Understory Plant Diversity Inventory

Three Years after the Hermit's Peak-Calf Canyon Wildfire

Photo by Emily Yannayon, plot 03.01_028

Submitted by:

Emily Yannayon, *Ecological Monitoring Specialist*

With Acknowledgements to: **Kathryn Mahan,** *Monitoring Program Manager*; **Carmen Melendez,** *former Crew Logistics Manager;* **Abbi Han,** GIS & Monitoring Specialist; **Alex Withnall,** *Monitoring Technician*; **Corey Beinhart,** *Monitoring Data Manager*; **Taryn Schlosser,** *Monitoring Technician Aide/Intern;* **Andrew Persante,** *Monitoring Technician Aide/Intern*

March 2026

Table of Contents

Figures List

Tables List

Introduction & Project Description

Background

The Southwest Ecological Restoration Institutes (SWERI) includes three university-based restoration institutes: the New Mexico Forest and Watershed Restoration Institute (NMFWRI), the Colorado Forest Restoration Institute (CFRI), and the Ecological Restoration Institute (ERI) in Arizona. These institutes work together to develop a program of applied research and service to help create healthy forests, prevent wildfires, sustain the resiliency of water supplies to wildfires, and create jobs. NMFWRI is located at Highlands University (HU) in Las Vegas, NM. According to the Southwest Forest Health and Wildfire Prevention Act (P.L. 108-317), the authorizing legislation for the SWERI, the purpose of the institutes is to "promote the use of adaptive ecosystem management to reduce the risk of wildfires and restore the health of forest and woodland ecosystems in the Interior West." NMFWRI has partnered with the United States Forest Service (USFS) and other agencies to monitor more than 2,500 plots on Collaborative Forest Restoration Program (CFRP) and other restoration projects across the state since 2007. NMFWRI's Ecological Monitoring Program maintains a professionally managed field crew to collect data on short and long-term ecosystem responses to restoration treatments and disturbances. This data provides a critical scientific basis for adaptive management decisions and improved treatment effectiveness. The field crew also provides hands-on internship and training opportunities for students and recent graduates to help build New Mexico's forestry workforce.

In spring 2022, the Hermit's Peak fire began as an escaped prescribed burn and later merged with the Calf Canyon fire which started as a winter pile burn. The Hermit's Peak Calf Canyon (HPCC) fire grew to become the largest and most destructive wildfire in New Mexico history at 341,471 acres. Of this footprint, 14.5% was classified as high soil burn severity, 33.3% was classified as moderate soil burn severity, 39.3% was classified as low soil burn severity, and 12.8% was classified as unburned. These data come from the Composite Burn Index (CBI), which is constructed by extrapolating on-the-ground data with 0.3-1-meter-high resolution imagery and 30 meter dNBR imagery. More information about the HPCC wildfire is available here:
https://storymaps.arcgis.com/stories/d48e2171175f4aa4b5613c2d11875653

Other post-fire reports, and a map of all NMFWRI monitoring within the burn scar, are available here:
https://nmfwri.org/monitoring/post-fire-monitoring-reports/

Purpose & Need

It is well-established in the literature that understory vegetation of forests is a crucial component for those ecosystems. The understory provides food and shelter for many species of vertebrate and invertebrate animals, each of which contribute to food webs and ecological function (Reynolds et al, 2013; Deng et al, 2023). Understory vegetation is also critical for soil stability, water infiltration, and nutrient cycling; which, in turn, benefits water quality and reduces flooding (Moir et al, 1997; Deng et al, 2023). These plant species also often play host to important mycorrhizal fungi that in turn, benefit overstory trees (Deng et al, 2023). The presence of understory vegetation can also benefit the regeneration of overstory trees through microsite cooling and moisture retention (Wolf et al, 2021). This is commonly known as the nurse shrub effect, has been observed many times across forest industries, and appears to follow for the dominant tree species represented in our study area (Graham and Jain, 2005; Laacke, 1990; Marsh et al, 2023). Perhaps the most beneficial trait of understory vegetation is its inherit variability. Across the globe, as well as at a regional and forest-level scale, understory vegetation communities in forests are highly variable, heterogeneric, and dynamic; with co-occurring species adapted to a wide range of conditions (Lentile et al, 2007; Antos, 2009). In forests globally, understory

vegetation accounts for more than 80% of the species diversity (Deng et al, 2023). A biodiverse understory plant community is critical for healthy, well-functioning ecosystems, which provide services for building healthy human communities (World Health Organization, 2025).

Collecting species-level data on non-woody understory species has not been a standard part of NMFWRI's upland monitoring protocol because understory plant surveys require a high time and labor investment, as well as staff well-versed in botany and plant identification across taxonomic groups. In the wake of the 2022 HPCC fire, the need to quantify understory vegetation, specifically herbaceous vegetation, became apparent to staff members observing the progress of recovery in the burn scar. Staff observed differences in plant communities across project sites that had experienced varying management activities before the HPCC fire.

After a development period in the late winter and spring of 2025, NMFWRI initiated a pilot study of understory vegetation in the burn scar. Staff selected a total of 12 plots, eight of which were chosen from existing monitoring projects, across a range of forest types and treatment histories, in order to capture the maximum amount of diversity and potential differences between these strata. The process of study site selection is described in *Monitoring Methods.*

This study is in fulfillment of NMFWRI's workplan Theme 3 to monitor "Ecosystem Response to Restoration Treatments and Disturbance." NMFWRI's annual workplan is funded by Congressional appropriations though the Cooperative and International Programs of the U.S. Forest Service, Department of Agriculture, under the Southwest Forest Health and Wildfire Prevention Act. As is established earlier in this section, understory vegetation is a critical component of forest health, and is overall understudied across forestry as a discipline (Golz, 2019; Huffman et al, 2020). In addition, the region in which this study is located is historically understudied, according to local Natural Resource Management professionals.

Monitoring Methods

Site Description

As stated above, NMFWRI selected 12 plots for the pilot understory inventory (Table 1, Figures 2-5), all located within the HPCC burn scar (Wildland Fire Interagency Geospatial Services Group, 2022). Half of the plots were located in lower elevation ponderosa pine forest, and half located in higher elevation mixed conifer forest. These forest types are defined later in this section.

Within these groups, two plots were selected with different pre-fire treatment histories and HPCC burn statuses: Treated pre-fire & Burned in the HPCC wildfire, Untreated pre-fire & Burned in the HPCC wildfire, and Untreated & Unburned in the HPCC wildfire. These groups are hereafter referred to as strata. Treated & Burned and Untreated & Burned plots were selected from pre-established long-term NMFWRI monitoring projects, treatments which were funded by the CFRP (Collaborative Forest Restoration Program). Existing plots were selected randomly from projects with the desired treatment and burn history, followed by a manual selection process that eliminated plots based on distance to roads and therefore accessibility for repeat monitoring visits. Many areas have experienced post-fire logging or fuelwood harvesting. This was considered and plots were excluded if they showed evidence of these activities.

Treated plots were selected from two projects treated under the CFRP: 03.01 La Jicarita Walker Flats CFRP and 28.10 Las Vegas Watershed Las Dispensas Griego CFRP. Treatment history is presented below in a bulleted list for clarity.

- *03.01 La Jicarita Walker Flats CFRP Project:* Mixed conifer forest type. Five periods of monitoring data, from 2007 to 2025.
    - 2005-2008: Selective thinning to remove small diameter and sick trees, to create an uneven-aged stand that preserved large trees.
    - 2008: A prescribed fire was conducted within the unit. Details and outcomes of the prescribed fire are not available, but it appears from plot photos that fire intensity was variable across the project area.
- *28.10 Las Vegas Watershed Las Dispensas Griego CFRP Project:* Ponderosa pine forest type. Four periods of monitoring data, from 2010 to 2025.
    - 2010-2012: Selective thinning to remove small diameter and sick trees, to create an uneven-aged stand that preserved large trees.
    - September 2014: A prescribed fire targeting an adjoining unit affected this area. This fire is presumed to have been low intensity and left evidence of char only on a few trees.

After the HPCC fire, there have been management actions taken by the USFS within the burn scar to encourage recovery and to mitigate effects such as erosion. NMFWRI has no official record for these actions, but we have been able to glean some details by utilizing the internet archive and news releases. According to archived records of the USFS BAER (Burned Area Emergency Response) website, the USFS conducted aerial application of seeds, mulch, and "certified weed-free straw" between August and September of 2022. This took place across approximately 9,400 acres, targeting areas of moderate to high soil burn severity, in the Gallinas Creek and Tecolote Creek watersheds. Press releases stated that the USFS would be spreading approximately 138 tons of seed and 5,440 tons of mulch. That seed was said to contain "native species" and a "non-persistent annual barley," likely referring to *Hordeum vulgare*. It should be noted that NMFWRI does not know whether any of our plots intersected with these areas, and that *H. vulgare* was not documented in any plot. News coverage from KOB4 and KRQE detailed a second known round of aerial seeding by the USFS in November of 2023, "between Las Vegas and Mora." The plan was to seed approximately 11,000 acres. There were also efforts by the USFS to outplant ponderosa pine seedlings within the Walker Flats area in summer of 2024, but no plots within this study were observed to contain outplanted seedlings that matched the age and size class of other plantings observed in the area.

Unfortunately, none of NMFWRI's 500+ long-term plots that fell within the HPCC burn perimeter remained unburned following the wildfire. Therefore, in order to have an appropriate control to compare to, we established new monitoring plots in unburned areas near existing study areas. These unburned areas were established by utilizing a spatial dataset developed by the New Mexico Forestry Division (NMFD) dubbed as "green islands." This dataset was developed using an algorithm that identified areas of vegetation within the burn scar that were greener than their surroundings. After identifying polygons from this dataset that were near existing plots and were reasonably accessible, post-fire satellite imagery was examined for burned trees. Accessible, in this case, is defined as less than one mile from a road and does not require travel through difficult terrain to access. If a polygon appeared to be unburned, staff scouted the conditions on the ground to determine suitability for the study. Requirements included: little to no evidence of burning, little to no evidence of restoration or

fuels reduction treatments, and similarity of the overstory community to existing study sites. Once suitable polygons were determined, staff utilized ArcPro tools to create random points within the polygon, followed by another random selection of two these points. These points were then dismissed or confirmed based on on-the-ground conditions. For example, if staff scouted a point and the overstory trees showed signs of significant char on the bole, the point was dismissed. Alternately, one plot was moved approximately one chain from the initial coordinates because a small drainage ran through the center of the plot.

NMFWRI employs the following definitions for forest types when classifying projects. These definitions are useful when analyzing data at the landscape scale. Examining habitat on the ground, within a small geographic area, it can be difficult to determine forest type; especially when many plots exist within a transition zone.

- *Ponderosa pine:* A forest type consisting of mainly ponderosa pine, sometimes with oak or grass understory; common up to 9,000 ft in elevation.
- *Dry mixed conifer:* A forest which remains proportionally dominated by ponderosa pine but with a large component of aspen, oak, limber pine, or firs. Dry mixed-conifer can be thought of as the transition between ponderosa pine and wet mixed-conifer.
- *Wet mixed-conifer:* A forest type consisting of an assortment of conifer species (e.g. firs, pines, spruces, sometimes aspen); dominated by aspen, fir, or blue spruce; from approximately 5,500 to 10,000 ft in elevation.
- *Spruce-fir:* A forest dominated by Engelmann spruce, Douglas-fir, aspen, corkbark or subalpine fir, usually 8,000 to 12,000 ft in elevation.

As stated above, six plots were located in mixed conifer forest, dominated by white fir, limber pine, Douglas-fir, and quaking aspen. These plots ranged from 8,973 to 9,498ft in elevation, with mostly northern aspects (Table 1). Slopes were moderate, ranging from 4 to 29%. Plots classified as “mixed conifer” forest type intergrade from the NMFWRI definitions for dry mixed conifer, to wet mixed conifer, to spruce-fir forest in the Untreated & Unburned plots. Ponderosa pine was present, but existed either in equal or lesser densities than other tree species. Ponderosa pine was entirely absent in the Untreated & Unburned strata of plots, which are at a higher elevation and located on a north-facing aspect. The lack of a disturbance regime in this stratum may be at least partly responsible for the absence of the shade-intolerant ponderosa pine.

Plots classified as “ponderosa pine” forest type intergrade between the NMFWRI definitions for ponderosa pine and dry mixed conifer forest types. These plots are dominated by ponderosa pine, with limber pine, Douglas-fir, and Gambel oak attaining secondary dominance. Despite the difference in overstory tree composition within assigned forest types, for the purpose of this report, we maintain these classifications due to their geographical nearness. The six plots located within ponderosa pine forest were dominated by ponderosa pine, white fir, and Gambel oak. These plots ranged from 7,621 to 8,018ft in elevation, on mostly eastern aspects. Slopes ranged from 10 to 38%.

Table 1. Summary of plot metadata for understory inventory plots.

Understory Plots Summary								
Forest Type	**Treatment & Burn Status**	**Plot Name**	**Elevation (ft)**	**Aspect**	**Azimuth (degrees)**	**Slope (%)**	**Latitude**	**Longitude**
Mixed Conifer	Treated & Burned	03.01_007	9,088	N	45	9	36.01764	-105.4491
		03.01_028	8,973	E	130	19	36.01102	-105.4471
	Untreated & Burned	12.16_054	9,245	N	25	29	36.01830	-105.4548
		12.16_106	9,203	W	266	4	36.02652	-105.4554
	Untreated & Unburned	UB_003	9,498	N	40	14	36.01170	-105.4693
		UB_004	9,439	E	60	27	36.01005	-105.4691
Ponderosa Pine	Treated & Burned	28.10_1_006	8,018	E	90	28	35.73738	-105.3856
		28.10_1_009	7,897	E	111	38	35.73533	-105.3860
	Untreated & Burned	T2RB_007	7,635	W	311	10	35.75145	-105.3592
		T2RB_009	7,621	S	180	15	35.74970	-105.3604
	Untreated & Unburned	UB_001	7,756	N	10	20	35.75811	-105.3844
		UB_002	7,792	E	79	10	35.75701	-105.3859

Field Methods

For overstory tree and other plot data, the NMFWRI monitoring crew followed the protocols published in their Field Monitoring Manual, linked here: https://nmfwri.org/resources/upland-forests-monitoring-field-manual/

These protocols are based on the Department of Interior's FEAT/FIREMON Integrated (FFI) sampling protocols. They used 1/10th acre fixed plots to assess tree size (diameter and height) and density (trees/acre). A nested sub-plot of 1/100th acre was used to estimate understory and ground cover in all years. Photo points were taken at each plot. Surface fuels were measured using Brown's transects. The location of the plots was based on a stratified random sampling design. Plots were originally generated on a sampling scheme to fall at appropriate sample densities within delineateated stand boundaries.

