderate
Allgoo-fs5?c-13-end	Mineral Creek	9/4/13	Hundreds	Light
Allgoo-2015-2	Mineral Creek	8/3/15	5 plants	Moderate to severe
Allgoo-2015-3	Mineral Creek	8/3/15	4 plants	Moderate to severe
Allgoo-18-2-13	BS Canyon	9/5/13	300 plants	Moderate
Allgoo-18-3-13	BS Canyon	9/5/13	25 plants	Moderate
Allgoo-18-4-13	BS Canyon	9/5/13	15 plants	Severe
Allgoo-18-5-13	BS Canyon	9/5/13	100-150 plants	Moderate
Allgoo-18-1-13	BS Canyon	9/5/13	15 plants	Severe
Allgoo-18-13	BS Canyon	7/31/13	5 plants	Severe
Allgoo-2015-26	BS Canyon	8/5/15	10 plants	Moderate
Allgoo-21-13	Upper Willow Creek	9/6/13	10 plants	Severe
Allgoo-FS4-1-14	Upper Iron Creek	8/27/14	500 plants	Light to moderate
Allgoo-FS13-1-14	Gooseberry Canyon	8/28/14	35-50 plants	Moderate to severe
Allgoo-FS13-2-14	Gooseberry Canyon	8/28/14	60 plants	Moderate to severe
Allgoo-FS13-3-14	Gooseberry Canyon	8/28/14	35 plants	Moderate to severe
Allgoo-FS13-4-14	Gooseberry Canyon	8/28/14	200 plants	Moderate to severe
Allgoo-FS13-5-14	Gooseberry Canyon	8/28/14	35-50 plants	Moderate to severe
Allgoo-FS13-6-14	Gooseberry Canyon	8/28/14	50-75 plants	Moderate to severe
Allgoo-FS13-7-14	Gooseberry Canyon	8/28/14	100 plants	Moderate to severe
Allgoo-FS13-8-14	Gooseberry Canyon	8/28/14	Hundreds	Moderate to severe
Allgoo-FS13-9-14	Gooseberry Canyon	8/28/14	50 plants	Moderate to severe
Allgoo-FS13-10-14	Gooseberry Canyon	8/28/14	100 plants	Moderate to severe
Allgoo-FS3-1-14	Gooseberry Canyon	8/28/14	50 plants	Light to moderate
Allgoo-FS3-2-14	Gooseberry Canyon	8/28/14	25 plants	Moderate to severe
Allgoo-FS3-3-14	Gooseberry Canyon	8/28/14	35 plants	Moderate to severe
Allgoo-FS13-11-14	Gooseberry Canyon	8/28/14	75 plants	Moderate to severe
Allgoo-FS13-12-14	Gooseberry Canyon	8/28/14	25 plants	Severe
Allgoo-fs9-2-13	Rainy Mesa Canyon	8/2/13	50 - 75 plants	Severe
Allgoo-fs-9-3-13	Rainy Mesa Canyon	8/2/13	250 plants	Severe
Allgoo-fs-9-1-13	Rainy Mesa Canyon	8/2/13	100 plants	Severe
Allgoo-fs-8-13-start	Upper Water Canyon	8/12/13	10 plants	Light or unburned
Allgoo-fs8-13 end	Upper Water Canyon	8/12/13	15 plants	Light or unburned
Allgoo-fs8-2-13	Upper Water Canyon	8/12/13	45 plants	Unburned

Waypoint/Site Name	Location	Last Observed	2013-2015 No of Plants	Fire Severity
Allgoo22-13	Little Turkey Creek	7/31/13	100 - 150 plants	Severe
Allgo23-13	Little Turkey Creek	7/31/13	50 - 75 plants	Severe
Allgoo22-3-13	Little Turkey Creek	7/31/13	25 - 50 plants	Severe
Allgoo-2015-15	Lower BS Canyon	8/5/15	75-100 plants	Moderate
Allgoo-2015-16	Lower BS Canyon	8/5/15	100 plants	Severe
Allgoo-2015-17	Lower BS Canyon	8/5/15	25 plants	Severe
Allgoo-2015-18	Lower BS Canyon	8/5/15	30 plants	Moderate
Allgoo-2015-19	Lower BS Canyon	8/5/15	50 plants	Moderate
Allgoo-2015-20	Lower BS Canyon	8/5/15	100 plants	Moderate
Allgoo-2015-21	Lower BS Canyon	8/5/15	50 plants	Moderate
Allgoo-2015-27	Willow Creek	8/5/15	150-200 plants	Unburned
Allgoo-2015-5	S Fork Gooseberry Canyon	8/4/15	12 plants	Moderate to severe
Allgoo-2015-6	S Fork Gooseberry Canyon	8/4/15	750 plants	Moderate
Allgoo-2015-7	S Fork Gooseberry Canyon	8/4/15	Hundreds	Moderate
Allgoo-2015-8	S Fork Gooseberry Canyon	8/4/15	75-100 plants	Moderate
Allgoo-2015-9	S Fork Gooseberry Canyon	8/4/15	75 plants	Moderate
Allgoo-2015-10	S Fork Gooseberry Canyon	8/4/15	50 plants	Moderate
Allgoo-2015-11	S Fork Gooseberry Canyon	8/4/15	5 plants	Severe

The density of invasive plant species varied between survey years. Most species were present in low densities in 2013 and 2014, but increased significantly by 2015, especially horseweed, *Conyza canadensis* (Table 3). High densities of horseweed were found throughout burned areas, especially at elevations below 8,000 ft., and were particularly prevalent in the lower BS Canyon area (Figure 6). The primary invasive introduced species was bull thistle (*Cirsium vulgare*) which occurred throughout the burned area in small groupings. Other invasives documented included mullein (*Verbascum thapsus*), broadleaf plantain (*Plantago major*), dandelion (*Taraxacum officinale*), and white goosefoot (*Chenopodium album*). Competition from the aggressive regeneration of native aspen stands may also impact some extant sites and habitat of Goodding's onion.

Table 3. Invasive plant species in the vicinity of occupied Goodding’s onion sites, 2013 – 2015.

Waypoint No/ Site Name	Location	Last Observed	Invasives
Allgoo-16-1-13	Bearwallow Creek	9/4/13	<i>Verbascum thapsus</i>
Allgoo-16-2-13	Bearwallow Creek	9/4/13	None
Allgoo-16-2b-13	Bearwallow Creek	9/4/13	None
Allgoo-16-3-13	Bearwallow Creek	9/4/13	None
Allgoo-16-3b-13	Bearwallow Creek	9/4/13	None
Allgoo-fs5?-13	Mineral Creek	9/4/13	None
Allgoo-fs5?b-13	Mineral Creek	9/4/13	None
Allgoo-fs5?c-13-end	Mineral Creek	9/4/13	None
Allgoo-2015-2	Mineral Creek	8/3/15	<i>Conyza canadensis</i>
Allgoo-2015-3	Mineral Creek	8/3/15	<i>Conyza canadensis</i>
Allgoo-18-2-13	BS Canyon	9/5/13	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i> , all in low densities. Seeded annual grasses dominant
Allgoo-18-3-13	BS Canyon	9/5/13	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i> , all in low densities. Seeded annual grasses dominant
Allgoo-18-4-13	BS Canyon	9/5/13	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i> , all in low densities. Seeded annual grasses dominant
Allgoo-18-5-13	BS Canyon	9/5/13	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i> , all in low densities. Seeded annual grasses dominant
Allgoo-18-1-13	BS Canyon	9/5/13	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i> , all in low densities. Seeded annual grasses dominant
Allgoo-18-13	BS Canyon	7/31/13	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i> , all in low densities. Seeded annual grasses dominant
Allgoo-2015-26	BS Canyon	8/5/15	<i>Cirsium vulgare</i>
Allgoo-21-13	Upper Willow Creek	9/6/13	<i>Cirsium vulgare</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i>
Allgoo-FS4-1-14	Upper Iron Creek	8/27/14	Some <i>Verbascum thapsus</i>
Allgoo-FS13-1-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza</i>

Waypoint No/ Site Name	Location	Last Observed	Invasives
Allgoo-FS13-2-14	Gooseberry Canyon	8/28/14	<i>canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-3-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-4-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-5-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-6-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-7-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-8-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-9-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-10-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS3-1-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities

Waypoint No/ Site Name	Location	Last Observed	Invasives
Allgoo-FS3-2-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza</i> <i>canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS3-3-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza</i> <i>canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-11-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza</i> <i>canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-FS13-12-14	Gooseberry Canyon	8/28/14	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza</i> <i>canadensis</i> , <i>Plantago major</i> , low densities
Allgoo-fs9-2-13	Rainy Mesa Canyon	8/2/13	<i>Taraxacum officinale</i>
Allgoo-fs-9-3-13	Rainy Mesa Canyon	8/2/13	None
Allgoo-fs-9-1-13	Rainy Mesa Canyon	8/2/13	None
Allgoo-fs-8-13-start	Upper Water Canyon	8/12/13	None
Allgoo-fs8-13 end	Upper Water Canyon	8/12/13	None
Allgoo-fs8-2-13	Upper Water Canyon	8/12/13	None
Allgoo22-13	Little Turkey Creek	7/31/13	None
Allgo23-13	Little Turkey Creek	7/31/13	None
Allgoo22-3-13	Little Turkey Creek	7/31/13	<i>Verbascum thapsus</i>
Allgoo-2015-15	Lower BS Canyon	8/5/15	<i>Cirsium vulgare</i> (scattered throughout N Fork and BS Canyon), <i>Conyza</i> <i>canadensis</i> (dominant in the vicinity of N Fork and BS Canyon jct) , <i>Verbascum thapsus</i> (scattered throughout), <i>Taraxacum officinale</i> (scattered throughout)
Allgoo-2015-16	Lower BS Canyon	8/5/15	<i>Cirsium vulgare</i> (scattered throughout N Fork and BS Canyon), <i>Conyza</i> <i>canadensis</i> (dominant in the vicinity of N Fork and BS Canyon jct) , <i>Verbascum thapsus</i> (scattered throughout), <i>Taraxacum officinale</i> (scattered throughout)
Allgoo-2015-17	Lower BS Canyon	8/5/15	<i>Cirsium vulgare</i> (scattered throughout N Fork and BS Canyon), <i>Conyza</i> <i>canadensis</i> (dominant in the vicinity of N Fork and BS Canyon jct) ,

Waypoint No/ Site Name	Location	Last Observed	Invasives
Allgoo-2015-18	Lower BS Canyon	8/5/15	<i>Verbascum thapsus</i> (scattered throughout), <i>Taraxacum officinale</i> (scattered throughout) <i>Cirsium vulgare</i> (scattered throughout N Fork and BS Canyon), <i>Conyza canadensis</i> (dominant in the vicinity of N Fork and BS Canyon jct) , <i>Verbascum thapsus</i> (scattered throughout), <i>Taraxacum officinale</i> (scattered throughout)
Allgoo-2015-19	Lower BS Canyon	8/5/15	<i>Cirsium vulgare</i> (scattered throughout N Fork and BS Canyon), <i>Conyza canadensis</i> (dominant in the vicinity of N Fork and BS Canyon jct) , <i>Verbascum thapsus</i> (scattered throughout), <i>Taraxacum officinale</i> (scattered throughout)
Allgoo-2015-20	Lower BS Canyon	8/5/15	<i>Cirsium vulgare</i> (scattered throughout N Fork and BS Canyon), <i>Conyza canadensis</i> (dominant in the vicinity of N Fork and BS Canyon jct) , <i>Verbascum thapsus</i> (scattered throughout), <i>Taraxacum officinale</i> (scattered throughout)
Allgoo-2015-21	Lower BS Canyon	8/5/15	<i>Cirsium vulgare</i> (scattered throughout N Fork and BS Canyon), <i>Conyza canadensis</i> (dominant in the vicinity of N Fork and BS Canyon jct) , <i>Verbascum thapsus</i> (scattered throughout), <i>Taraxacum officinale</i> (scattered throughout)
Allgoo-2015-27	Willow Creek	8/5/15	No
Allgoo-2015-5	S Fork Gooseberry Canyon	8/4/15	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Conyza canadensis</i> , low densities
Allgoo-2015-6	S Fork Gooseberry Canyon	8/4/15	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Conyza canadensis</i> , low densities
Allgoo-2015-7	S Fork Gooseberry Canyon	8/4/15	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Conyza canadensis</i> , low densities
Allgoo-2015-8	S Fork Gooseberry Canyon	8/4/15	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Conyza canadensis</i> , low densities
Allgoo-2015-9	S Fork Gooseberry Canyon	8/4/15	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Conyza canadensis</i> , low densities

Waypoint No/ Site Name	Location	Last Observed	Invasives
Allgoo-2015-10	S Fork Gooseberry Canyon	8/4/15	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Conyza canadensis</i> , low densities
Allgoo-2015-11	S Fork Gooseberry Canyon	8/4/15	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Conyza canadensis</i> , low densities



Figure 5. Post-fire habitat conditions, 2006 Bear Fire.



Figure 6. Horseweed (*Conyza canadensis*) and bull thistle (*Cirsium vulgare*) in lower BS Canyon, 2015

Mogollon death camas

(*Anticlea mogollonensis*)



Mogollon death camas is a perennial herb in the lily family (Liliaceae). It is endemic to the Mogollon Mountains on the Gila National Forest in Catron County, NM. It occurs in the understory of upper montane and subalpine coniferous forest, often with aspen, between 9,000 and 10,500 ft. Associated species include Douglas fir (*Pseudotsuga menziesii*), aspen (*Populus tremuloides*), corkbark fir (*Abies arizonica*), Rocky Mountain maple (*Acer glabrum*), rock spirea (*Holodiscus dumosus*), and a sparse understory of nodding ragwort (*Senecio bigelovii*), wild geranium (*Geranium richardsonii*), thimbleberry (*Rubus parviflorus*), green death camas (*Anticlea virescens*), fleabane (*Erigeron* sp.), fireweed (*Chamerion angustifolium*), and Canada violet (*Viola canadensis*). No inventory had been completed to document the abundance and distribution of Mogollon death camas prior this study, but it had been documented from 5 sites, primarily located in the Gila Wilderness. All of the known sites burned in 2012. Plants were documented in 2013 and 2015 (Moeny 2016). Mogollon death camas is a USFWS and State of New Mexico Species of Concern and is a Forest Service Sensitive species. NatureServe gives Mogollon death camas an updated conservation rank of S1 (critically imperiled) (2016).

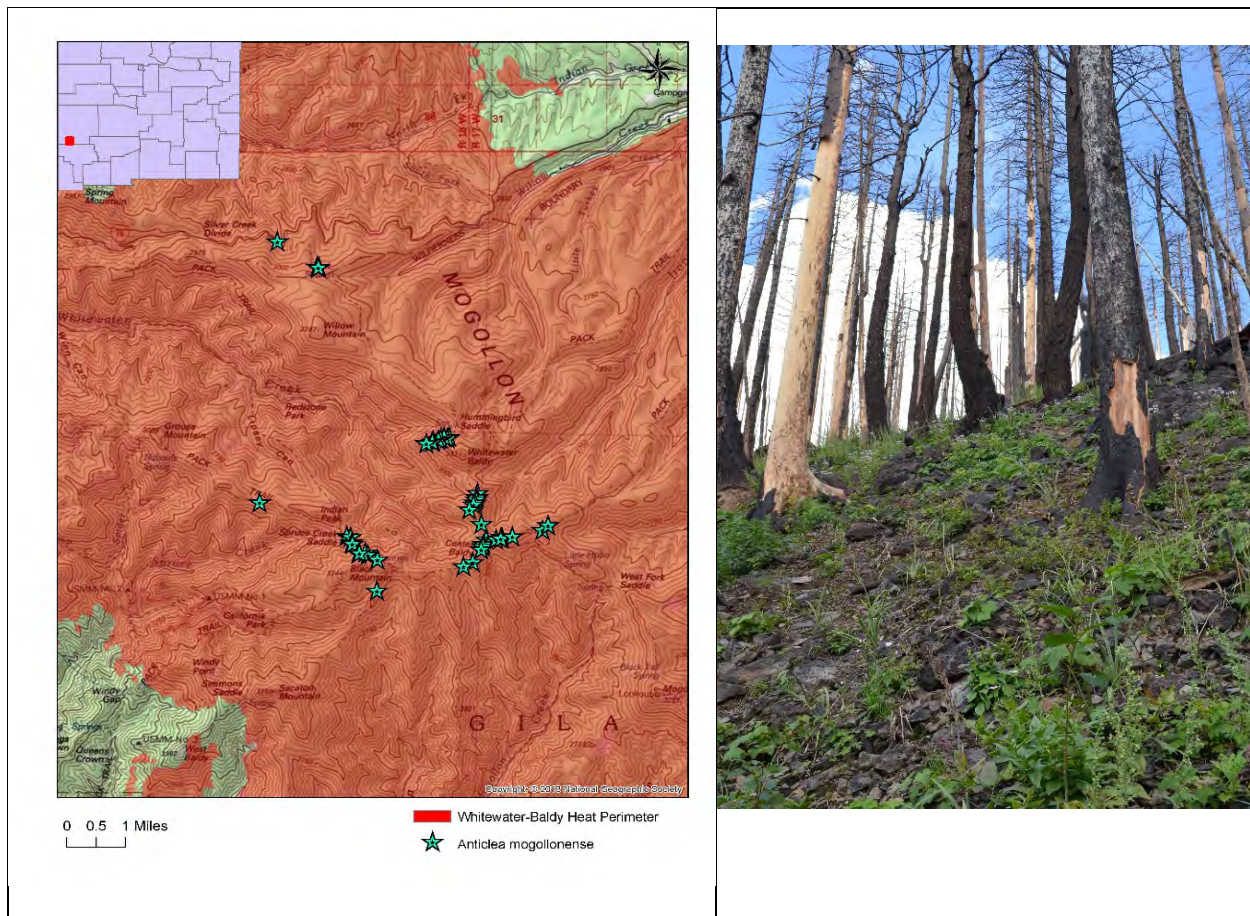


Figure 7. 2015 known distribution of Mogollon death camas and habitat condition.