For understory plant data, the NMFWRI understory crew used a modified version of CFRI's *Protocol for Monitoring Understory Plant Response to … Treatments,* linked here: https://sites.warnercnr.colostate.edu/wp-content/uploads/sites/32/2016/09/FR-CFLRP-Understory-Monitoring-Protocol-2015.pdf

An understory plant is any plant that does not fulfill NMFWRI's working definition of a mature tree. This includes all herbaceous plants, and all woody plants less than 4.5ft tall or less than 1in DBH. NMFWRI established three 37.3ft transects, at 0, 120, and 240 degrees, using a compass declinated for the region. A buffer of 11.76ft was established for each transect to minimize trampling around PC (plot center) and autocorrelation of counts. Crews began LPI (line-point-intercept) at 12ft, recording any understory plant present at 26 evenly spaced points (every 1-foot) on all three transects, using a pin flag for precision. If more than one species was visible as a sampling point, all species were recorded. If no vegetation was observed at a sampling point, ground cover type was recorded.

In order to fully capture species richness of less-dominant species on a given plot, NMFWRI also estimated aerial cover for all understory species. This method proved to produce vastly different results in species richness and cover. On average, the aerial cover method documented 20 more unique species per plot than the LPI method. The LPI method also tended to estimate a higher percent cover in 94% of all occurrences. As a goal of this study was to capture the maximum amount of diversity, therefore, the results of the LPI method are not presented here, but are available upon request. See more in *Supplemental Information D: LPI vs Ocular Estimation* (page 51). These observations of the difference in

results between LPI and ocular (aerial cover) estimation methods are repeated in the literature (Buckner, 1985; Dethier et al, 1993; Godínez-Alvarez et al, 2009). Ocular estimation produces higher species counts, and tends to be poorly correlated with cover estimates of point-intercept methods. Ocular estimation has also shown to be more similar to digital estimation methods from photographs when compared with point-intercept data (Dethier et al, 1993). However, there is evidence that this varies between vegetation communities (Godínez-Alvarez et al, 2009). Additionally, cover estimates for rare species were highly variable, while estimates were far less variable when cover was at least fifty percent (Dethier et al, 1993; Morrison, 2016). Precision and variation between and within observers can be minimized through consistent and continued training and calibration (Dethier et al, 1993; Trevithick et al, 2012; Morrison, 2016)

The nature of species-specific cover estimation methods means that cover totals for plots represented in this report are cumulative: the cover of some species may overlap with others. For example, the cover provided by a small gentian will be quantified, as well as the cover of the sedge that is shading it.

Three sampling periods took place, in June, July, and August of 2025. Cursory analysis of this data shows that the data collected in August, at the peak of the growing season, presented the highest species richness and cover. Therefore, the results presented in this report represent only the data from the August sampling period. See more in *Supplemental Information C: Metrics Across Time* (page 49).

Data Analysis

Due to the small sample size presented here, no statistical methods were performed on this data. All data were recorded using FFI data entry platform and protocols. All summary reporting was performed using custom R scripts. These scripts are also available upon request. In this report, “species richness” is defined as a count of unique species observed, whereas aerial cover is a mean of plot means for a given stratum.

Plant Nomenclature

In order to maintain consistency and comparability to other agencies, all plant nomenclature follows the USDA PLANTS database to species, genus, and family. This follows for growth habit and native status of all plants, with a few exceptions that are described in the following report. Many plant species were identified using the dichotomous key Flora Neomexicana III (Allred et al, 2020). Due to the constant changing nature of taxonomy in the age of genetic sequencing, many of the names in Flora Neomexicana III are not recognized in the USDA PLANTS database. Upon those circumstances, staff attempted to identify the most appropriate and most recent synonym of a given species.

Disclaimer

NMFWRI provides this report and the data collected with the disclaimer that the information contained in these data is dynamic and may change over time. The data are not better than the original sources from which they were derived. It is the responsibility of the data user to use the data appropriately and within the limitations of monitoring data in general, and these data in particular. NMFWRI gives no warranty, expressed or implied, as to the accuracy, reliability, or completeness of these data. This data and related graphics are not legal documents and are not intended to be used as such. This includes but is not limited to using these data as the primary basis for the development of thinning prescriptions or

timber sales. NMFWRI shall not be held liable for improper or incorrect use of the data described and/or contained in this report.

Analysis was also done according to our standard protocols. Note that some values reported are expressed on a per acre basis, but represent only area actually sampled. We do not scale up these values to calculate volume of wood over the project area, and warn readers of this report that they are not intended for that purpose. The accompanying tables show summaries of our data, and some differences are discussed below; however, differences that seem apparent here may not stand up to rigorous statistical tests. For some estimates, the standard deviation exceeds the mean (i.e., the coefficient of variation is greater than 100 percent), and sampling errors for some estimates exceed 100 percent. Therefore, data should be used and results interpreted with appropriate caution.

Summary

Plot Summary

Table 2. Summary table of understory vegetation inventory. Mean percent cover is a mean of plot totals of vegetation cover. Unique species were summarized by treatment & burn status (a.k.a. stratum).

Understory Vegetation Inventory Summary Table			
Forest Type	**Treatment & Burn Status**	**Mean Percent Cover**	**Unique Species Count**
Mixed Conifer	Treated/ Burned	38.5	65
	Untreated/ Burned	64.1	60
	Untreated/ Unburned	56.2	59
Ponderosa Pine	Treated/ Burned	68.8	66
	Untreated/ Burned	58.5	79
	Untreated/ Unburned	56.2	57

Mixed Conifer Forest

Among the plots located in mixed conifer forests, the highest number of unique species were identified in the Treated & Burned plots (Table 2). However, the mean percent vegetation cover at these plots is nearly half that of the untreated and burned plots, at 38.5 and 64.1%, respectively. This appears to be related to the condition of the overstory tree community. The Treated & Burned plots are characterized by well-spaced, large-diameter trees (mean DBH for all trees is 13 inches, and the density of growing stock trees and snags are nearly equal; see *Overstory Trees*, page 27). This results in highly variable understory microhabitats, but increased competition for light and moisture among these sites. Conversely, the untreated and burned plots are characterized by dense stands of snags, with few living trees remaining. This results in, essentially, a free-for-all, hence the highest vegetation cover and high species count (60 species). There is little to no competition from overstory trees, so several species are able to colonize the area. Tree species that are able to readily re-sprout from underground rhizomes following disturbance events, such as quaking aspen or Gambel oak, also take advantage of these resources.

The Untreated & Unburned plots serve as a pseudo-control in this inventory. However, please recall that there are geographic and topographical variations in plot locations that may explain differences or

similarities more than treatment and burn history. Relative to the burned plots, the cover and species richness of the undisturbed plots was still high, despite high competition from overstory trees.

Across all strata, forbs were the most species-rich growth habit, whereas woody shrubs and tree regeneration accounted for most of the vegetation cover (see *Growth Habit of Understory Plants*, page 20). Up to six species of introduced plants were recorded across the whole area, but cover, on average, was less than 1% (see *Abundance of Introduced Species in the Understory,* page 24). This is also true of annual or biennial species. The vast majority of all species recorded were long-lived perennials (*Life Cycle Duration of Understory Plants*, page 22).

Ponderosa Pine Forest

Among the plots located in ponderosa pine-dominated forests, the highest number of unique species were identified in the Untreated & Burned plots (Table 2). This is the highest number of species recorded in any stratum (79 species). This effect can be in part attributed to the extremely high mortality of overstory trees that occurred at these sites, hence the high number of snags (700 per acre, see *Overstory Trees*, page 27). There is little to no competition from overstory trees and many species of plants take advantage of the surplus resources. This stratum had the second highest total vegetation cover (58.5 %), succeeded by the treated and burned plots. This pattern is reversed in the plots located in the mixed conifer forest (see above). This may be an effect of the different compositions of species that are adapted to the specific conditions of these different forest types and geographic ranges.

The Untreated & Unburned plots serve as a pseudo-control in this inventory. However, please recall that there are geographic and topographical variations in plot locations that may explain differences or similarities more than treatment and burn history. Relative to the burned plots, the cover and species richness of the undisturbed plots was comparable, despite high competition from overstory trees.

Across all strata, forbs were the most species-rich growth habit, whereas graminoids and tree regeneration accounted for most of the cover of vegetation (see *Growth Habit of Understory Plants*, page 20). Up to fifteen species of introduced species were recorded across the whole area. These species mostly occurred in the Untreated & Burned plots, of which cover totaled to 16% (see *Abundance of Introduced Species in the Understory*, page 24). These plots are on private land that has a history of livestock activity, particularly as an area through which many ranchers moved their herds. Though long-term, high-intensity grazing did not occur here, and livestock have not grazed the land in over 20 years, these animals may have transported seeds of non-native species into the area which then became established in the area. Non-native seed transport could also have been from vehicles traveling the road/driveway, during wildfire response or other activities. The Treated & Burned and the Untreated & Unburned plots had less numbers of introduced species, as well as substantially lower percent cover. The Treated & Burned plots had more introduced species and higher cover of introduced than the Untreated & Unburned plots. This can be attributed to the disturbance that's occurred at these plots as a result of treatments and the HPCC fire. The majority of species, and the cover of those species, in all plots were long-lived perennials (see *Life Cycle Duration of Understory Plants*, page 22).

Management Implications (Mixed Conifer & Ponderosa Pine Forests)

Overall, the recovery of understory vegetation looks promising for these areas. Species diversity is high, total cover of understory vegetation was over 50% in most plots, and the plant communities were dominated by long-lived perennials This reduces concerns for continued erosion and the danger of flash

flooding from the burn scar. Tree regeneration was present in the understory, though this was mostly composed of species that readily re-sprout following disturbance (quaking aspen and Gambel oak), and low densities of conifers. However, this is to be expected three years post-fire, as conifers require much more specific conditions and more time to regenerate. Recall that conifers, even the shade-intolerant ponderosa pine, benefit when microsite variations can contribute to survival early on in their lives (Graham and Jain, 2005; Laacke, 1990; Marsh et al, 2023; Wolf et al, 2021). The cover of introduced species and of short-lived annuals and biennials is low across all plots, indicating that these areas are no longer within an early seral state. The high productivity of the understory vegetation, as well as the ongoing decay of snags killed by the HPCC fire, will continue to contribute nutrients and energy into the forest ecosystem, further promoting recovery in the burn scar.

The literature shows that species composition and structure were historically highly variable and diverse in both Ponderosa Pine forests and in Mixed Conifer forests (Reynolds et al, 2013). There are multiple sub-types of each of these recognized in the literature. Some understory communities were dominated by bunchgrasses, oaks, shrubs, or forbs; depending on elevation, local climate, moisture, microsite variability, and the history of disturbance. Rather than focusing on reference conditions, which range widely, NMFWRI encourages prioritizing ecosystem resilience, as well as adaptations to increasing disturbance as well as conditions such as drought. The productivity and species diversity observed in this inventory is a trend towards resilience of these ecosystems.

Douglas-fir seedling (*Pseudotsuga menziesii*). Photo by Emily Yannayon.

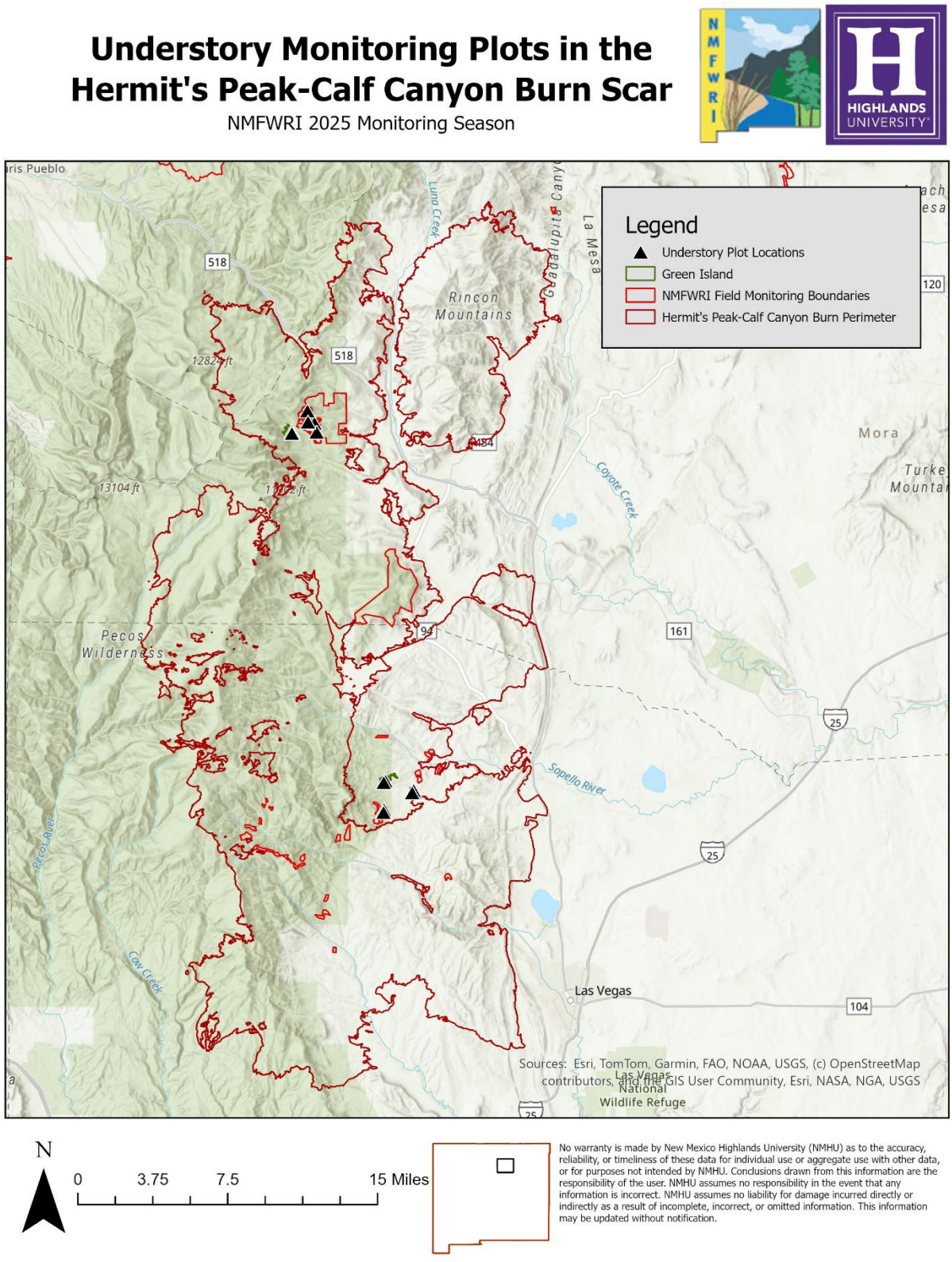


Figure 1. Overview of Understory Monitoring Inventory Study Area.