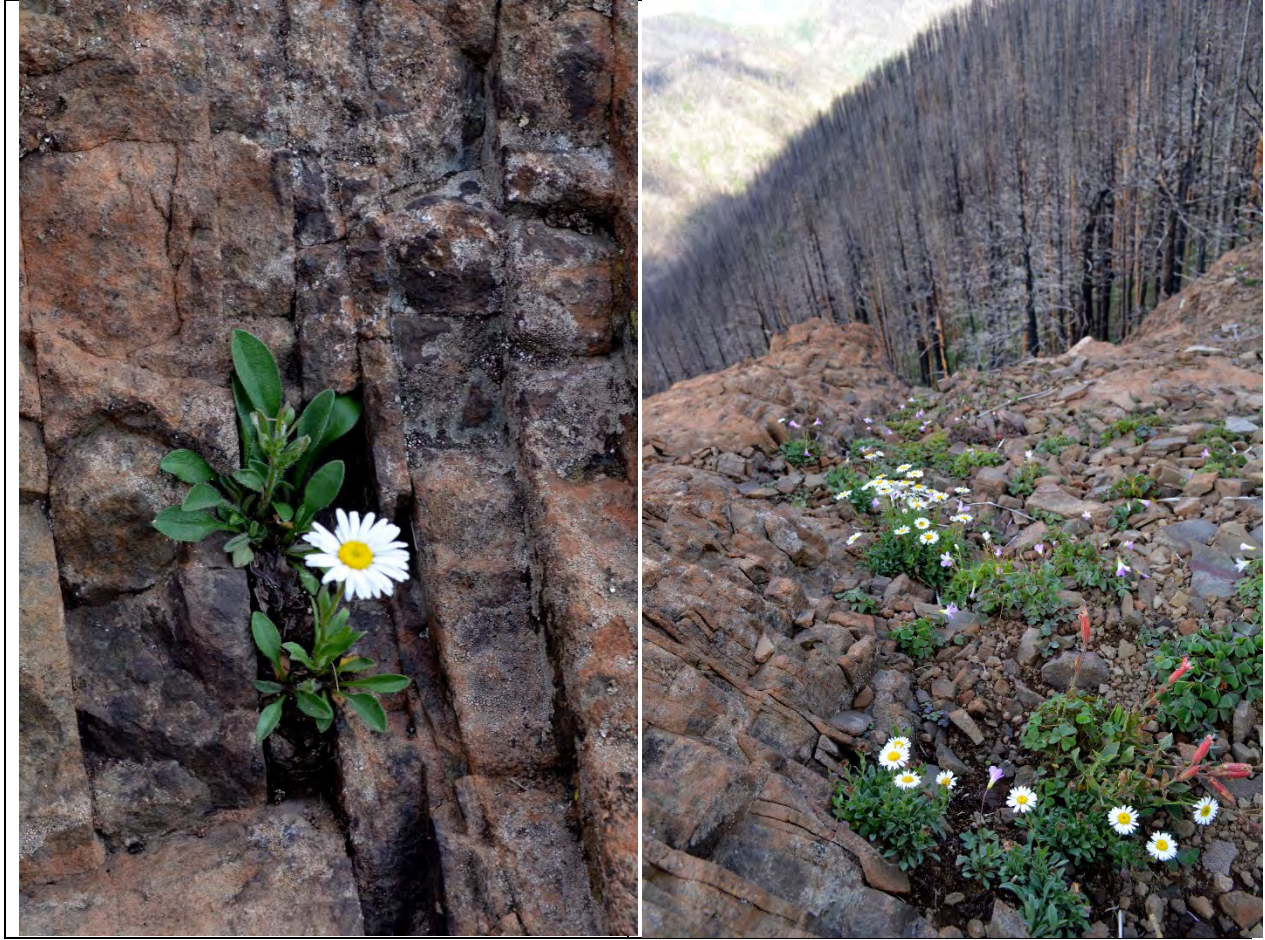
Post-fire surveys in 2013 and 2015 documented Mogollon death camas from a total 34 waypoints in the vicinity of previously documented sites and beyond along the trails in the Whitewater-Baldy area, over an area stretching approximately 5 miles x 6.5 miles (Figure 7). Seventeen sites were documented in 2013 and an additional 17 sites were documented in 2015 by another researcher (Moeny 2016). Fourteen of the 17 sites documented in 2013 were revisited in 2015. Up to several thousand plants were documented from primarily severely burned forest (Table 4). Only six of the 34 documented sites had not burned and plants were located in small patches of unburned forest. The majority of documented sites were located in severely burned forest inside the Gila Wilderness with little or no live canopy present. Because Mogollon death camas has never been observed to grow naturally in open areas, the species may not persist over time in the majority of documented sites on the Gila National Forest due to radical habitat alterations caused by the Whitewater-Baldy Fire. In addition, although no invasive species were documented in the vicinity of Mogollon death camas sites, some areas experienced substantial aspen regeneration providing significant resource competition for Mogollon death camas. Therefore, persistence and population trends of Mogollon death camas should be closely monitored. Seed banking should be considered to maintain an ex-situ collection, in the event that reintroduction will become necessary in the future.

Table 4. Number of Mogollon death camas plants in 2013 and 2015 and fire severity at each site within the Whitewater-Baldy Fire perimeter.

Waypoint No/ Site Name	No of Plants	Last Survey Date	Fire Severity
Antmog-1-13	46 plants	2013	Light to unburned
Antmog-2-13	85 plants	2015	Light
Antmog-4-13	1 plant	2015	Severe
Antmog-5-13	170 plants	2015	Severe
Antmog-6-13	30 plants	2015	Severe
Antmog-7-13	25 plants	2015	Severe
Antmog-8-13	25 plants	2013	Severe
Antmog-9-13	1 plant	2015	Severe
Antmog-10-13	9 plants	2015	Severe
Antmog-11-13	35 plants	2015	Severe
Antmog-12-13	Hundreds	2015	Severe
Antmog-13-13	7 plants	2015	Severe to moderate
Antmog-14-13	Couple hundred plants	2015	Severe
Antmog-15-13a	30 plants	2015	Severe
Antmog-15-13b	50 plants	2015	Severe
Antmog-16-13	120 plants	2015	Severe
Antmog2-13	12 plants	2013	Severe
Antmog_j1_15	4 plants	2015	Not reported
Antmog_j2_15	3 plants	2015	Unburned
Antmog_j3_15	14 plants	2015	Light
Antmog_j4_15	1 flowering	2015	Moderate
Antmog_j5_15	4 plants	2015	Moderate
Antmog_j6_15	50 plants	2015	Severe
Antmog_j7_15	Hundreds	2015	Severe
Antmog_j8_15	Hundreds	2015	Severe
Antmog_j9_2015	Hundreds	2015	Severe
Antmog_j11_15	50 plants	2015	Unburned
Antmog_j10_15	5 plants	2015	Unburned
Antmog_j13_15	8 plants	2015	Unburned
Antmog_j12_15	12 plants	2015	Unburned
Antmog_j14_15	25 plants	2015	Burned to unburned transition
Antmog_j15_15	60 plants	2015	Burned
Antmog_j16_15	30 plants	2015	Severe
Antmog-2015	3 plants	2015	Unburned

Hess' fleabane

(*Erigeron hessii*)



Hess' fleabane is a perennial herb in the aster family (Asteraceae). It is endemic to the Gila Wilderness in the Mogollon Mountains of Catron County, New Mexico, where it grows in open areas from bedrock cracks on andesitic dikes in otherwise rhyolitic rock in upper montane to subalpine conifer forests from 9,500 to 10,200 ft (NMRPTC 1999). Hess' fleabane is a USFWS and State of New Mexico Species of Concern and is a Forest Service Sensitive species. NatureServe gives Hess' fleabane an updated conservation rank of S1 (critically imperiled)(2016).

No inventory had been completed to document the abundance and distribution of Hess fleabane prior this study, but it had been documented from 3 sites, all of which burned in 2012. Only one of the three sites could be relocated during 2013 surveys in the Gila Wilderness. Wilderness trails were largely obliterated by post-fire erosion, ash deposits, and aspen regeneration. Because of the difficulty in access combined with only general locational description, two sites were not found but are likely still in existence.



Figure 8. 2013 documented distribution of Hess' fleabane

Approximately 100 plants were found in full to late flowering stage on a rock outcrop along the Crest Trail in August of 2013 (Figure 8). Plants were scattered in cracks of the rock outcrop with Indian pink (*Silene laciniata*), birdbill dayflower (*Commelina dianthifolia*), alpine woodsorrel (*Oxalis alpina*), pink alumroot (*Heuchera rubescens*), cinquefoil (*Potentilla* sp.), and various grasses. Although the surrounding forest was burned severely, the majority Hess fleabane plants were protected from direct impacts by nature of their exposed habitat. Therefore the species is not expected to experience negative impacts on populations or their habitat caused by the Whitewater-Baldy Fire. In addition, no invasive species or other disturbances were found in the vicinity of Hess' fleabane plants or their habitat. However, due to the extreme rarity of this species, limited habitat availability, and uncertainties about the response of this high elevation species to climate change, inventories to determine the true distribution, abundance and status of the species on the Gila National Forest are highly recommended. Seed banking should be considered to maintain an ex-situ collection, in the event that reintroduction will become necessary in the future.

Gila thistle

(*Cirsium gilense*)



Gila thistle is a biennial herb in the aster family (Asteraceae). It is only known to occur in Catron County, NM, and adjacent Arizona. It prefers to grow in moist areas along streams and drainage bottoms or mountain meadows in montane coniferous forest above 7,000 ft. Associated species include aspen (*Populus tremuloides*), Douglas fir (*Pseudotsuga menziesii*), Ponderosa pine (*Pinus ponderosa*), orange sneezeweed (*Hymenoxys hoopesii*), mountain brome (*Bromus carinatus*), yarrow (*Achillea millefolium*), cutleaf coneflower (*Rudbeckia laciniata*), Chiricahua Mountain dock (*Rumex orthoneurus*), thimbleberry (*Rubus parviflorus*), gooseberry (*Ribes* sp.), Rocky Mountain maple (*Acer glabrum*), and New Mexico locust (*Robinia neomexicana*). Gila thistle is a USFWS and State of New Mexico Species of Concern and is a Forest Service Sensitive species. NatureServe gives Gila thistle a conservation rank of S2 (imperiled).

Prior to this study it was documented from only 2 locations within the Whitewater-Baldy fire perimeter, although it was reported to potentially increase with disturbances (NMRPTC 1999). Gila thistle was documented from 14 sites within the Whitewater-Baldy fire perimeter between 2013 and 2015 (Figure 9). However, the Gila thistle is distributed throughout the area and is frequently found along roadsides, streams, drainage bottoms, and moist north facing slopes, but also thrives in disturbed and burned areas, regardless of fire severity. Therefore not all locations observed were recorded. Although it is generally found scattered and in low numbers, one site was found to contain thousands of plants in severely burned forest in the Gila Wilderness (Figure 10). The species was previously under-documented and is considered secure despite the disturbances to its habitat.

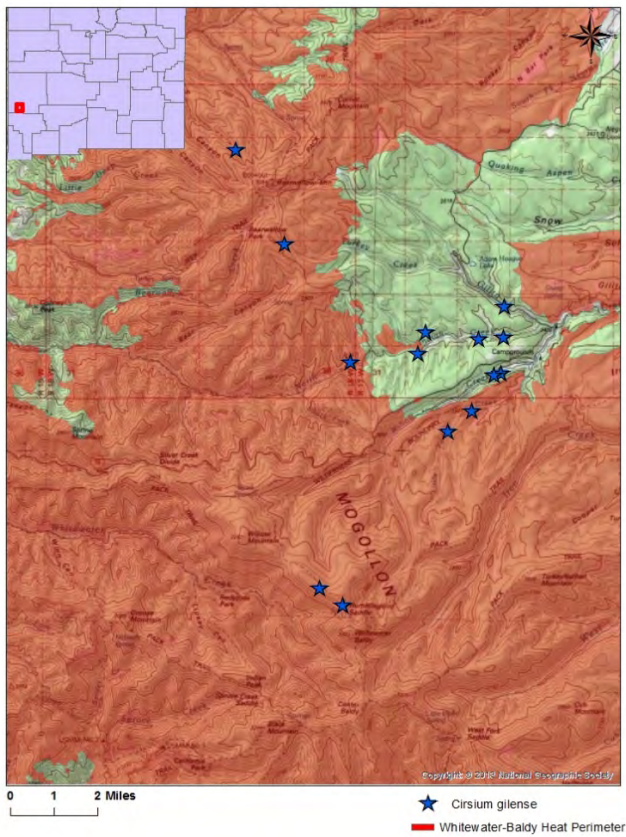


Figure 9. Documented distribution of Gila thistle, 2013 – 2015.



Figure 10. Gila thistle in burned forest along the Crest Trail in the vicinity of Hummingbird Saddle, 2013.

Heartleaf groundsel

(*Packera cardamine*)



Heartleaf groundsel is a perennial herb in the aster family (Asteraceae). It is only known from the Mogollon Mountains, NM, and the White Mountains in AZ. It generally grows on steep north-facing slopes and in the forest understory of upper montane coniferous forest above 8,000 ft. It is generally associated with Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), Mountain spray (*Holodiscus dumosus*), aspen (*Populus tremuloides*), alpine woodsorrel (*Oxalis alpina*), wild geranium (*Geranium sp.*), nodding ragwort (*Senecio bigelovii*), and Canadian violet (*Viola canadensis*). Heartleaf groundsel is a USFWS and State of New Mexico Species of Concern and is a Forest Service Sensitive species. NatureServe gives heartleaf groundsel an updated conservation rank of S2 (imperiled) (2016). All of the 10 previously documented sites in New Mexico burned in 2012.

Between 2013 and 2015, 55 waypoints documented the presence of heartleaf groundsel from 7 general locations within the Whitewater-Baldy Fire perimeter (Figure 11). Thousands of plants were documented, primarily on steep, north-facing slopes. Plants were found in groupings from a few to thousands of plants, well past flowering stage. The majority of sites were severely burned with few live trees left (Table 5). Only one site was documented from an unburned patch.

The density of invasive plant species varied between survey years. Most species were present in low densities in 2013 and 2014, but increased significantly by 2015, especially horseweed, *Conyza canadensis* (Table 5). High densities of horseweed were especially prevalent in the lower BS Canyon area, but occurred throughout burned areas and especially at elevations below 8,000 ft (Figure 5). The primary invasive introduced species was bull thistle (*Cirsium vulgare*) which occurred throughout the burned area in small groupings. Other invasives documented included mullein (*Verbascum thapsus*), broadleaf plantain (*Plantago major*), dandelion (*Taraxacum officinale*), and white goosefoot (*Chenopodium album*). Competition from the aggressive regeneration of native aspen and other deciduous native woody species may also impact some extant sites and habitat of heartleaf groundsel.

Because heartleaf groundsel has never been observed to grow naturally in open areas, the species may not persist over time in the majority of documented sites on the Gila National Forest due to radical habitat alterations caused by the Whitewater-Baldy Fire. Persistence of heartleaf groundsel should be closely monitored. Seed banking should be considered to maintain an ex-situ collection, in the event that reintroduction will become necessary in the future.

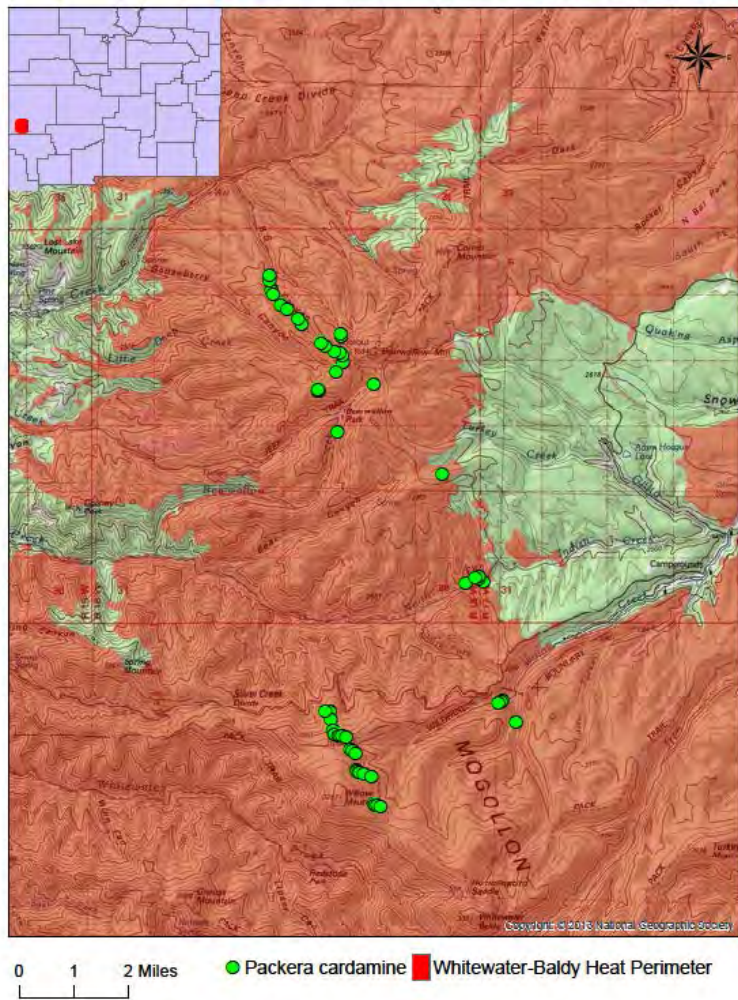


Figure 11. Documented distribution of heartleaf groundsel, 2013 – 2015.

Table 5. Number of heartleaf groundsel plants in 2013 and 2015, fire severity, and invasive species present at each site within the Whitewater-Baldy Fire perimeter.

Waypoint No/ Site Name	No of plants	Fire severity	Invasives
Paccar-1-13	11 plants	Severe	None
Paccar-2-13	15 plants	Severe	None
Paccar-3-13	20 plants	Severe	None
Paccar-4-13	30 plants	Unburned	None
Paccar-5-13	20 plants	Light	None
Paccar-6-13	25 plants	Light	None
Paccar-7-13	100 plants	Light	None
Paccar-8-13	30 plants	Light	None
Paccar-9-13	60 plants	Severe	None
Paccar-10-13	100 plants	Severe	None
Paccar-11-13	150 plants	Severe	None
Paccar-11-13	30 plants	Severe	None
Paccar-12-13	75 plants	Severe	None
Paccar-13-13	75 plants	Severe	None
Paccar-14-13	150 plants	Severe	None
Paccar-15-13	Thousands	Severe	None
Paccar-16-13	30 plants	Severe	None
Paccar-17-13	100 plants	Severe	None
Paccar-18-13	25 plants	Severe	None
Paccar-19-13	15 plants	Severe	None
Paccar-20-13	Several hundred plants	Light	None
Paccar-21-13	75 plants	Light	None
Paccar-23-13	25 plants	Moderate	None
Paccar-23-13	Hundreds of plants	Moderate	None
Paccar-24-13	100-200 plants	Moderate	None
Paccar-24-13	Hundreds of plants	Light	None
Paccar-25-13	100 plants	Severe	None
Paccar-26-13	150 plants	Light to moderate	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i>
Paccar-26-13	25 plants	Severe	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i>
Paccar-27-13	100-150 plants	Severe	<i>Cirsium vulgare</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i>
Paccar-28-13		Severe	<i>Cirsium vulgare</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i>
Paccar-29-13	100 plants	Severe	<i>Cirsium vulgare</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i>