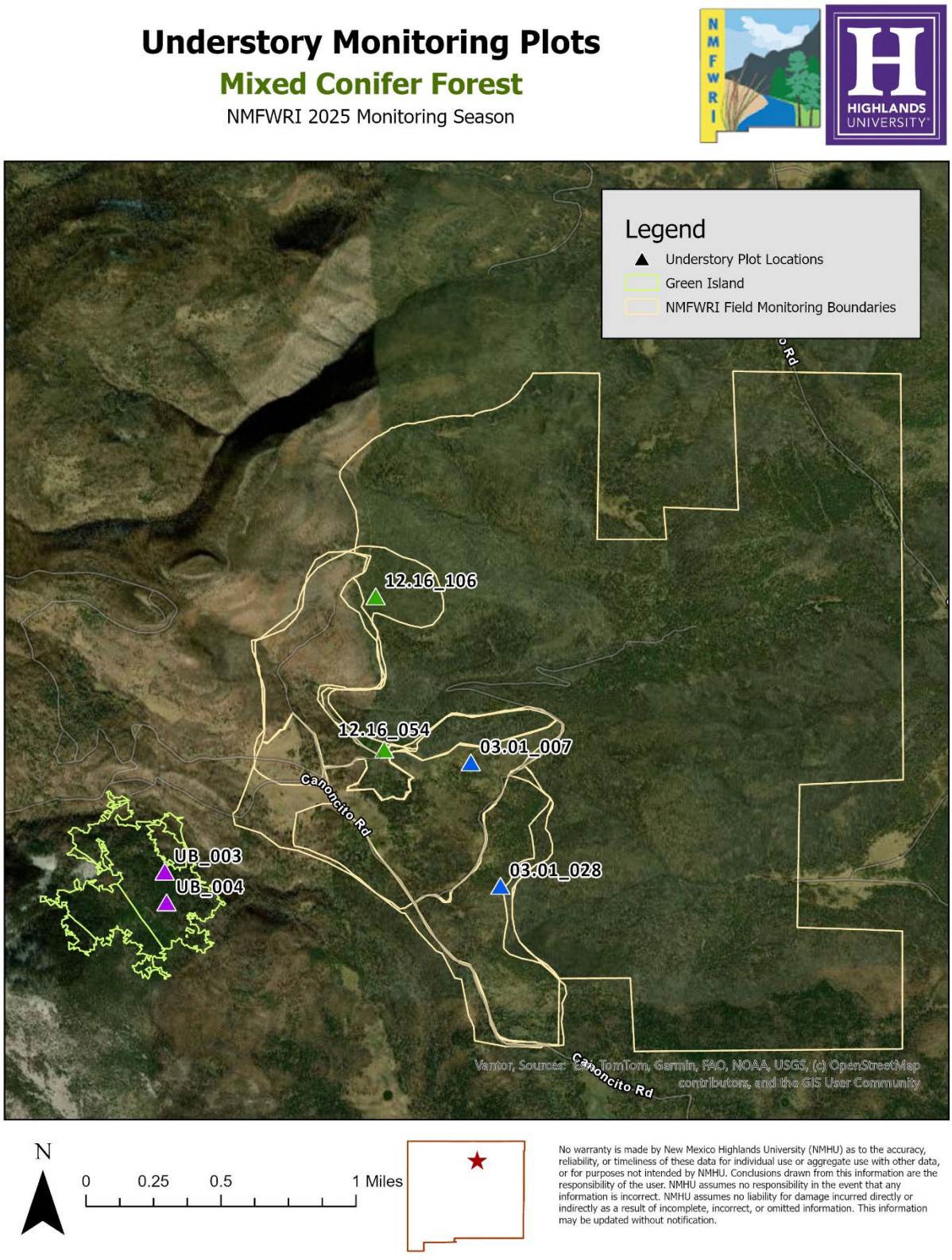


Figure 2. Map of Understory Monitoring plots located in the mixed conifer forest type.

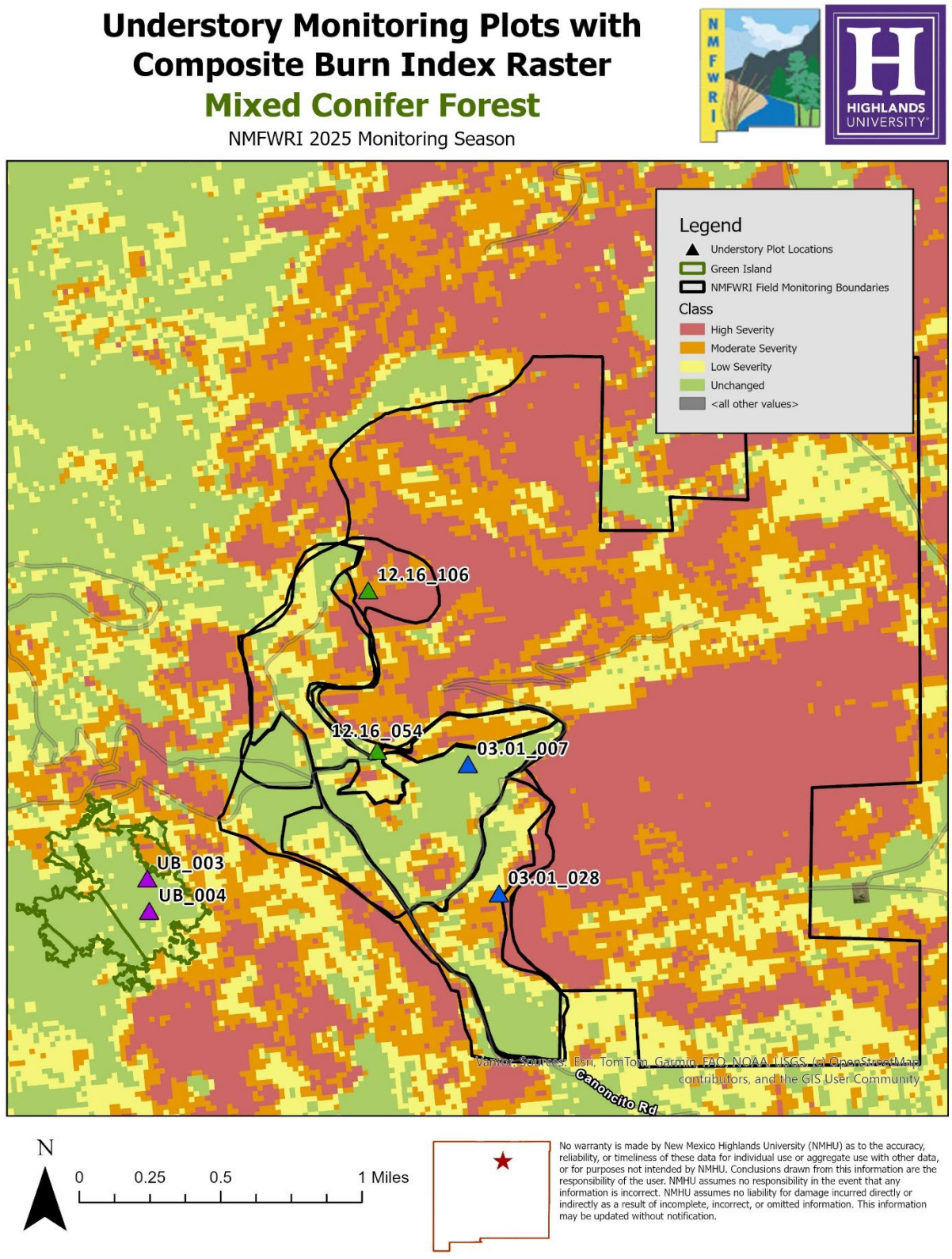


Figure 3. Map of Understory Monitoring plots located in the mixed conifer forest type, overlaid with the Composite Burn Index (CBI) raster for the HPCC burn scar.

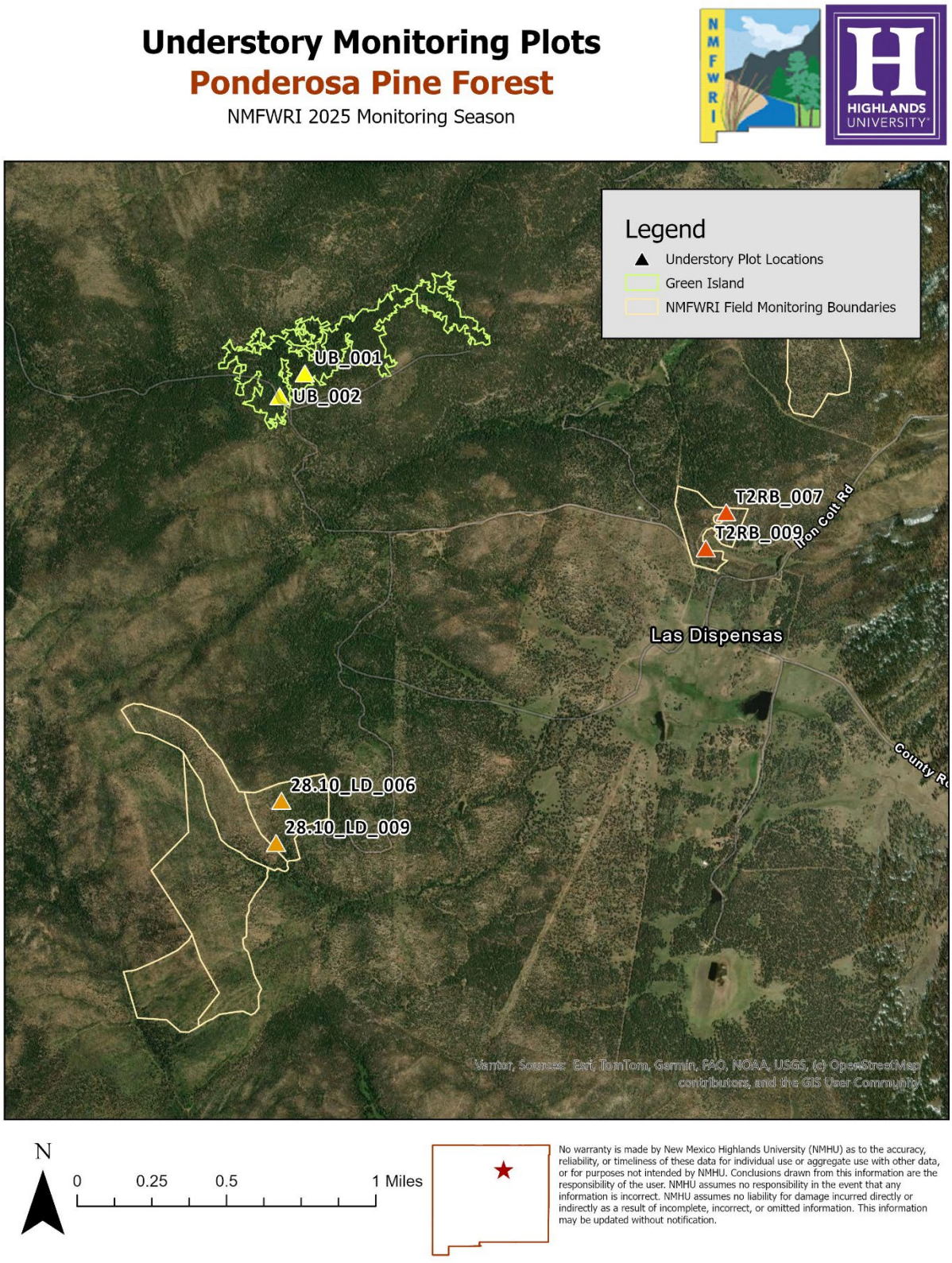


Figure 4. Map of Understory Monitoring plots located in the ponderosa pine forest type.

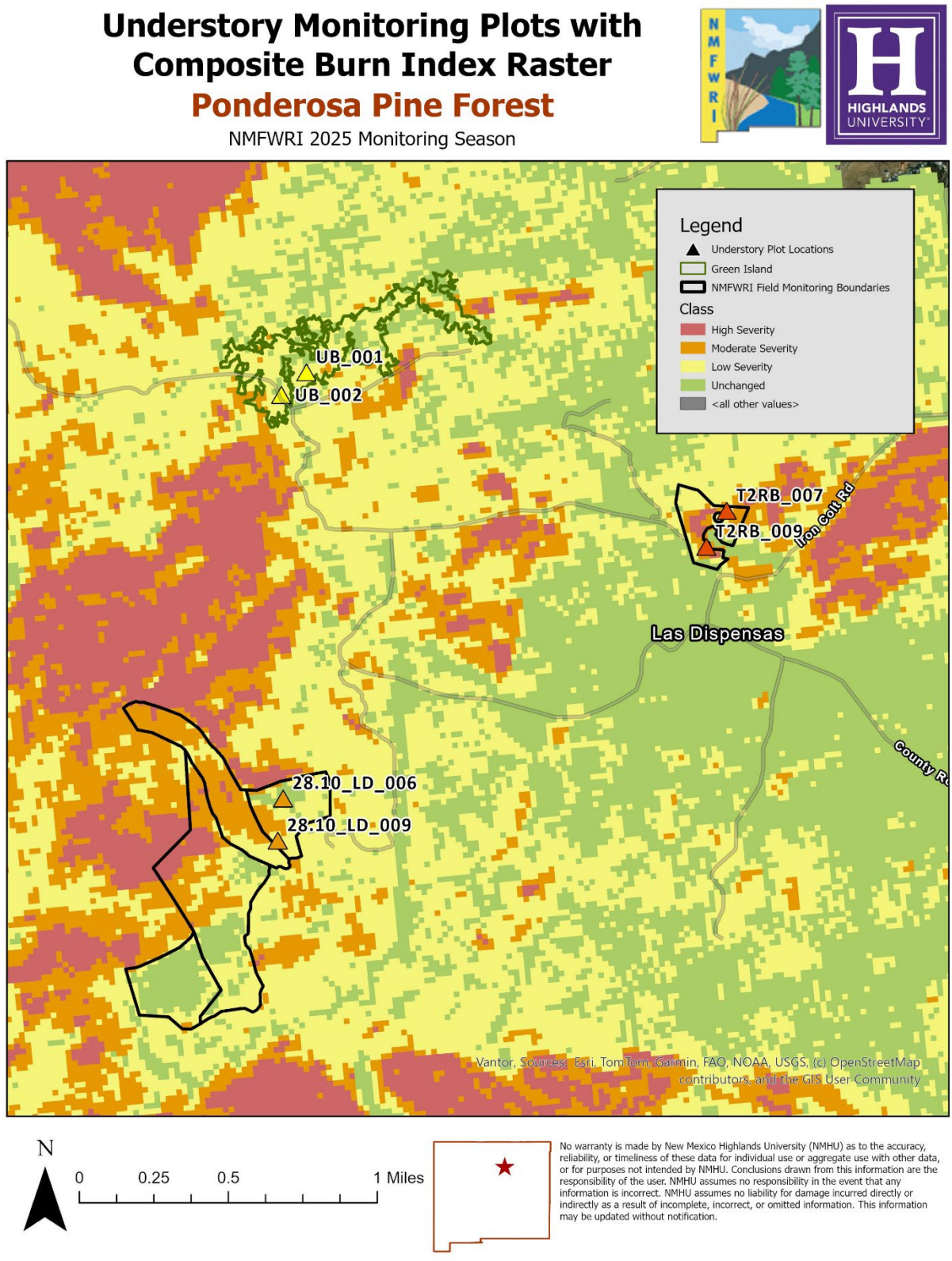


Figure 5. Map of Understory Monitoring plots located in the mixed conifer forest type, overlaid with the Composite Burn Index (CBI) raster for the HPCC burn scar.