Waypoint No/ Site Name	No of plants	Fire severity	Invasives
Paccar-3-2014	Thousands	Severe	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i> , <i>Plantago major</i> , low densities
Paccar-2015-2	50-75 plants	Light	<i>Conyza canadensis</i> , <i>Verbascum thapsus</i>
Paccar-2015-1	Thousands	Moderate	<i>Conyza canadensis</i> , <i>Verbascum thapsus</i>
Paccar-2015-3	100 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>
Paccar-2015-4	500-1000 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>
Paccar-2015-5	500 plants	Severe	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i>
Paccar-2015-6	500-1000 plants	Severe	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i>
Paccar-2015-7	200 plants	Moderate to severe	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i>
Paccar-2015-8	750 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>
Paccar-2015-9	500 plants	Severe	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i>
Paccar-2015-10	Thousands	Moderate	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i>
Paccar-2015-11	300-500 plants	Moderate	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Plantago major</i> , <i>Conyza canadensis</i>
Paccar-2015-12	200 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>
Paccar-2015-13	1000 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>
Paccar-2015-14	200 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>

Waypoint No/ Site Name	No of plants	Fire severity	Invasives
Paccar-2015-15	300 plants	Moderate	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Conyza canadensis</i> ,
Paccar-2015-16	Hundreds	Moderate	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Conyza canadensis</i> ,
Paccar-2015-17	150-200 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>
Paccar-2015-18	12 plants	Severe	None
Paccar-2015-19	50 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>
Paccar-2015-20	200-300 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>
Paccar-2015-21	100 plants	Severe	<i>Cirsium vulgare</i> , <i>Conyza canadensis</i>
Paccar-2015-22	Hundreds	Severe to moderate	<i>Cirsium vulgare</i> , <i>Verbascum thapsus</i> , <i>Taraxacum officinale</i> , <i>Conyza canadensis</i>

Mogollon hawkweed

(*Hieracium brevipilum*)



Mogollon hawkweed is a perennial herb in the aster family (Asteraceae). It is only known from the Mogollon Mountains, NM, and the White Mountains in AZ (NMRPTC 1999). It occurs in grassy openings in ponderosa pine forests and in mountain meadows between 8,200 and 10,500 ft. Associated species include Ponderosa pine (*Pinus ponderosa*), Gambel oak (*Quercus gambelii*), mountain muhly (*Muhlenbergia montana*), Thurber fescue (*Festuca thurberi*), Scouler catchfly (*Silene scouleri*), yarrow (*Achillea millefolium*), Junegrass (*Koeleria macrantha*), bluebells (*Campanula rotundifolia*), Rincon Indian paintbrush (*Castilleja austromontana*), bracken fern (*Pteridium aquilinum*), and fleabanes (*Erigeron* sp.) Mogollon hawkweed is a USFWS and State of New Mexico Species of Concern and is a Forest Service Sensitive species. NatureServe gives Mogollon hawkweed an updated conservation rank of S2 (imperiled) (2016). Prior to this study it was documented from 3 locations in NM, 2 burned in 2012, one burned in 2006 (Sivinski 2009).

Between 2013 and 2015 Mogollon hawkweed was documented from 7 waypoints in 5 locations (Figure 12). No population estimates were available for the three previously documented locations. Only one of the 7 sites where Mogollon hawkweed was found burned severely, which was the site with the fewest

plants (Table 6). Plants were largely vegetative with few in full flower or late flowering stage. Plants were generally highly localized, but abundant where they occurred, ranging from 50 to thousands of plants (Table 6). The primary invasive species documented in the vicinity of Mogollon hawkweed was mullein (*Verbascum thapsus*) which was found in low densities throughout the burned areas. Horseweed (*Conyza canadensis*) was found in abundance in the vicinity of two hawkweed sites at the bottom of the Mineral Creek drainage (Hieracium 2332, Hier2332).

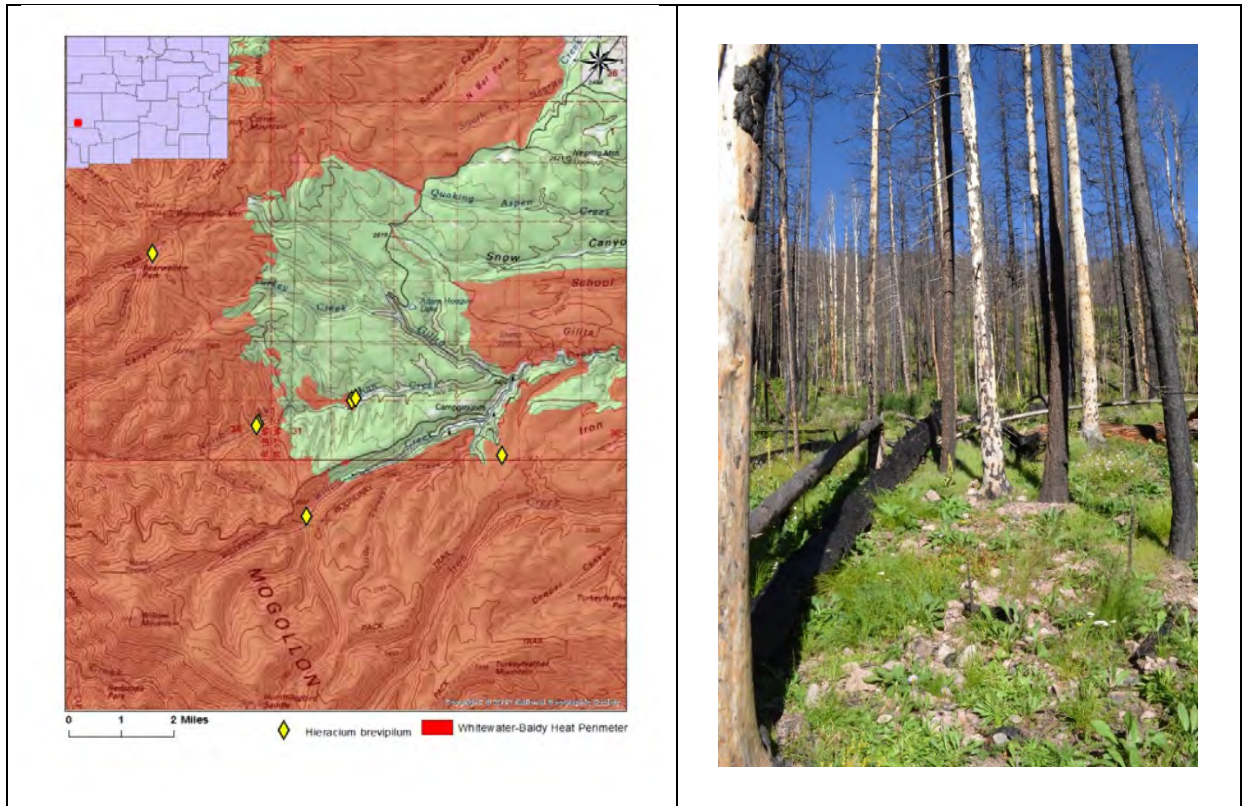


Figure 12. Documented distribution of Mogollon hawkweed in 2014 and post-fire severe burn habitat condition.

Table 6. Number of Mogollon hawkweed plants in 2013 and 2014, fire severity, and invasive species present at each site within the Whitewater-Baldy Fire perimeter.

Waypoint No/ Site Name	No of plants	Fire severity	Invasives
Hiebre-fs-2-13	500 - 750	Moderate (2006)	None
Hiebre-fs-2-2-13	200- 250	Light to unburned	<i>Verbascum thapsus</i>
Hiebre-6-13	Thousands	Moderate to severe	<i>Verbascum thapsus</i>
Hieracium-2-13	Occasional	Light	None
Hieracium 2332	Hundreds	Light to moderate	<i>Conyza canadensis</i> , <i>Verbascum thapsus</i>
Hieracium 2344	50	Severe	<i>Verbascum thapsus</i>
Hier2332	locally common	Light to moderate	<i>Conyza canadensis</i> , <i>Verbascum thapsus</i>

Mogollon hawkweed occurs primarily in open areas, meadows, and under the open canopy of Ponderosa pine forests. These habitats burned primarily lightly to moderately, with little long-term changes. Plants generally fared well post-fire and were often found in abundance. Therefore the species is expected to persist into the future. One of the previously documented locations in the Gila Wilderness was not relocated during the 2013 – 2015 surveys due to difficulties in reaching the site because of post-fire trail conditions. This site is presumed intact by nature of its described habitat (open meadow along trail; Sivinski 7747, UNM 124827). Four previously undocumented sites were found during the 2013 – 2015 surveys. This was likely due to the lack of backcountry surveys prior to this study combined with the cryptic nature of this species. Additional surveys would likely document Mogollon hawkweed from other locations in the appropriate habitat within the Gila National Forest.

SILVER FIRE

The Silver Fire burned 138,698 acres of the Black Range in 2013, including the entire known range for Metcalfe's penstemon (*Penstemon metcalfei*) and a significant portion of the know range of Mimbres figwort (*Scrophularia macrantha*)(Figure 13).