Understory Vegetation

Understory Plant Family Abundance

There were 216 unique species of plants recorded in understory plots across 156 genera and 52 families. See supplementary information for a full list of species (*A: Species List*). Three specimens were unable to be identified to species, and are not represented in this data. Asteraceae and Poaceae were overwhelmingly the most well-represented families in both forest types (Table 3). This is consistent with patterns across the southwest and the entire United States (Dawson and Krening, 2021). In terms of cover, the most abundant families in the understory of mixed conifer forest were Salicaceae and Ericaceae. In the understory of ponderosa pine forest, the families Fagaceae and Cyperaceae occupied the highest proportion of vegetation cover.

Table 3. Species count and mean percent cover for all plant families observed across plots, by forest type.

Plant Family Abundance in Mixed Conifer Forest		
Family	**Species Count**	**Mean Percent Cover**
Asteraceae	25	4.70
Poaceae	13	3.40
Rosaceae	8	2.40
Pinaceae	5	2.70
Scrophulariaceae	5	0.36
Apiaceae	3	0.23
Cyperaceae	3	5.80
Fabaceae	3	0.16
Liliaceae	3	0.16
Orchidaceae	3	0.20
Pyrolaceae	3	0.17
Ranunculaceae	3	0.84
Brassicaceae	2	0.13
Ericaceae	2	12.00
Gentianaceae	2	0.10
Salicaceae	2	16.00
Aceraceae	1	0.23
Apocynaceae	1	0.10
Berberidaceae	1	0.20
Boraginaceae	1	0.10
Campanulaceae	1	0.20
Caprifoliaceae	1	1.70
Caryophyllaceae	1	0.10
Celastraceae	1	0.43
Cupressaceae	1	0.10
Dennstaedtiaceae	1	7.00
Elaeagnaceae	1	0.75
Fagaceae	1	6.00
Geraniaceae	1	0.10
Onagraceae	1	0.10
Plantaginaceae	1	0.10
Primulaceae	1	0.10
Rhamnaceae	1	2.00
Rubiaceae	1	0.30
Verbenaceae	1	0.10
Violaceae	1	0.20

Plant Family Abundance in Ponderosa Pine Forest		
Family	**Species Count**	**Mean Percent Cover**
Asteraceae	42	7.00
Poaceae	25	10.00
Fabaceae	10	0.38
Cyperaceae	7	13.00
Rosaceae	5	0.44
Pinaceae	4	1.80
Lamiaceae	3	0.20
Amaranthaceae	2	0.10
Apiaceae	2	0.15
Chenopodiaceae	2	0.20
Convolvulaceae	2	2.70
Fagaceae	2	20.00
Iridaceae	2	0.15
Liliaceae	2	0.18
Polemoniaceae	2	0.38
Ranunculaceae	2	0.40
Scrophulariaceae	2	6.80
Apocynaceae	1	0.55
Brassicaceae	1	0.10
Campanulaceae	1	0.20
Commelinaceae	1	0.20
Cupressaceae	1	0.10
Ericaceae	1	0.55
Euphorbiaceae	1	0.15
Geraniaceae	1	1.20
Juncaceae	1	0.10
Monotropaceae	1	0.10
Nyctaginaceae	1	0.10
Onagraceae	1	0.20
Orchidaceae	1	0.10
Orobanchaceae	1	0.20
Poaeceae	1	0.10
Rhamnaceae	1	1.10
Rubiaceae	1	0.20

Growth Habit of Understory Plants

NMFWRI uses USDA PLANTS designations for growth habit of plants that may be contradictory to other agencies or methods. For example, common juniper (*Juniperus communis,* JUCO6), rarely grows taller than five feet in the southwestern US, and therefore functions as a shrub. USDA PLANTS designates this species as a tree, as it can grow to heights of over 20 feet in in the northeastern U.S. In this dataset, common juniper is designated as a tree.

In mixed conifer and ponderosa pine forest, the most species-rich growth habit for all treatment/burn statuses was forbs (Table 4, Figure 7). However, forbs dominated the aerial cover of vegetation in only one stratum – Untreated & Burned ponderosa pine forest, at 31% (Figure 6). Coincidentally, this is also the stratum with the highest number of forb species. The Untreated & Unburned ponderosa pine plots were dominated by trees, followed by graminoids. The Treated & Burned ponderosa pine plots were dominated by graminoids, followed by trees. In the Treated & Burned mixed conifer forest, the stratum with the lowest amount of understory vegetation cover, vegetation was dominated by shrubs and trees. The Untreated & Burned mixed conifer plots were dominated by trees, whereas the Untreated & Unburned mixed conifer plots were dominated by shrubs.

Table 4. Species richness and mean cover by growth habit of understory plants.

Species Richness and Cover by Growth Habit				
Forest Type	**Treatment & Burn Status**	**Growth Habit**	**Species Count**	**Percent Cover**
Mixed Conifer	Treated/ Burned	Forb	35	5.20
		Graminoid	10	6.50
		Shrub	12	13.90
		Tree	7	12.90
	Untreated/ Burned	Forb	29	3.55
		Graminoid	11	14.60
		Shrub	12	3.45
		Tree	7	42.50
	Untreated/ Unburned	Forb	27	9.40
		Graminoid	6	0.50
		Shrub	14	37.45
		Tree	10	8.75
Ponderosa Pine	Treated/ Burned	Forb	38	11.60
		Graminoid	13	33.95
		Shrub	7	1.80
		Tree	7	21.40
	Untreated/ Burned	Forb	46	25.90
		Graminoid	23	16.45
		Shrub	6	2.00
		Tree	3	14.15
	Untreated/ Unburned	Forb	27	4.90
		Graminoid	13	18.70
		Shrub	7	1.40
		Tree	8	31.10

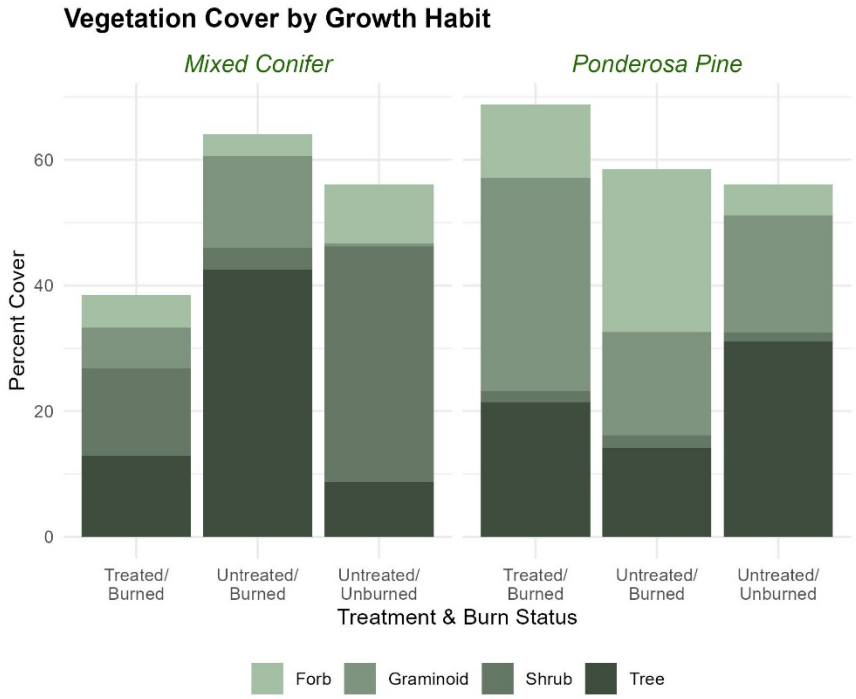


Figure 6. Mean aerial cover of understory vegetation by growth habit, forest type, and treatment & burn status.

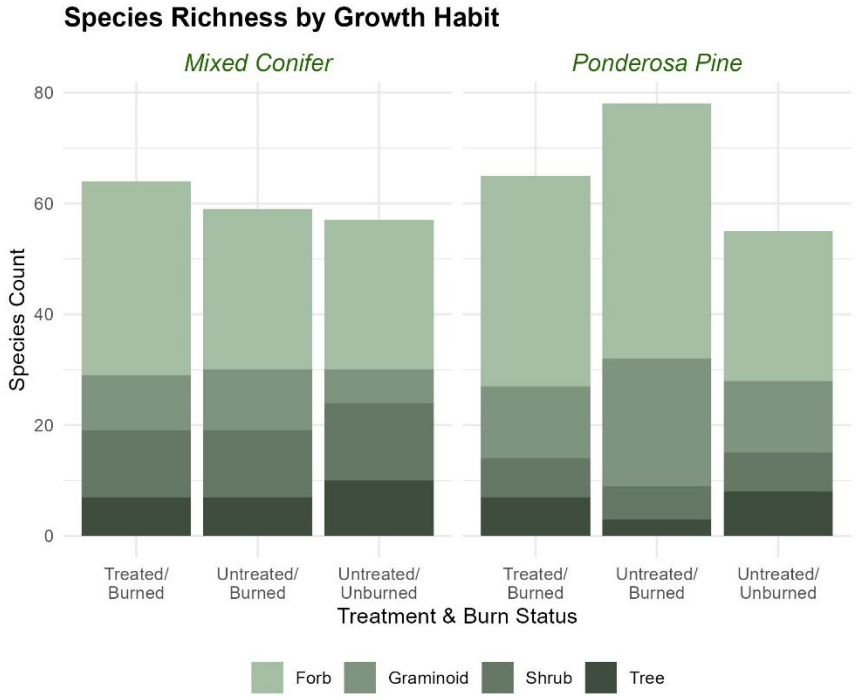


Figure 7. Species richness of understory vegetation by growth habit, forest type, and treatment & burn status.

Life Cycle Duration of Understory Plants

The life cycle of understory plants is determined by the designation assigned by USDA PLANTS. If USDA PLANTS lists multiple life cycles, the life cycle designation was taken from Flora Neomexicana III (Allred et al, 2020); the life cycle of many wide-ranging species is determined by the local climate. If the Flora's text referred to a species as a "short-lived perennial," which is commonly defined as a lifespan of three to five years, these were categorized as annual/biennials; considering the decades-long lifespan of other perennials found in these habitats, such as trees or some species of bunchgrasses.

Across all strata, in both measured forest types, perennial species dominated understory plant communities, in species richness as well as cover (Table 5, Figures 8-9). This is encouraging for the long-term soil stability in burned areas. Ponderosa pine forest plots had higher species richness and cover of short-lived (annual-biennial) plant species than in mixed conifer forest plots, with the exception of the Untreated & Unburned plots.

In mixed conifer forest, the stratum with the highest proportion of annual plants species was the Untreated & Burned plots, at 10% of unique species identified, whereas the Untreated & Unburned plots had the lowest proportion of annual plant species, at 3.5%. The vegetative cover of annual and biennial plants was on average, less than 1% in all mixed conifer plots.

The stratum of ponderosa pine forest with the highest proportion of annual plant species was also the untreated and burned plots, at 29%, but this was only marginally higher than the Treated & Burned plots, at 28%. Cover, however, of annual and biennial plants was over four times higher in the Untreated & Burned plots than in the Treated & Burned plots.

Table 5. Species richness and mean cover by the life cycle duration of understory plants.

Species Richness and Cover by Life Cycle Duration				
Forest Type	**Treatment & Burn Status**	**Life Cycle Duration**	**Species Count**	**Percent Cover**
Mixed Conifer	Treated/ Burned	Annual/Biennial	5	0.55
		Perennial	59	37.95
	Untreated/ Burned	Annual/Biennial	6	0.45
		Perennial	53	63.65
	Untreated/ Unburned	Annual/Biennial	2	0.15
		Perennial	55	55.95
Ponderosa Pine	Treated/ Burned	Annual/Biennial	18	4.80
		Perennial	47	63.95
	Untreated/ Burned	Annual/Biennial	23	19.25
		Perennial	55	39.25
	Untreated/ Unburned	Annual/Biennial	5	0.35
		Perennial	50	55.75

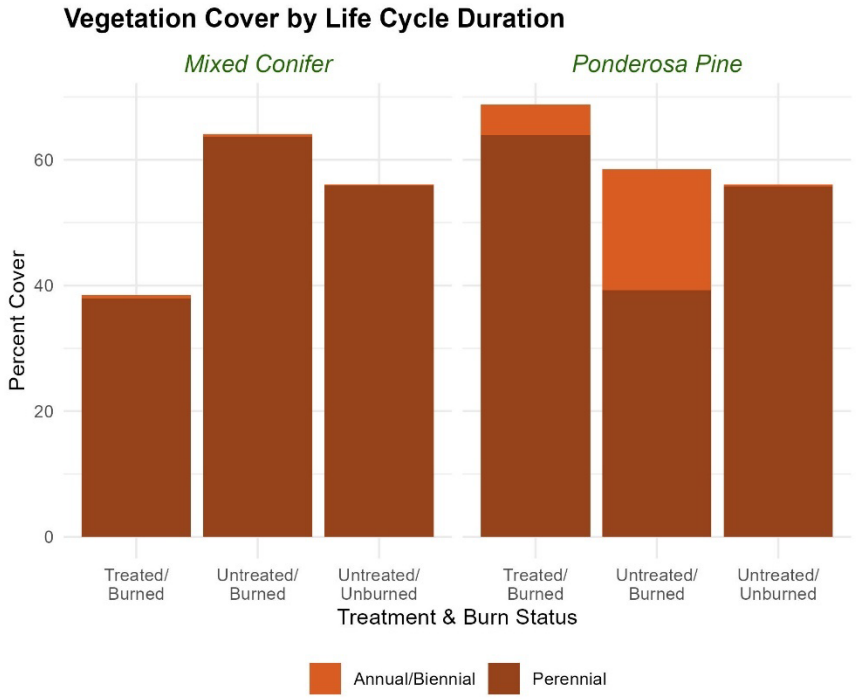


Figure 8. Mean aerial cover of understory vegetation by life cycle duration, forest type, and treatment & burn status.