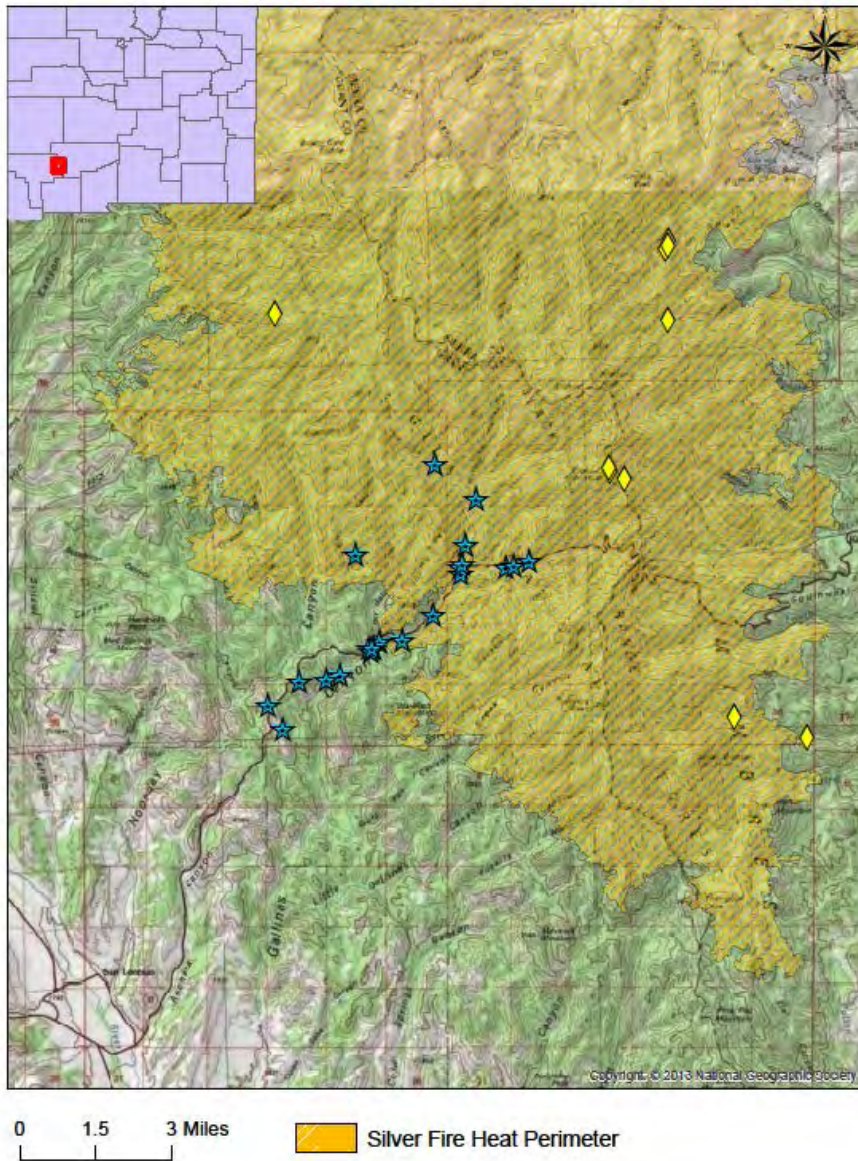


Figure 13. Documented rare plant locations within the Silver Fire perimeter, prior to 2013. Yellow diamonds = *Penstemon metcalfei*; blue stars = *Scrophularia macrantha*

RESULTS

Summary

Although both plant Species of Concern were documented to be extant after the 2013 Silver Fire, both species appeared to be in decline and were documented from fewer sites and contained fewer plants than previously reported. Metcalfe's penstemon was not located at the type locality from where it was previously documented in the thousands. Another site could not be relocated due to limited locational information. Severe burns and post-fire conditions appeared to have significantly impacted the persistence of the species. Pre-fire documentation of Mimbres figwort came primarily from a very old specimen record, providing largely only general locational information and little information on the number of plants present prior to the fire. Plants were not found in most unburned sites from where they were previously documented for unknown reasons. Impacts of fire severity and post-fire habitat conditions on extant populations are unclear.

Very few or no invasive species were documented from the vicinity of extant Metcalfe's penstemon or Mimbres figwort sites in the Black Range. However, competition from native woody species including aspen, oak, New Mexico locust, and chokecherry may provide significant resource competition to the recovery of both species.

Mimbres figwort

(*Scrophularia macrantha*)



Mimbres figwort is a perennial herb in the figwort family (Scrophulariaceae). It is only known to occur in Grant and Luna counties of New Mexico, where it grows on steep, rocky, usually north-facing igneous cliffs and talus slopes, and occasionally in canyon bottoms along streams in piñon-juniper woodlands and lower montane coniferous forests between 6,500 and 8,200 ft (NMRPTC 1999). Associated species include ponderosa pine (*Pinus ponderosa*), pinion pine (*Pinus edulis*), Douglas fir (*Pseudotsuga menziesii*), chokecherry (*Prunus virginiana*), New Mexico locust (*Robinia neomexicana*), Arizona walnut (*Juglans major*), alder (*Alnus oblongifolia*), boxelder (*Acer negundo*), scarlet cinquefoil (*Potentilla thurberi*), Fendler brickellbush (*Brickellia fendleri*), mountain brickellbush (*Brickellia grandiflora*), James buckwheat (*Eriogonum jamesii*), mountain brome (*Bromus carinatus*), Gambel oak (*Quercus gambelii*), Mexican catchfly (*Silene laciniata*), scarlet bugler (*Penstemon barbatus*), fetid goosefoot (*Dysphania graveolens*), scarlet gilia (*Ipomopsis aggregata*), sweet four o'clock (*Mirabilis longiflora*), mountain leaftail (*Pericome caudata*), and Carruth sagewort (*Artemisia carruthii*). Mimbres figwort is a USFWS and State of New Mexico Species of Concern and is a Forest Service Sensitive species. NatureServe gives Mimbres figwort an updated conservation rank of S2 (imperiled) (2016).

Prior to this study Mimbres figwort was documented from 22 locations in the Black Range of the Gila National Forest, primarily in the Gallinas/Railroad Canyon areas and the vicinity of Iron Creek (Figure 14; Table 7; NHNM 2013; SEINet 2013). Two disjunct populations known from BLM lands in the Cooke's Range of Luna County and the Chino Mine (Kneeling Nun) in Grant County were not evaluated for this study. Eleven of the locations known from the Black Range were located within the 2013 Silver Fire perimeter (Figure 14). No previous inventories to determine actual distribution and abundance on the Gila National Forest had been completed to assess the status of this species prior to the fire. All of the known locations were derived from the specimen record and were collected prior to 1993, except for one, documented in 2011 (FS 030602EO00012, Sclmac-nmhp22-14). Therefore the majority of documented locations for Mimbres figwort were very general in nature and did not contain any information on abundance.

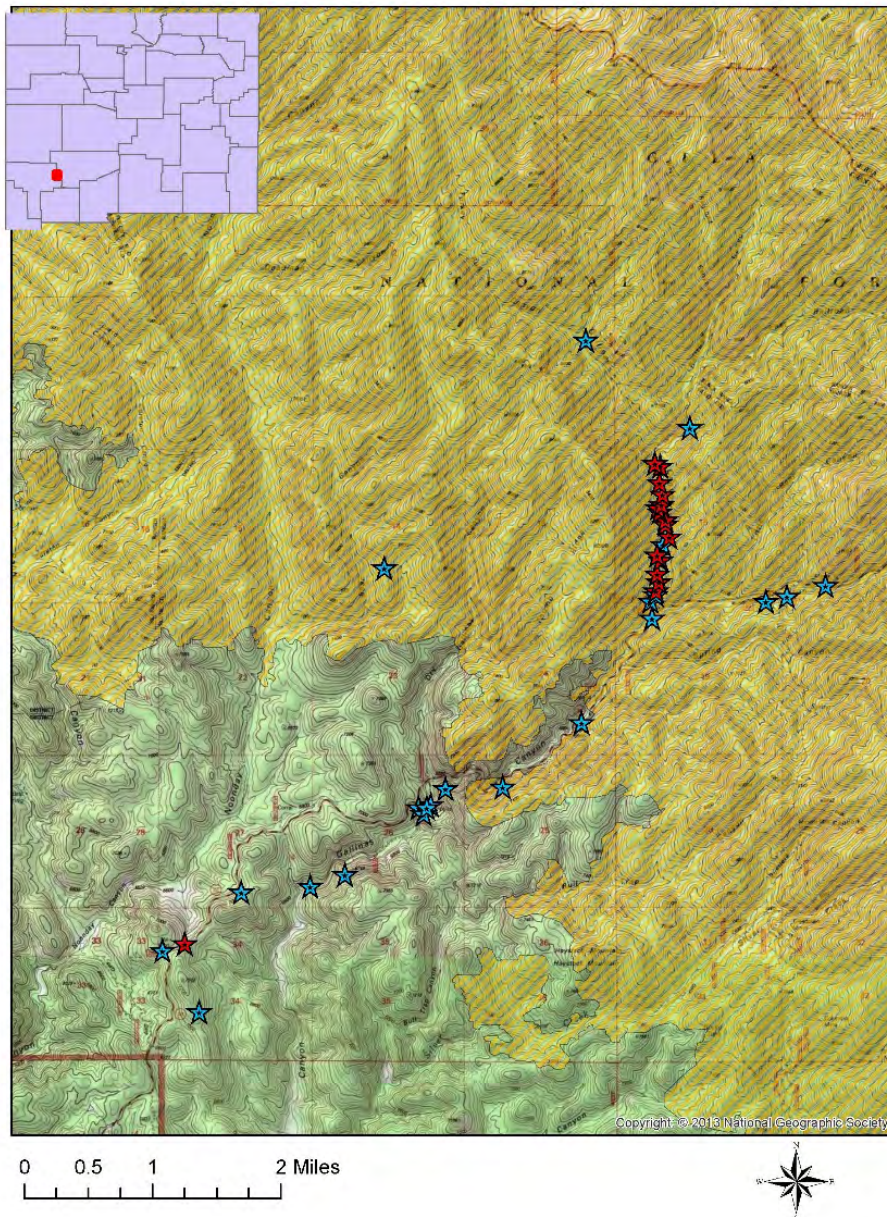


Figure 14. Documented sites of Mimbres figwort, prior to 2013 (blue stars) and 2014 documented distribution (red stars).

A total of 15 of the 22 documented sites in the Black Range were searched for in 2014, inside and outside the fire perimeter. Various attempts to relocate these 15 sites took place during the flowering season in July and August of 2014, based on the available location descriptions and maps (NHNM 2013, SEINet 2013). Only three of these 15 sites could be relocated with extant plants (Table 8). Two general locations containing 16 occupied sites were found during surveys, one of which was inside the fire perimeter (Figure 14, Table 7). The second location was outside the fire perimeter, along Highway 152, in an open N-facing roadcut (Scrmac-081914). This site had been previously documented. No plants were found along Iron Creek anywhere within Gallinas Canyon. Areas surveyed included the Iron Creek and Gallinas (upper and lower) campgrounds and surrounding areas, and the area surrounding the junction of Iron Creek and Railroad Canyon (Table 8). One documented population from the Iron Creek campground area, contained the similar looking mountain figwort (*Scrophularia montana*), which occurred within the habitat of Mimbres figwort (D. Roth 2423, 7/18/2014; D. Roth 2458, 8/18/2014). No Mimbres figwort was observed in this area. Therefore it is assumed this location may have been a misidentification.

No documentation on the abundance of plants prior to the fire was available. In 2014 fewer than 400 plants were documented from areas inside the fire perimeter and only 10 plants were found outside the fire perimeter (Table 7; Scrmac-081914). Except for one site (Scrmac-nmhp22-15-14), plants were largely scattered in small groupings of 25 or fewer plants per site. The site with the most plants was the northernmost occupied site documented during this survey. The area burned moderately to severely with much of the overstory trees dead or dying. No additional plants were found for approximately 1.5 mile past (north) from this site in Gallinas Canyon, nor for 1 mile upstream in Railroad Canyon. Plants were generally found vigorous and in full flower. In addition to fire severity impacts and canopy removal, much of the stream bank habitat of Mimbres figwort was significantly impacted by post-fire erosion, including stream bank scouring and incision, debris flows and large volumes of debris deposition.

Invasive species were sparsely distributed in the vicinity of occupied sites and limited to a few scattered mullein (*Verbascum thapsus*) and dandelion (*Taraxacum officinale*) plants (Table 7). However, the regeneration of deciduous native woody species including aspen, Gambel oak, New Mexico locust, and chokecherry may provide significant resource competition and impact the recovery of some Mimbres figwort sites.

Table 7. Number of Mimbres figwort plants, fire severity, and invasive species present at each site extant in 2014.

Waypoint No/ Site Name	No of plants	Fire severity	Invasives
Scrmac-nmhp22-15-14	100-200 plants	Moderate to severe	None
Sclmac-nmhp22-14	6 plants	Unburned	<i>Verbascum thapsus</i>
Scrmac-nmhp22-1-14	7 plants	Light	None
Scrmac-NMHP22-3-14	5 plants	Light	None
Scrmac-nmhp22-4-14	3 plants	Light	None
Scrmac-nmhp22-5-14	25 plants	Moderate	None
Scrmac-nmhp22-6-14	6 plants	Moderate	None
Scrmac-nmhp22-7-14	15 plants	Light	None
Scrmac-nmhp22-8-14	10 plants	Light	None
Scrmac-nmhp22-9-14	15 plants	Severe	None
Scrmac-nmhp22-10-14	25 plants	Moderate to severe	None
Scrmac-nmhp22-11-14	5 plants	Moderate	None
Scrmac-nmhp22-12-14	25 plants	Severe	<i>Verbascum thapsus</i> , <i>Taraxacum officinale</i>
Scrmac-nmhp-22-13-14	4 plants	Severe	None
Scrmac-nmhp22-14-14	4 plants	Light	None
Scrmac-081914	10 plants	Outside of fire perimeter	None

Table 8. Number of sites previously documented from the Gallinas & Iron canyon area and 2014 survey results. N/A = not attempted

NHNM Element Occurrence No	NHNM Source Feature ID	USFS Site ID	Surveyed in 2014	Plants found/ ID	Fire severity	Comments
1	10590	030607EO00011	No	N/A	N/A	Location too general for reasonable relocation
None	None	030607EO00025	Yes	No	Moderate to severe	No plants at mapped location or anywhere in the vicinity. Habitat marginal at best. Not likely mapped at the right location
2	10600	030607EO00018	Yes	No	Light to moderate	Habitat present. No plants at mapped location or anywhere in the vicinity.
2	10592	030607EO00013	Yes	No	Light to moderate	No plants found along Iron Creek in any mapped location. Found <i>S. montana</i> . Possibly misidentified
None	None	030607EO00026	Yes	No	Light to moderate	No plants found along Iron Creek in any

NHNM Element Occurrence No	NHNM Source Feature ID	USFS Site ID	Surveyed in 2014	Plants found/ ID	Fire severity	Comments
						mapped location. Found <i>S. montana</i> . Possibly misidentified
None	None	030607EO00024	Yes	No	Severe	No plants found along Iron Creek in any mapped location. Found <i>S. montana</i> . Possibly misidentified
2	10596	030607EO00016	Yes	Yes/ ScImac- nmnh22-5- 14 & -6-14	Moderate	No plants found at exact mapped location, but within several hundred feet
2	38398	030602EO00012	Yes	Yes/ ScImac- nmnh22-14	Light to Moderate	No plants found at exact mapped location, but within 150 feet, in small unburned patch
None	None	030607EO00027	Yes	No	Light	No plants found in mapped location, possibly not mapped correctly.
None	None	030607EO00029	Yes	No	Light	No plants found in mapped location, possibly not mapped correctly.
2	10593	030607EO00014	No	N/A	N/A	Location too general for reasonable relocation. No plants found anywhere near creek and HWY throughout canyon area.
2	10595	030607EO00015	No	N/A	N/A	
2	10604	030607EO00021	No	N/A	Not burned	Not likely mapped correctly. Gallinas Campground location is associated with FS Site Nos 28 -31 (no NHNM Nos)
None	None	030607EO00028	Yes	No	Not burned	No plants found near mapped areas. Possibly on other side of creek. If so, they were not flowering. Did not cross due to flooding.

NHNM Element Occurrence No	NHNM Source Feature ID	USFS Site ID	Surveyed in 2014	Plants found/ ID	Fire severity	Comments
None	None	030607EO00029	Yes	No	Not burned	No plants found near mapped areas. Possibly on other side of creek. If so, they were not flowering. Did not cross due to flooding.
None	None	030607EO00030	Yes	No	Not burned	No plants found near mapped areas. Possibly on other side of creek. If so, they were not flowering. Did not cross due to flooding.
None	None	030607EO00031	Yes	No	Not burned	No plants found near mapped areas. Possibly on other side of creek. If so, they were not flowering. Did not cross due to flooding.
2	10591	030607EO00012	Yes	Yes/Scrmac-081914	Not burned	Roadside. Outside fire perimeter. Likely W.L. Wagner 2340, Aug. 8 1976, Gila NF Herbarium)
2	10599	030607EO00017	No	N/A	Not burned	
2	10602	030607EO00020	No	N/A	Not burned	
2	10601	030607EO00019	Yes	No	Not burned	Possibly the same as 10591
None	None	030607EO00022	No	N/A	Not burned	

Mimbres figwort is far more rare than previously thought. It appears to no longer occupy certain areas from where it was previously documented for unclear reasons. No plants were found along Iron Creek, including well documented sites in the campground areas (Iron Creek and Gallinas campgrounds). Most of these previously documented sites did not burn, but may have experienced some post-fire flooding and associated scouring of the stream banks. Nonetheless, plants should still be expected along the slopes adjacent to the stream banks, from where they were previously reported. Some of these sites may have been actually mountain figwort, mistaken for Mimbres figwort. Although some of the better documented sites in the vicinity of the campgrounds may be extirpated, some of the previously known sites might have been poorly mapped by various agencies, based on general location descriptions from herbarium

labels. This may perhaps be the most likely cause of the absence of these plants from various mapped areas outside the fire perimeter, in addition to misidentification.

Because Mimbres figwort appears to have a preference for growing in cool, shady areas, underneath the canopy of mixed conifer forests and along stream banks, the species may not persist over time in the majority of documented sites on the Gila National Forest due to radical habitat alterations caused by the Silver Fire. In addition, many of the sites previously documented outside the fire perimeter were not found in 2014 and may no longer exist. Inventories to determine the actual distribution and abundance of this species on the Gila National Forest are essential to assess the true status of Mimbres figwort. In addition, the persistence of the extant sites within the Silver Fire perimeter should be closely monitored. Seed banking should be considered to maintain an ex-situ collection, in the event that reintroduction will become necessary in the future.

Metcalfe's penstemon

(*Penstemon metcalfei*)



Metcalfe's penstemon is a perennial herb in the plantain family (Plantaginaceae). It is restricted to the Black Range of the Gila National Forests in Sierra County. It occurs on cliffs or steep, north-facing slopes and drainage bottoms in lower and upper montane coniferous forest between 6,600 and 9,500 ft (NMRPTC 1999). Associated species include Douglas fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), Gambel oak (*Quercus gambelii*), orange gooseberry (*Ribes pinetorum*), alpine woodsorrel (*Oxalis alpina*), scarlet penstemon (*Penstemon barbatus*), New Mexico locust (*Robinia neomexicana*), red elderberry (*Sambucus racemosa*), chokecherry (*Prunus virginiana*), canyon maple (*Acer grandidentatum*), and aspen (*Populus tremuloides*). Metcalfe's penstemon is a USFWS and State of New Mexico Species of Concern and is a Forest Service Sensitive species. NatureServe gives Metcalfe's penstemon an updated conservation rank of S1 (critically imperiled) (2016).