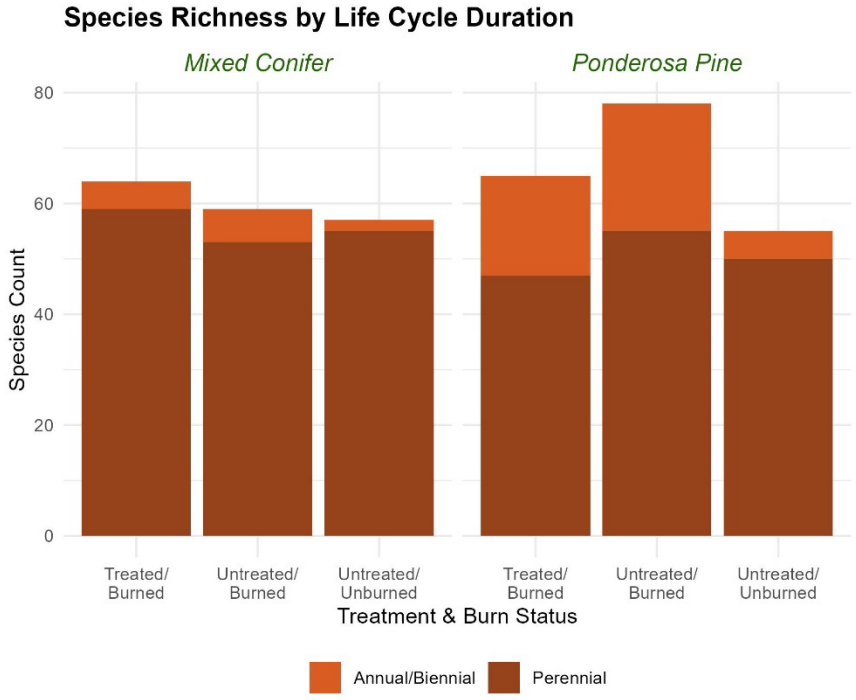


Figure 9. Species richness of understory vegetation by life cycle duration, forest type, and treatment & burn status.

Abundance of Introduced Species in the Understory

Please note that the definition of “native” in this context is defined as native to North America; conversely, "introduced” is defined as being native to other continents and was introduced to North America via human activity. There are indeed species native to North America which may be considered “invasive” or “introduced” in northern New Mexico, despite being indigenous to this continent. The terms “invasive,” “non-native,” “introduced,” and “exotic” also have inconsistent definitions across different agencies. We recognize the inherent weight of the word “invasive,” and its potential negative connotations. NMFWRI makes no attempt to ascribe moral value to any of the “invasive” species. The presence of non-native species and the decision whether or not to manage a species is complex and should be treated on a case-by-case basis. Some introduced species may be harmful to native plant communities and wildlife, while others may be relatively benign, dependent on a variety of human and non-human factors. Due to the complexity, dissension, and subjectivity surrounding the concept of “invasive species,” as well as the difficulty in parsing the geographic history of any plant species, we utilize the USDA PLANTS designation of nativity. In the context of this report, “introduced” species are discussed in the context of disturbance and past human activity and land management.

The species richness and cover of introduced species was, on average, greater in ponderosa pine forest than in mixed conifer forest (Table 6, Figures 10-11). The stratum with the highest proportion of introduced species in both forest types were the Untreated & Burned plots, followed by the Treated & Burned plots. The Untreated & Unburned plots had the lowest proportion of introduced species.

Mean vegetation cover of introduced species was less than 1% in all mixed conifer plots. In ponderosa pine plots, the highest mean cover of introduced species occurred in the Untreated & Burned stratum, at 16% cover. This is four times as much cover as was documented in the Treated & Burned stratum, at 4.1%.

Table 6. Species richness and mean aerial cover by the native or introduced status of understory plants.

Abundance of Native vs Introduced Species				
Forest Type	**Treatment & Burn Status**	**Nativity**	**Species Count**	**Mean Percent Cover**
Mixed Conifer	Treated/ Burned	Introduced	4	0.45
		Native	60	38.00
	Untreated/ Burned	Introduced	5	0.50
		Native	54	64.00
	Untreated/ Unburned	Introduced	1	0.10
		Native	56	56.00
Ponderosa Pine	Treated/ Burned	Introduced	10	4.10
		Native	55	65.00
	Untreated/ Burned	Introduced	15	16.00
		Native	63	42.00
	Untreated/ Unburned	Introduced	5	1.40
		Native	50	55.00

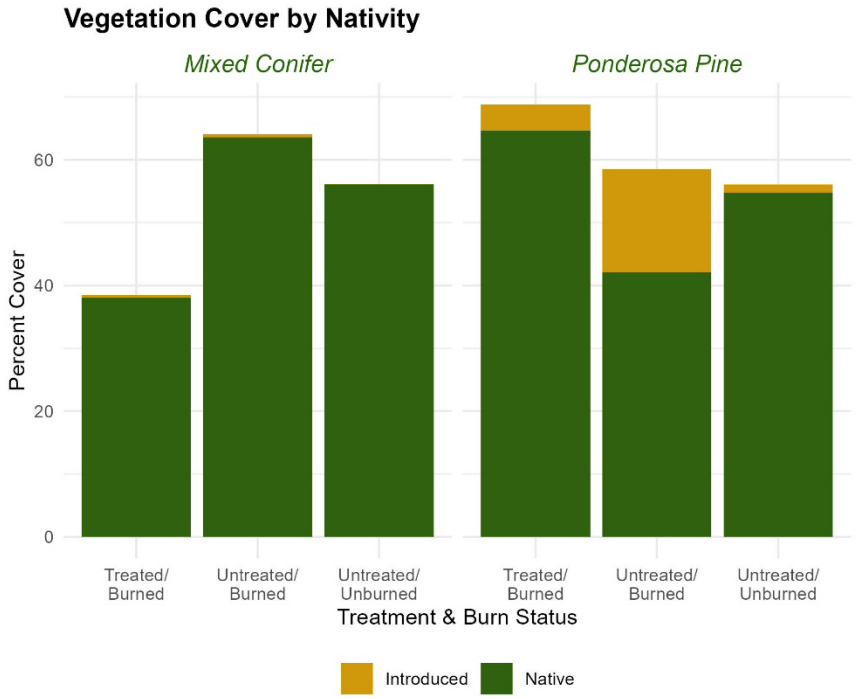


Figure 10. Mean aerial cover of understory vegetation by native or introduced status, forest type, and treatment & burn status

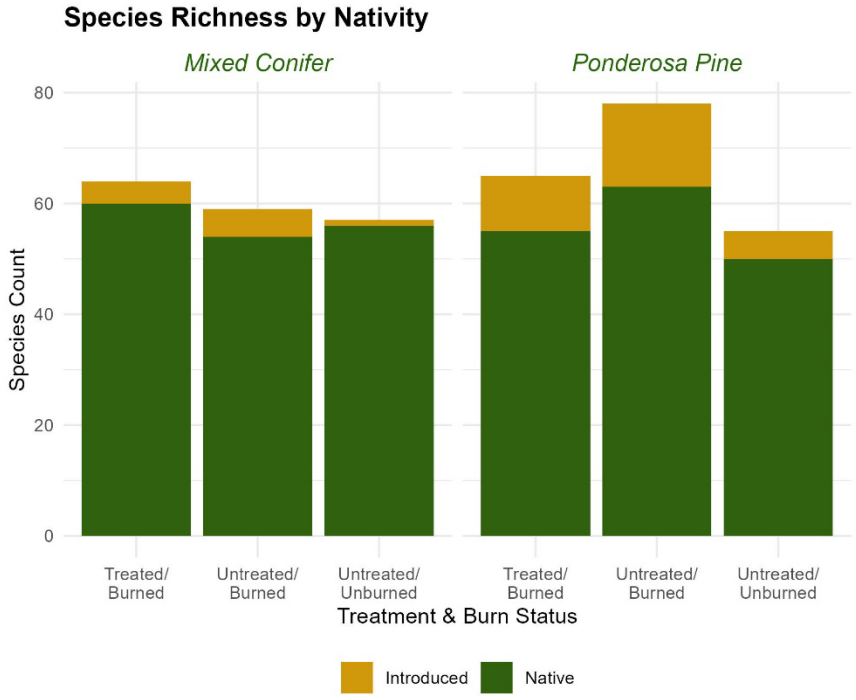


Figure 11. Species richness of understory vegetation by native or introduced status, forest type, and treatment & burn status

There were 25 unique species of introduced plants documented across the 12 understory plots (Table 7). Twelve of these species were annuals or biennials, the remaining 13 were perennials. All introduced species recorded were either forbs or graminoids; there were no shrub or tree species observed. The

vast majority of these species were introduced to North America between the 17th and 19th centuries. Some were introduced intentionally, as an ornamental plant or for livestock forage. Other species were introduced accidentally, such as a contaminant in a crop seed mix.

Notable species observed include the nodding plumeless thistle, or musk thistle; cheatgrass; and Canada thistle, or creeping thistle: these species are listed as noxious weeds by the New Mexico Department of Agriculture (NMDA). The Canada or creeping thistle is a class A noxious weed, meaning that their distribution in the state is limited and "preventing new infestations of these species and eradicating existing infestations is the highest priority." Musk thistle and cheatgrass are both Class C species, meaning it is widespread in the state, and management for these species must be based on the level of infestation and the ability of land managers to address the infestation.

Especially concerning in the post-wildfire landscape is the proliferation of fast-growing annual introduced species, including kochia, Russian thistle (tumbleweed), and cheatgrass. These species can grow extremely quickly with minimal moisture, produce large amounts of fertile seed, and grow in dense monocultures. The annual habit, along with their success as early seral species, creates concerns for fire risk. The dry standing dead of the previous seasons' growth can catch fire easily, and fire can be carried quickly across the uninterrupted populations.

Evidence from iNaturalist observations and from digitized herbarium specimens (Accessed through SEINet) prior to 2022, located within the HPCC burn perimeter, is available for at least 15 of 25 introduced species observed in the study plots (Figure 12). Note that these observations and specimens do not intersect with the plot areas, but are located in similar habitats. NMFWRI photos also show the presence of mullein (*Verbascum thapsus*) in at least one of the study plots in 2018 (plot 28.10_1_006). The earliest herbarium specimens available of introduced species were collected in 1908, of orchardgrass (*Dactylis glomerata*) and white clover (*Trifolium repens*). Kentucky bluegrass (*Poa pratensis*) was collected as early as 1923.

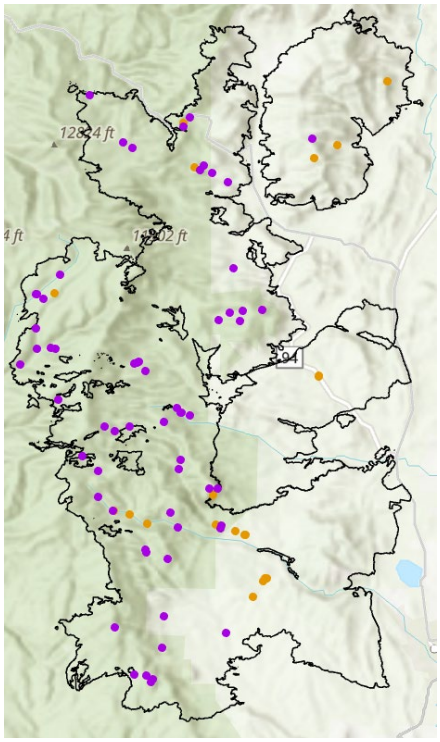


Figure 12. Locations of iNaturalist (orange) and digitized herbarium records (purple), observation or collected dated pre-2022.

Note that absence of collections at any given time or place does not necessarily commute to absence of the plant in the area. Herbarium collections and iNaturalist observations are clustered around well-traveled, easily accessible areas such as roads and hiking trails (James et al, 2018; Daru et al, 2017). Botanists collecting herbarium specimens are often targeting specific taxa, and there is a high spatial and temporal bias based upon the availability of funding for such projects, as well as other social or political barriers (James et al, 2018). Herbarium specimen collectors and iNaturalist observers alike are more likely to record plants that are unfamiliar to them, and plants that are more "showy" or eye-catching (Ackerfield et al, 2024). This means introduced species that are common in residential areas and non-showy species such as grasses are less likely to be present in these datasets. All evidence suggests these species were likely present on the landscape prior to the HPCC fire. However, it remains unknown whether these plants were present within the study area

pre-fire, whether they were spread by wildfire suppression action or post-fire cattle grazing, or whether they have simply capitalized on the massive disturbance event. There is also a possibility that supplies of seed, or machinery used for post-fire seeding activities may have been contaminated with non-native species.

Table 7. Introduced or non-native species of plants observed across all understory monitoring plots.

Introduced Plant Species recorded in Understory Plots					
Life Cycle Duration	**Growth Habit**	**USDA Species Symbol**	**Latin Name**	**Common Name**	**Noxious Weed Classification**
Annual/Biennial	Forb	BASC5	Bassia scoparia	burningbush, kochia	
		CANU4	Carduus nutans	nodding plumeless thistle	C
		CHAL7	Chenopodium album	lambsquarters	
		EUDA5	Euphorbia davidii	David's spurge	
		LASE	Lactuca serriola	prickly lettuce	
		MELU	Medicago lupulina	black medick	
		MEOF	Melilotus officinalis	sweetclover	
		SATR12	Salsola tragus	prickly Russian thistle	
		TRDU	Tragopogon dubius	yellow salsify	
		VETH	Verbascum thapsus	common mullein	
		VIVI	Vicia villosa	winter vetch	
	Graminoid	BRTE	Bromus tectorum	cheatgrass	C
Perennial	Forb	CIAR4	Cirsium arvense	Canada thistle	A
		COAR4	Convolvulus arvensis	field bindweed	
		ONVI	Onobrychis viciifolia	sainfoin	
		PLLA	Plantago lanceolata	narrowleaf plantain	
		SCLA6	Scorzonera laciniata	cutleaf vipergrass	
		TAOF	Taraxacum officinale	common dandelion	
		TRRE3	Trifolium repens	white clover	
	Graminoid	AGGI2	Agrostis gigantea	redtop	
		BRIN2	Bromus inermis	smooth brome	
		DAGL	Dactylis glomerata	orchardgrass	
		PACO2	Panicum coloratum	kleingrass	
		POCO	Poa compressa	Canada bluegrass	
		POPR	Poa pratensis	Kentucky bluegrass	

Overstory Trees

There was a relatively high diversity of growing stock trees recorded in the overstory of all plots. In mixed conifer forest, there were seven species recorded: white fir, Rocky Mountain maple, limber pine, ponderosa pine, blue spruce, quaking aspen, and Douglas-fir. In ponderosa pine forest, there were six tree species recorded: white fir, Rocky Mountain juniper, limber pine, ponderosa pine, Douglas-fir, and Gambel oak. A breakdown of the following metrics by species is available upon request.