Prior to the 2013 Silver Fire it was known from 5 sites, all of which burned (Figure 15). All these 5 known sites were searched for during July and August 2014. Plants were found in 3 of the 5 known locations, totaling 138 plants in all sites (Figure 15; Table 9). One Site was likely miss-mapped; no suitable habitat was present at the mapped location or anywhere near it (O.F. Williams s.n., July 20, 1996; SNM 6284). No plants were found at or near the type locality in Trujillo Canyon, where thousands of

plants were previously recorded (NHNM EO #3 & 6). This site had severely burned and experienced extreme flooding and debris deposition on the drainage floor following the 2013 fire (Figure 16).

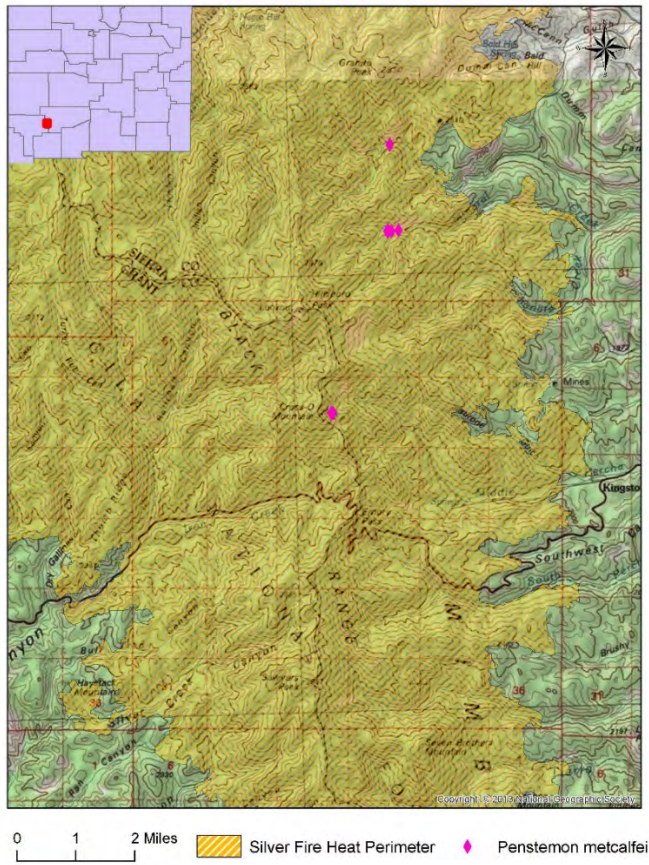


Figure 15. Post fire distribution of Metcalfe’s penstemon, 2014.



Figure 16. Habitat condition at the Trujillo Canyon the type locality for Metcalfe’s penstemon, 2014.

Table 9. Number of Metcalfe’s penstemon sites previously documented and 2014 survey results.

NHNM Element Occurrence No	NHNM Source Feature ID	USFS Site ID	Location Name	1999 No of Plants	2014 No of Plants	Fire severity	Comments
6	10568	030602EO00005	Trujillo Canyon	1000s plants	None	Severe	Likely the same as FS 030602EO00002, NHNM EO #3 (SF 10565) Type locality – severely eroded, no invasives
5	10567	030602EO00004	Cross-O Mountain	100 plants	100 plants	Moderate to severe	Likely the same as FS 030602EO00001 and FS 030602EO00007 NHNM EO #2 (SF 10564). Dead, seeded annual grasses
1	10992	030602EO00006	Mineral Creek	100 plants	18 plants	Severe	Dead, seeded annual grasses
None	None	030605EO00009	Quaking Aspen Canyon	N/A	No	Moderate	Likely miss-mapped, habitat marginal. O. Williams 96027. No invasives
4	10566	030602EO00008	North Percha Canyon	N/A	20 plants	Light to moderate	Likely the same as FS 030602EO00010 and FS 030602EO00003. Slopes heavily eroded. No invasives.

The majority of the occupied habitat of Metcalfe’s penstemon burned moderately to severely in the 2013 Silver Fire. In addition to fire severity impacts and canopy removal, much of the stream bank habitat of Metcalfe’s penstemon was significantly impacted by post-fire erosion, including stream bank scouring and incision, debris flows and large volumes of debris deposition (Figure 16).

No invasive species were documented in the vicinity of any of the Metcalfe’s penstemon sites (Table 9). The regeneration of deciduous native woody species including aspen, Gambel oak, New Mexico locust, and chokecherry may provide significant resource competition and impact the recovery of some Metcalfe’s penstemon sites and habitat.

Because very few plants were documented in 2014 and Metcalfe's penstemon appears to have a preference for growing in cool, shady areas, underneath the canopy of mixed conifer forests and along stream banks, the species may not persist over time in the majority of documented sites on the Gila National Forest, due to radical habitat alterations caused by the Silver Fire. Because of its extreme rarity and alterations to all of the known habitat, inventories to document the actual distribution and abundance of this species and close monitoring to determine population trends of this species are highly recommended. Seed banking should be considered to maintain an ex-situ collection, in the event that reintroduction will become necessary in the future.

CONCLUSION

Unfortunately only very limited data was available on the pre-fire abundance and distribution of the eight Species of Concern. Except for Goodding's onion, no targeted surveys had been performed to document the occurrence of these plants on the Gila National Forest. Therefore, accurate analysis of survival and abundance post-fire is limited. Based on the findings of these surveys, rare plants appear to generally survive fires. Plants whose habitat was little altered by the fires are expected to persist in burned areas. Rare plants are more vulnerable to post fire activities and changes in their habitats associated with fires, than to the fire itself, including floods, erosion, competition with native woody species, as well as post fire clean-up and restoration activities. Large scale high severity fires are expected to have significant long term impacts on the persistence of some rare plants, because of the complete alteration of the majority of their habitat and expected long periods of time until the habitat is recovered. Plants requiring cool, shaded N-facing slopes and drainage bottoms for survival and persistence are expected to have a slow or even no recovery. These include Goodding's onion (*Allium gooddingii*), Mogollon death camas (*Anticlea mogollonensis*), Metcalfe's penstemon (*Penstemon metcalfei*), heartleaf groundsel (*Packera cardamine*), and possibly Mimbres figwort (*Scrophularia macrantha*). Although these plants still exist on the landscape within a couple of years after the fire, they may not persist over the long term in areas that were severely burned, as indicated by the complete absence of Goodding's onion from previously known sites within the 2006 Bear Fire perimeter in the Indian Creek drainage.

Invasive species are not expected to be a threat to the recovery of the 8 Species of Concern, although the aggressive recovery of native aspen stands and other native deciduous woody species in the habitat and near some of the documented sites may impact the persistence of some species and should be closely monitored (Goodding's onion, Mogollon death camas, Metcalfe's penstemon, heartleaf groundsel, Mimbres figwort).

Follow-up surveys to determine long term persistence are essential to determine the vulnerability and potential for extinction of these species. In addition, regular monitoring to determine post-fire population trends is highly recommended. Seed banking should be considered to maintain an ex-situ collection, in the event that reintroduction will become necessary in the future.

MANAGEMENT RECOMMENDATIONS

Although little can be done about the occurrence of wildfires and more frequent and catastrophic large fires are expected in the future, a variety of management actions can be implemented to minimize the potential devastating impacts on vulnerable Species of Concern.

➤ **Collect baseline information**

Obtaining baseline information on the actual distribution, abundance and potential threats to a sensitive species is essential in determining the status of a species and determining what, if any, management action needs to be taken to ensure persistence of a species on the Forest. In addition, baseline information is fundamental to analyzing the potential impacts of management activities, including wildfire suppression and management, thinning & logging projects, road maintenance,

habitat improvement & restoration projects, and recreational activities such as trail & campground building and maintenance.

➤ **Assess vulnerability**

Once baseline data has been collected, the vulnerability of species can be assessed and proper management actions can be implemented, if needed, to protect a species from stochastic events caused by wildfires, floods, and forest management activities

➤ **Increase resilience with prescribed fires and thinning**

Habitat improvement projects focusing on plant species determined to be vulnerable to extinction caused by potential catastrophic wildfires can significantly improve a species' ability to survive wildfires and persist following the fire if the habitat experiences little post-fire alteration.

➤ **Add vulnerable sensitive species habitats to the priority treatment list**

Occupied habitats of species determined to be vulnerable to habitat alteration associated with wildfires need to be prioritized for restoration treatments, including thinning and prescribed burns.

➤ **Avoid sensitive species populations during firefighting and post-fire clean-up & restoration activities**

Knowing the location of sensitive species (baseline information) and sharing this information with firefighters and post-fire management activities can significantly increase the survival of sensitive plant species during and after the fire. Firefighting and post-fire activities may include the construction of fire breaks, application of fire suppressants, mulching & seeding, post-fire erosion control, and various restoration projects.

➤ **Stock up seed banks**

Ex-situ conservation of these vulnerable species in the form of seed banking may be the last resort for plants that are extremely limited in their distribution and whose post-fire long term persistence is questionable. This is especially urgent for species whose entire range has already burned and whose habitat has been severely altered. In addition, all sensitive plant species determined to be vulnerable to extinction from catastrophic wildfires should be collected for storage and potential post-fire restoration projects.

➤ **Monitor vulnerable populations and adjust management based on monitoring results**

Monitoring population trends of plant species determined to be vulnerable to wildfires and species whose habitat has already been altered by wildfires is essential to determine endangerment and provide appropriate management.

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