Table 8. Species list of overstory trees.

USDA Species Code	Scientific Name	Common Name
ABCO	*Abies concolor*	White fir
ACGL	*Acer glabrum*	Rocky Mountain maple
JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper
PIFL2	*Pinus flexilis*	Limber pine
PIPO	*Pinus ponderosa*	Ponderosa pine
PIPU	*Picea pungens*	Blue spruce
POTR5	*Populus tremuloides*	Quaking aspen

PSME	*Pseudotsuga menziesii*	Douglas-fir
QUGA	*Quercus gambelii*	Gambel oak

Trees per Acre

The highest mean trees per acre in the mixed conifer plots occurred in the Untreated & Unburned plots, at 365 trees per acre (Figure 13). The second highest trees per acre occurred in the Treated & Burned stratum, at 165 trees per acre; followed by the Untreated & Burned stratum, at 80 trees per acre. While we do not have pre-wildfire data for all plots in this dataset, the snags per acre metric can provide a glimpse into the possible pre-fire conditions of these plots. The highest snags per acre occurred in the Untreated & Burned stratum. This, along with the low growing stock density, indicates extremely high tree density pre-wildfire, and, concurrently, high mortality rates. High mortality rates are also indicated in the Treated & Burned stratum; the densities of snags are only marginally less than the growing stock density. The snag density is high in the Unburned stratum: this, of course, does not necessarily indicate recent mortality. It is more likely representative of the natural mortality and snag decay rates of a mixed conifer forest.

Similarly, to the mixed conifer plots, the highest mean trees per acre in the ponderosa pine plots occurred in the Untreated & Unburned stratum, at 1,010 trees per acre. This high density can be accounted for partially by the density of mature Gambel oak stands, as well as shade-tolerant young Douglas-fir and white fir. The second highest tree density occurred in the Untreated & Burned stratum, at 845 trees per acre. This can again be partially attributed to the density of Gabel oak regeneration following disturbance, but ponderosa pine makes up a large proportion of the growing stock in this stratum as well. There is a mean snag density of 700 per acre in the Untreated & Burned stratum, indicating a high post-fire mortality rate. The snag density in the Treated & Burned stratum is the lowest of the three, at 100 per acre.

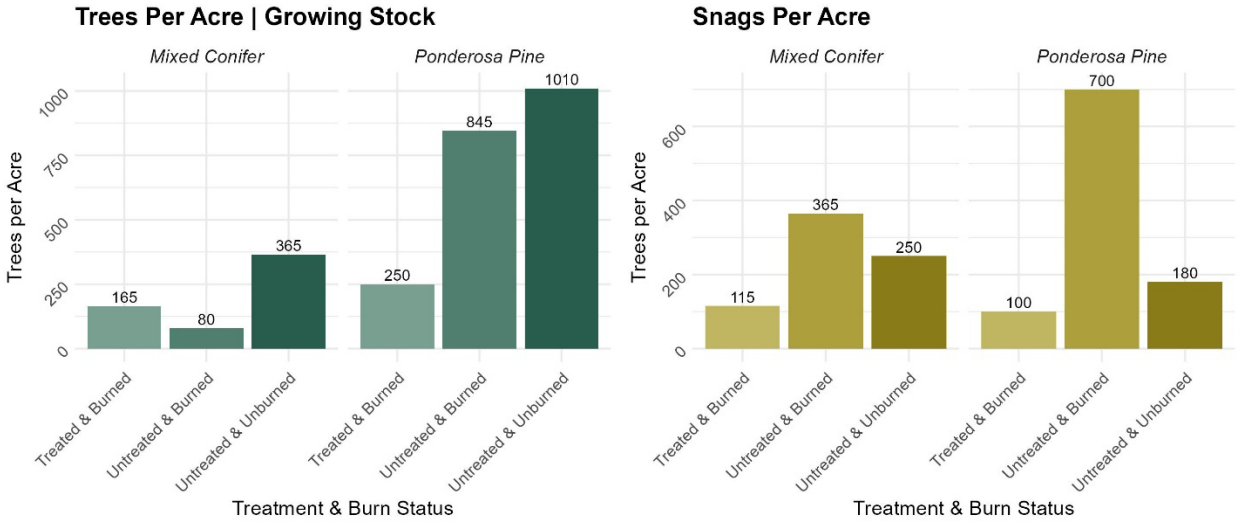


Figure 13. Trees per acre for growing stock trees and snags, by forest type and treatment & burn status.

Basal Area & Quadratic Mean Diameter

The Treated & Burned stratum in the mixed conifer forest has the highest mean basal area per acre (Figure 14). This shows, along with its low tree density and high mean tree diameter, that the tree community is made up of majority larger, and thus more mature trees, relative to the other Treatment/Burn strata (Figure 15). The lowest mean basal area was documented in the Untreated & Burned stratum, with a mean diameter of 11 inches, indicating that the overstory at these plots are likely made up of a few large trees, with a younger cohort beneath.

The Treated & Burned stratum in the ponderosa pine forest, as in the mixed conifer forest, has the highest mean basal area and diameter, while having the lowest tree density of the strata. These plots are made up of large, mature trees, with minimal recruitment of younger trees. The Untreated & Burned stratum had the next highest mean basal area and diameter, while also having a drastically high snags per acre and mean basal area of snags. This suggests that this stratum may have had a high mortality rate, though a good many trees of similar size survived the wildfire.

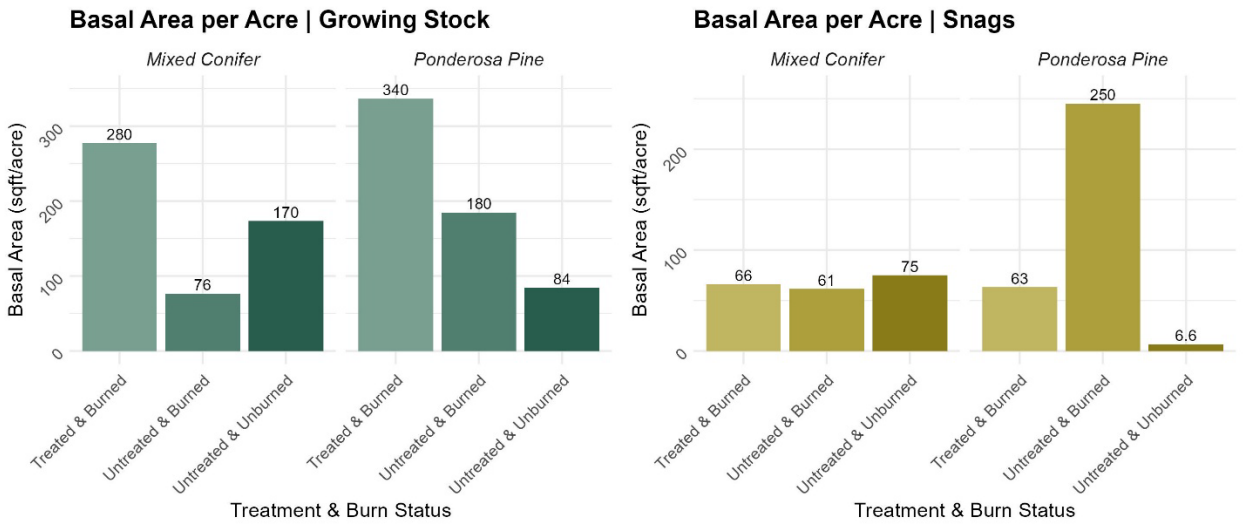


Figure 14. Basal area per acre for growing stock trees and snags, by forest type and treatment & burn status.

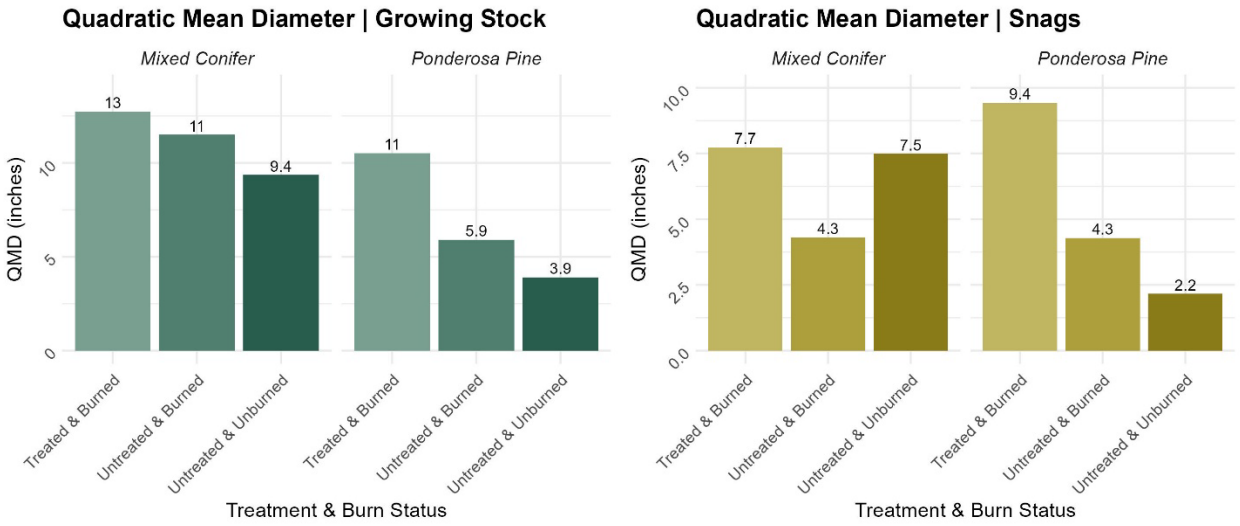


Figure 15. Quadratic mean diameter for growing stock trees and snags, by forest type and treatment & burn status.

Canopy Cover

NMFWRI measures the percentage of closed canopy using a convex spherical densiometer. The highest percent closed canopy in both forest types occurred in the Untreated & Unburned stratum (Figure 16). This follows with the history of disturbance in recent decades at these plots, which is little to none. The lowest canopy cover in both forest types was observed in the Untreated & Burned stratum. Canopy cover can be a predictor of the makeup of an understory plant community due to the availability of light that is able to reach the forest floor. However, there are many different life strategies among plants that may thrive in more or less light.

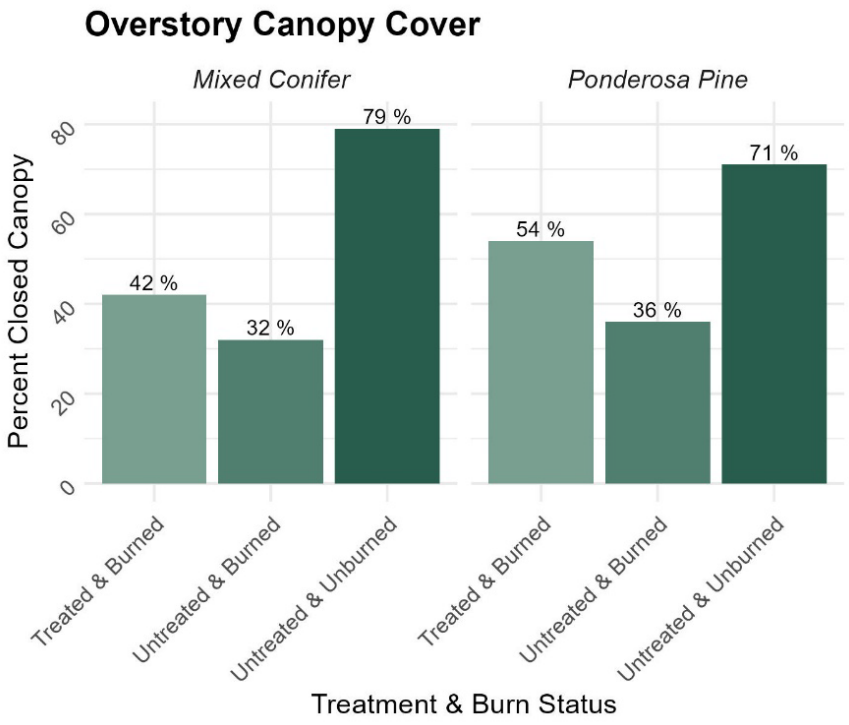


Figure 16. Percent closed canopy as measured by a spherical densiometer, by forest type and treatment & burn status.

Surface Fuels

Litter & Duff

The trend in litter and duff is similar in both forest types. The depth is comparable in the Treated & Burned and in the Untreated & Unburned strata, but the depth in the Untreated & Burned stratum is substantially lower (Figure 17). The depth of litter can be an indicator of productivity since the fire, as well as limitations to productivity through burial. Since duff takes some time to develop, it can be an indicator of fuels consumed by prescribed fire treatments, or by the HPCC fire, depending on the treatment history.

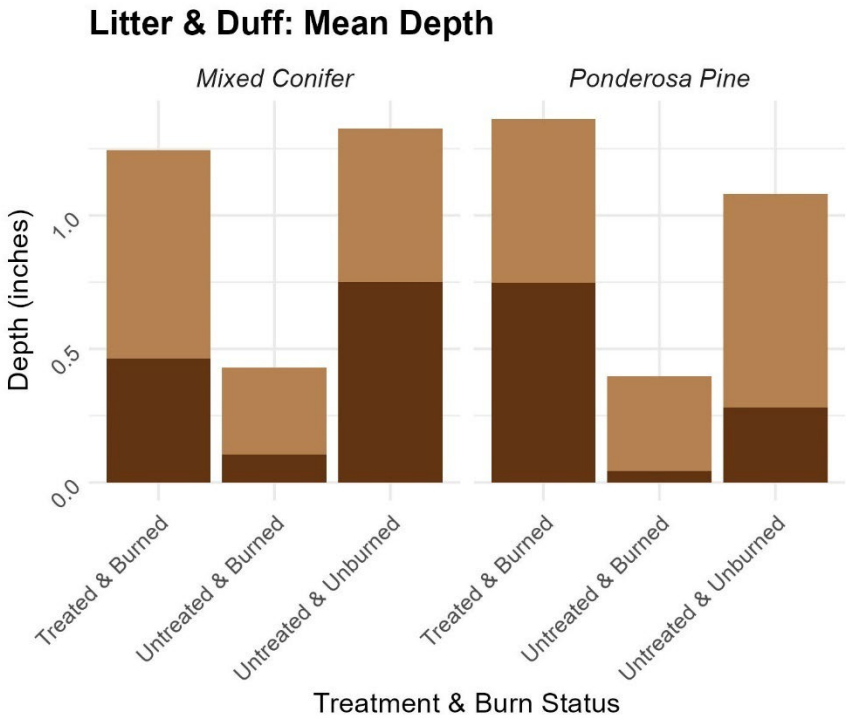


Figure 17. Mean litter and depth by forest type and treatment & burn status.

Plot Photos

The following is a selection of plot photos from each stratum that we believe to best represent the areas. Perspective and dimensions of photos may appear different due to separate camera models utilized by different crews.

Plot: 03.01_007 | **Transect:** 0˚
Forest Type: Mixed Conifer
Treatment & Burn Status: Treated & Burned

Plot: 12.16_054 | **Transect:** 120˚
Forest Type: Mixed Conifer
Treatment & Burn Status: Untreated & Burned
*2 photos are included for this stratum because of the plots' stark inherit differences

Plot: 12.16_106 | **Transect:** 0˚
Forest Type: Mixed Conifer
Treatment & Burn Status: Untreated & Burned
*2 photos are included for this stratum because of the plots' stark inherit differences

Plot: UB_003 | **Transect:** 240˚
Forest Type: Mixed Conifer
Treatment & Burn Status: Untreated & Unburned

Plot: 28.10_1_006 | **Transect:** 0˚
Forest Type: Ponderosa Pine
Treatment & Burn Status: Treated & Burned

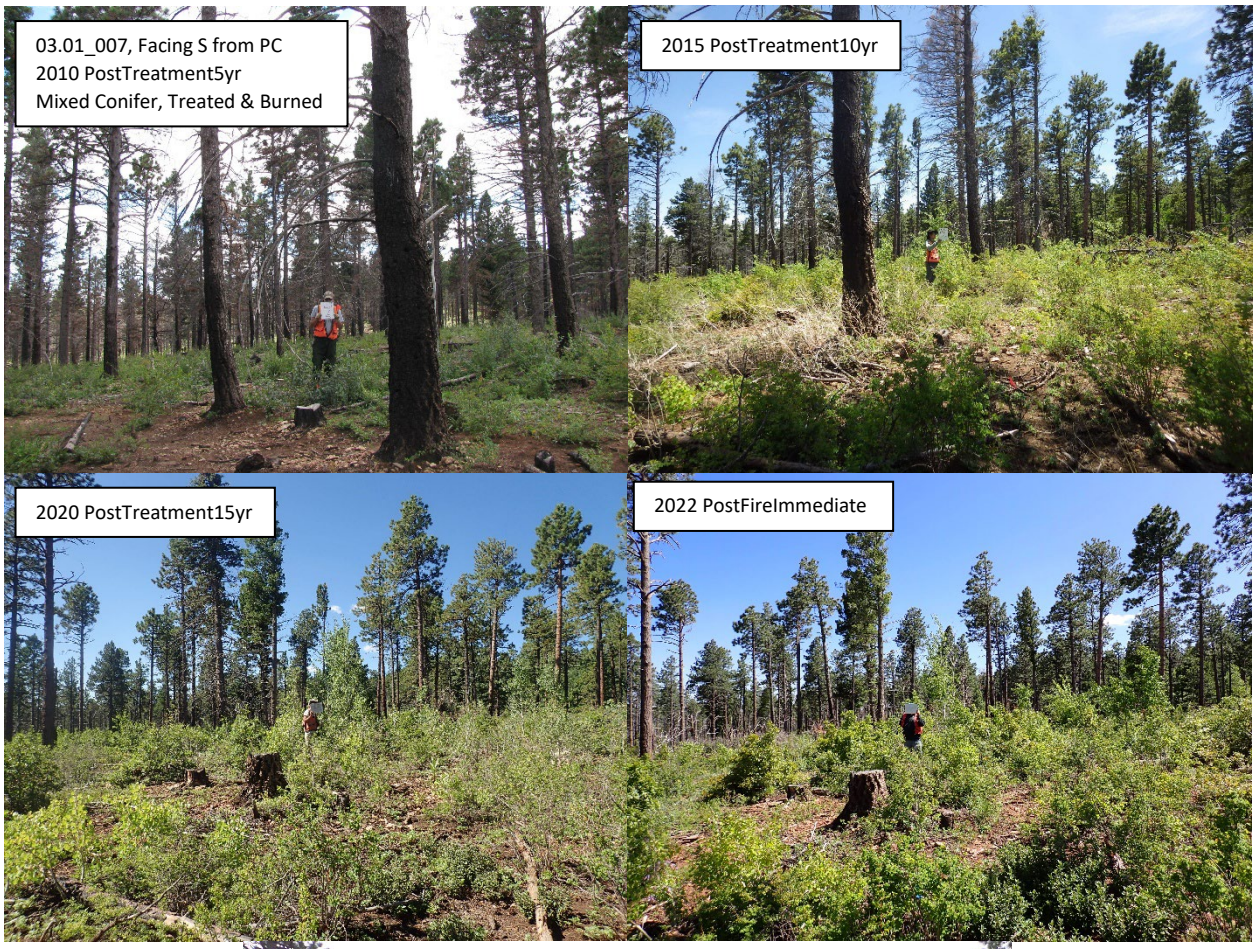
Plot: T2RB_007 | **Transect:** 120˚
Forest Type: Ponderosa Pine
Treatment & Burn Status: Untreated & Burned
*2 photos are included for this stratum because of the plots' stark inherit differences

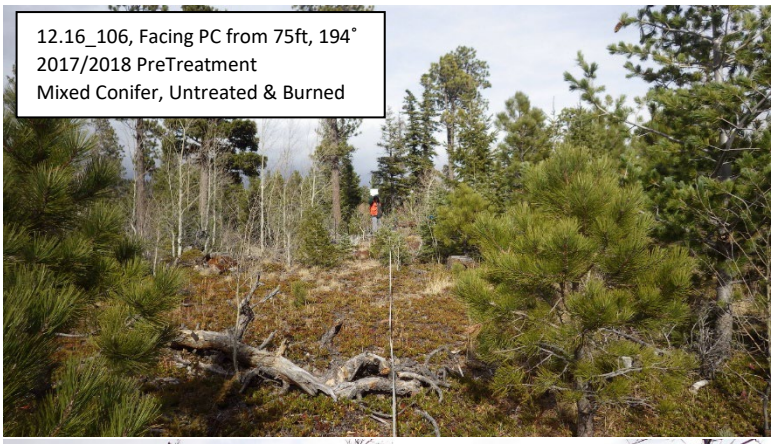
Plot: T2RB_009 | **Transect:** 240˚
Forest Type: Ponderosa Pine
Treatment & Burn Status: Untreated & Burned
*2 photos are included for this stratum because of the plots' stark inherit differences

Plot: UB_002 | **Transect:** 0˚
Forest Type: Ponderosa Pine
Treatment & Burn Status: Untreated & Unburned

Photo Comparisons (Time Series)

The following is a selection of plot photos from NMFWRI's Common Stand Exam protocol. These photos display pre-fire conditions for some plots. Recall the unburned plots are newly established, so NMFWRI does not have pre-fire data or photos.

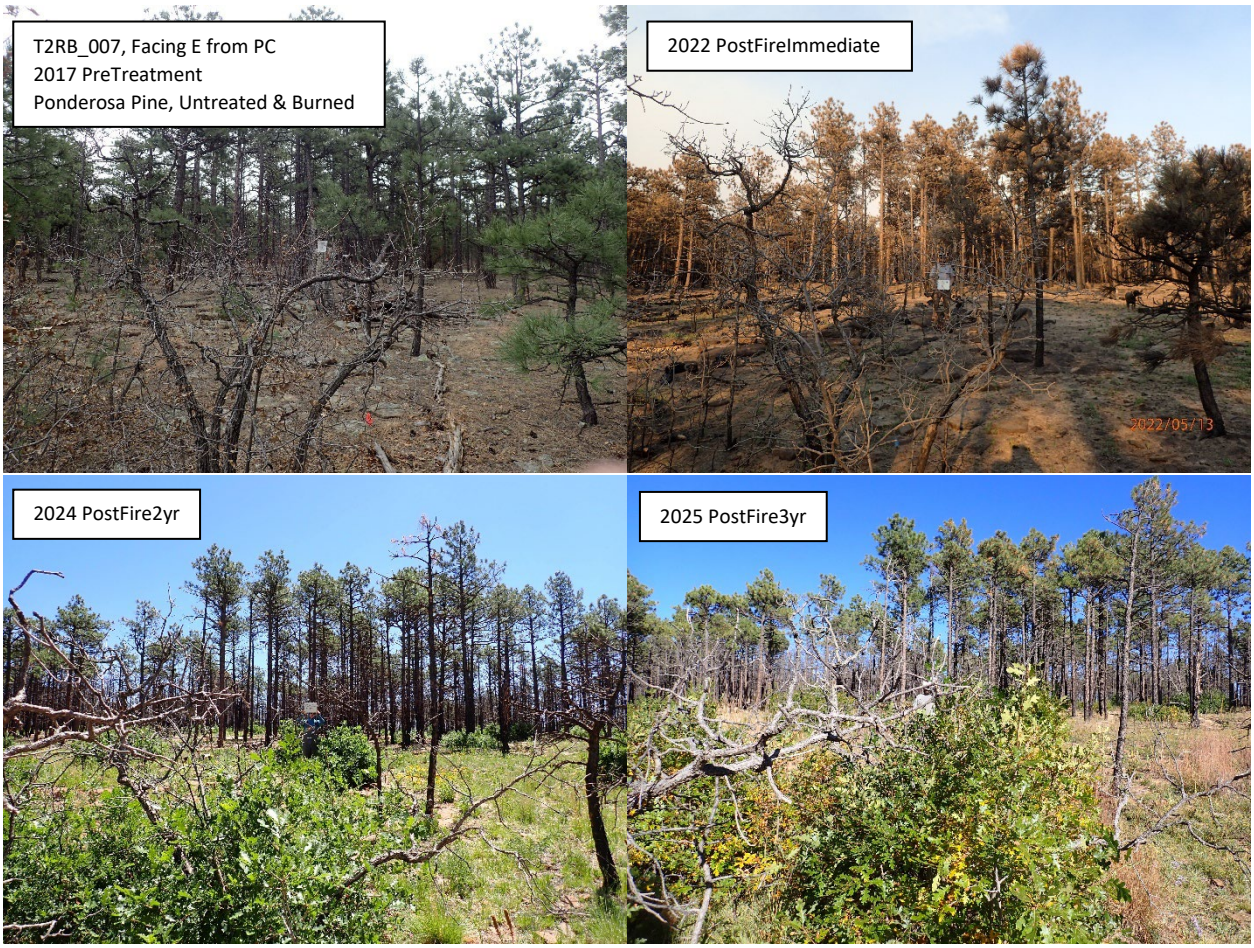



12.16_106, Facing PC from 75ft, 194˚
2017/2018 PreTreatment
Mixed Conifer, Untreated & Burned

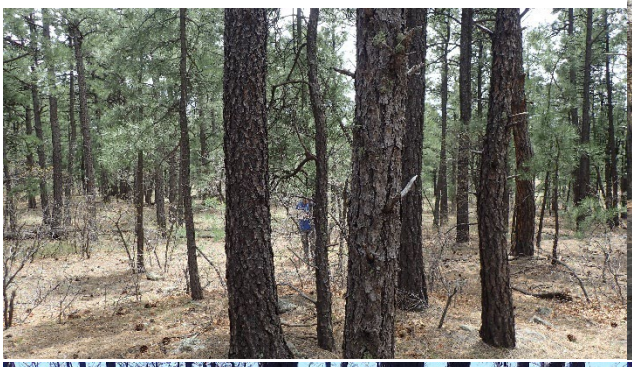

2024 PostFire2yr


2025 PostFire3yr


28.10_1_006, Facing S from PC
2010 PreTreatment
Ponderosa Pine, Treated & Burned
2018 PostTreatment5yr
2022 PostFireImmediate
2025 PostFire3yr


T2RB_007, Facing E from PC
2017 PreTreatment
Ponderosa Pine, Untreated & Burned
2022 PostFireImmediate
2022/05/13
2024 PostFire2yr
2025 PostFire3yr

T2RB_009, Facing S from PC
2017 PreTreatment
Ponderosa Pine, Untreated & Burned



2022 PostFireImmediate

2024 PostFire2yr

2024 PostFire3yr

Works Cited

Ackerfield, J.; Boom, B. M.; Gandy, E.; & Paradiso, L. (2024). EcoFloras Elucidate Insights from Biodiversity Data: Evaluating the Strengths and Limitations of iNaturalist Observations and Herbarium Specimens. *Preprints.* doi: 10.20944/preprints202410.0017.v1

Allred, K.W.; Jercinovic, E. M.; & Dewitt Ivey, R. (2020). Flora Neomexicana III: An Illustrated Identification Manual. Second Edition.

Antos, J. A. (2009). Understory Plants in Temperate Forests. Forests and Forest Plants – Volume I. Eolss Publishers Co. Ltd. Oxford, United Kingdom.

Buckner, D. L. (1985). Point-intercept sampling in revegetation studies: Maximizing objectivity and repeatability. Proceedings America Society of Mining and Reclamation. P. 110-113. DOI: 10.21000/JASMR85010110

Daru, B. H.; Park, D. S.; Primack, R. B. et al. (2017). Widespread sampling biases in herbaria revealed from large-scale digitization. *New Phytologist.* 217(2), 939-955. https://doi.org/10.1111/nph.14855

Deng, J.; Fang, S.; Fang, X. et al. (2023). Forest understory vegetation study: current status and future trends. *Forestry Research* 3:6 DIOi: 10.48130/FR-2023-0006

Dethier, M. N.; Grahan, E. S.; Cohen, S.; & Tear, L. M. (1993). Visual versus random-point percent cover observation: 'objective' is not always best. *Marine Ecology Progress Series.* 96, 93-100.

Derr, T., McGrath, D., Estrada, V., Krasilovsky, E., & Evans, Z. (2008). MONITORING THE LONG TERM ECOLOGICAL IMPACTS OF NEW MEXICO'S COLLABORATIVE FOREST RESTORATION PROGRAM.

Godínez-Alvarez, H., Herrick, J.E., Mattocks, M. et al. 2009. Comparison of three vegetation monitoring methods: Their relative utility for ecological assessment and monitoring. *Ecological Indicators.* 9, 1001-1008. DOI: 10.1016/j.ecolind.2008.11.011

Golz, H. M. (2019). The understudied understory: restoration with herbaceous species under climate change. *A Thesis Submitted to the Faculty of the University of Minnesota in Partial Fulfillment of the Requirements for the Degree of Master of Science.*

Graham, R. T. & Jain, T. B. (2005). Ponderosa Pine Ecosystems. Gen. Tech. Rep. PSW-GRT-198. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Huffman, D. W.; Roccaforte, J. P.; Springer, J. D.; & Crouse, J. E. (2020). Restoration applications of resource objective wildfires in western US forests: a status of knowledge review. *Fire Ecology.* 16(18). https://doi.org/10.1186/s42408-020-00077-x

iNaturalist. Available from https://www.inaturalist.org. Accessed January 28, 2025.

Incident Information System. (2022). Aerial Seeding and Mulching Operations Completed. *NMSNF Hermits Peak-Calf Canyon BAER.* https://web.archive.org/web/20221204115646mp_/https://inciweb.nwcg.gov/incident-publication/nmsnf-hermits-peak-and-calf-canyon-baer/aerial-seeding-and-mulching-operations-completed

James, S. A.; Soltis, P. S.; Belbin, L. et al. (2018). Herbarium data: Global biodiversity and societal botanical needs for novel research. *Appl Plant Sci.* 6(2). Doi: 10.1002/aps3.1024

Laacke, R. J. (1990). Abies concolor (Gord & Glend.) Lindl. ex Hildebr. White Fir. Silvics of North America, U.S. Department of Agriculture, Forest Service. https://research.fs.usda.gov/silvics/

Lentile, L. B.; Morgan, P.; Hudak, A. T. et al. (2007). Post-Fire Burn Severity and Vegetation Response Following Eight Large Wildfires Across the Western United States. *Fire Ecology Special Issue*. 3(1), 91-108.

Marsh, C.; Blankinship, J. C.; & Hurteau, M. D. (2023). Effects of nurse shrubs and biochar on planted conifer seedling survival and growth in a high severity burn patch in New Mexico, USA. https://doi.org/10.1016/j.foreco.2023.120971

Moir, W. H.; Benoit, M. A.; & Scurlock, D. (1997). Chapter 1 Ecology of Southwestern Ponderosa Pine Forests. Gen. Tech. Rep. RMRS-GTR-292. U.S. Department of Agriculture, Forest Service.

Morrison, L. W. (2016). Observer error in vegetation surveys: a review. *Journal of Plant Ecology.* 9(4), 367-379. https://doi.org/10.1093/jpe/rtv077

Natural Resources Conservation Service. *PLANTS Database*. United States Department of Agriculture. Accessed February 24, 2026, from https://plants.usda.gov.

New Mexico Fire Information (August 12, 2022). Forest Service BAER Aerial Seeding & Mulching Treatments set to begin for the Hermits Peak-Calf Canyon Fire Area. Accessed February 2026. https://nmfireinfo.com/2022/08/12/forest-service-baer-aerial-seeding-mulching-treatments-set-to-begin-for-the-hermits-peak-calf-canyon-fire-area/

New Mexico Forest and Watershed Restoration Institute. (2024). Guidelines and Protocols for Monitoring Upland Forests Field Manual, First Edition.

New Mexico Forest and Watershed Restoration Institute. (2022, August 24). Hermit's Peak and Calf Canyon Fire. ArcGIS StoryMaps. https://storymaps.arcgis.com/stories/d48e2171175f4aa4b5613c2d11875653

Reynolds, Richard T.; Sánchez Meador, Andrew J. et al. (2013). Restoring composition and structure in Southwestern frequent-fire forests: A science-based framework for improving ecosystem resiliency. Gen. Tech. Rep. RMRS-GTR-310. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Schacht, S. (2023). Forest Service talks aerial reseeding of Calf Canyon/Hermits Peak Fire burn scar. *KOB4 Eyewitness News.* https://www.kob.com/new-mexico/forest-service-talks-aerial-reseeding-of-calf-canyonhermits-peak-fire-burn-scar/

Segarra, C. (2023). Aerial seeding begins on Hermits Peak-Calf Canyon burn scar. *KRQE News*. https://www.krqe.com/news/wildfires/aerial-seeding-begins-on-hermits-peak-calf-canyon-burn-scar/#:~:text=SANTA%20FE%2C%20N.M.%20(KRQE),and%20help%20prevent%20future%20fires.&text=For%20aerial%20seeding%2C%20the%20U.S.,works%20well%20in%20your%20community

SEINet - AZ/NM Node. https://swbiodiversity.org/seinet. Accessed January 28, 2025.

Southwest Forest Health and Wildfire Prevention Act of 2004, no. 108–317, 108th Congress (2004). https://www.congress.gov/108/plaws/publ317/PLAW-108publ317.pdf

U.S. Department of the Interior, Bureau of Land Management. 2021. Recognizing Plant Families of the West: Field Guide. Bureau of Land Management, Colorado.

Wildland Fire Interagency Geospatial Services (WFIGS) Group. WFIGS Current Interagency Fire Perimeters. Accessed February 24, 2026. https://data-nifc.opendata.arcgis.com/datasets/nifc::wfigs-current-interagency-fire-perimeters/about

Wolf, K. D.; Huguera, P. E.; Davis, K. T.; & Dobrowski, S. Z. (2021). Wildfire impacts on forest microclimate vary with biophysical context. *Ecosphere.* 12(5). https://doi.org/10.1002/ecs2.3467

Wolk, B; Ertle, E; & Fornwalt, P. (2017). Protocol for Monitoring Understory Plant Response to Front Range Collaborative Forest Landscape Restoration Program (FR-CFLRP) Treatments. https://cfri.colostate.edu/wp-content/uploads/sites/22/2017/12/FR-CFLRP-Understory-Monitoring-Protocol-2015.pdf

World Health Organization. (2025, February 18). Biodiversity. https://www.who.int/news-room/fact-sheets/detail/biodiversity

Supplemental Information

A: Species List

Table 9. All species identified in NMFWRI's 2025 understory inventory and monitoring study (1 of 5)

Understory Plant Species List (1 of 5)						
USDA PLANTS Code	**Scientific Name**	**Common Name**	**Family**	**Growth Habit**	**Life Cycle**	**Nativity**
ABCO	Abies concolor	white fir	Pinaceae	Tree	Perennial	Native
ABLA	Abies lasiocarpa	subalpine fir	Pinaceae	Tree	Perennial	Native
ACGL	Acer glabrum	Rocky Mountain maple	Aceraceae	Tree	Perennial	Native
ACMI2	Achillea millefolium	common yarrow	Asteraceae	Forb	Perennial	Native
AGGI2	Agrostis gigantea	redtop	Poaceae	Graminoid	Perennial	Invasive
AGSC5	Agrostis scabra	rough bentgrass	Poaceae	Graminoid	Perennial	Native
ALCE2	Allium cernuum	nodding onion	Liliaceae	Forb	Perennial	Native
ALGE	Allium geyeri	Geyer's onion	Liliaceae	Forb	Perennial	Native
AMAL2	Amelanchier alnifolia	Saskatoon serviceberry	Rosaceae	Tree	Perennial	Native
AMCA6	Amorpha canescens	leadplant	Fabaceae	Shrub	Perennial	Native
AMFR	Amorpha fruticosa	false indigo bush	Fabaceae	Shrub	Perennial	Native
AMPA	Amaranthus palmeri	carelessweed	Amaranthaceae	Forb	Annual/Biennial	Native
AMRE	Amaranthus retroflexus	redroot amaranth	Amaranthaceae	Forb	Annual/Biennial	Native
ANCY	Anemone cylindrica	candle anemone	Ranunculaceae	Forb	Perennial	Native
ANEL5	Anticlea elegans	mountain deathcamas	Liliaceae	Forb	Perennial	Native
ANGE	Andropogon gerardii	big bluestem	Poaceae	Graminoid	Perennial	Native
ANMA	Anaphalis margaritacea	western pearly everlasting	Asteraceae	Forb	Perennial	Native
ANMA5	Antennaria marginata	whitemargin pussytoes	Asteraceae	Forb	Perennial	Native
ANPA4	Antennaria parvifolia	small-leaf pussytoes	Asteraceae	Forb	Perennial	Native
ANSE4	Androsace septentrionalis	pygmyflower rockjasmine	Primulaceae	Forb	Annual/Biennial	Native
APAN2	Apocynum androsaemifolium	spreading dogbane	Apocynaceae	Forb	Perennial	Native
AQEL	Aquilegia elegantula	western red columbine	Ranunculaceae	Forb	Perennial	Native
ARFR3	Artemisia franserioides	ragweed sagebrush	Asteraceae	Forb	Perennial	Native
ARFR4	Artemisia frigida	prairie sagewort	Asteraceae	Shrub	Perennial	Native
ARLA4	Arenaria lanuginosa	spreading sandwort	Caryophyllaceae	Forb	Perennial	Native
ARLU	Artemisia ludoviciana	white sagebrush	Asteraceae	Shrub	Perennial	Native
ARPU9	Aristida purpurea	purple threeawn	Poaceae	Graminoid	Perennial	Native
ARUV	Arctostaphylos uva-ursi	kinnikinnick	Ericaceae	Shrub	Perennial	Native
BADI	Bahia dissecta	ragleaf bahia	Asteraceae	Forb	Annual/Biennial	Native
BASC5	Bassia scoparia	burningbush, kochia	Chenopodiaceae	Forb	Annual/Biennial	Invasive
BITE	Bidens tenuisecta	slimlobe beggarticks	Asteraceae	Forb	Annual/Biennial	Native
BLTR	Blepharoneuron tricholepis	pine dropseed	Poaceae	Graminoid	Perennial	Native
BOCU	Bouteloua curtipendula	sideoats grama	Poaceae	Graminoid	Perennial	Native
BOGR2	Bouteloua gracilis	blue grama	Poaceae	Graminoid	Perennial	Native
BRAN	Bromus anomalus	nodding brome	Poaceae	Graminoid	Perennial	Native
BRBR2	Brickellia brachyphylla	plumed brickellbush	Asteraceae	Shrub	Perennial	Native
BRCA5	Bromus carinatus	California brome	Poaceae	Graminoid	Annual/Biennial	Native
BRGR	Brickellia grandiflora	tasselflower brickellbush	Asteraceae	Shrub	Perennial	Native
BRIN2	Bromus inermis	smooth brome	Poaceae	Graminoid	Perennial	Invasive
BRRU	Brickellia rusbyi	stinking brickellbush	Asteraceae	Shrub	Perennial	Native
BRTE	Bromus tectorum	cheatgrass	Poaceae	Graminoid	Annual/Biennial	
CABR10	Carex brevior	shortbeak sedge	Cyperaceae	Graminoid	Perennial	Native
CABU	Calypso bulbosa	fairy slipper	Orchidaceae	Forb	Perennial	Native
CACA4	Calamagrostis canadensis	bluejoint	Poaceae	Graminoid	Perennial	Native
CADU6	Carex duriuscula	needleleaf sedge	Cyperaceae	Graminoid	Perennial	Native
CAGE2	Carex geyeri	Geyer's sedge	Cyperaceae	Graminoid	Perennial	Native
CAHE5	Carex heliophila	sun-loving sedge	Cyperaceae	Graminoid	Perennial	Native
CAMI12	Castilleja miniata	giant red Indian paintbrush	Scrophulariaceae	Shrub	Perennial	Native
CANE2	Carex nebrascensis	Nebraska sedge	Cyperaceae	Graminoid	Perennial	Native
CANU4	Carduus nutans	nodding plumeless thistle	Asteraceae	Forb	Annual/Biennial	Invasive
CAPR5	Carex praegracilis	clustered field sedge	Cyperaceae	Graminoid	Perennial	Native
CARO2	Campanula rotundifolia	bluebell bellflower	Campanulaceae	Forb	Perennial	Native
CARO5	Carex rossii	Ross' sedge	Cyperaceae	Graminoid	Perennial	Native

Table 10. All species identified in NMFWRI's 2025 understory inventory and monitoring study (2 of 5)

Understory Plant Species List (2 of 5)						
USDA PLANTS Code	**Scientific Name**	**Common Name**	**Family**	**Growth Habit**	**Life Cycle**	**Nativity**
CEFE	Ceanothus fendleri	Fendler's ceanothus	Rhamnaceae	Shrub	Perennial	Native
CEMO2	Cercocarpus montanus	alderleaf mountain mahogany	Rosaceae	Tree	Perennial	Native
CHAL7	Chenopodium album	lambsquarters	Chenopodiaceae	Forb	Annual/Biennial	Invasive
CHAN9	Chamerion angustifolium	fireweed	Onagraceae	Forb	Perennial	Native
CHER2	Chaetopappa ericoides	rose heath	Asteraceae	Shrub	Perennial	Native
CHUM	Chimaphila umbellata	pipsissewa	Pyrolaceae	Shrub	Perennial	Native
CIAR4	Cirsium arvense	Canada thistle	Asteraceae	Forb	Perennial	Invasive
CIUN	Cirsium undulatum	wavyleaf thistle	Asteraceae	Forb	Perennial	Native
CLCO2	Clematis columbiana	rock clematis	Ranunculaceae	Forb	Perennial	Native
COAL6	Conopholis alpina	alpine cancer-root	Orobanchaceae	Forb	Perennial	Native
COAR4	Convolvulus arvensis	field bindweed	Convolvulaceae	Forb	Perennial	Invasive
COCA5	Conyza canadensis	Canadian horseweed/mare's tail	Asteraceae	Forb	Annual/Biennial	Native
CODI4	Commelina dianthifolia	birdbill dayflower	Commelinaceae	Forb	Perennial	Native
COLA5	Coreopsis lanceolata	lanceleaf tickseed	Asteraceae	Forb	Perennial	Native
COPA12	Cosmos parviflorus	southwestern cosmos	Asteraceae	Forb	Annual/Biennial	Native
COWI5	Corallorhiza wisteriana	spring coralroot	Orchidaceae	Forb	Perennial	Native
CYFE2	Cyperus fendlerianus	Fendler's flatsedge	Cyperaceae	Graminoid	Perennial	Native
CYLE6	Cymopterus lemmonii	mountain spring-parsley	Apiaceae	Forb	Perennial	Native
CYSC3	Cyperus schweinitzii	Schweinitz's flatsedge	Cyperaceae	Graminoid	Perennial	Native
DAGL	Dactylis glomerata	orchardgrass	Poaceae	Graminoid	Perennial	Invasive
DAPO3	Dalea polygonoides	sixweeks prairie clover	Fabaceae	Forb	Annual/Biennial	Native
DASP2	Danthonia spicata	poverty oatgrass	Poaceae	Graminoid	Perennial	Native
DICA18	Dieteria canescens	Hoary tansyaster	Asteraceae	Forb	Annual/Biennial	Native
DRAU	Draba aurea	golden draba	Brassicaceae	Forb	Perennial	Native
DRHE	Draba helleriana	Heller's draba	Brassicaceae	Forb	Perennial	Native
DYGR	Dysphania graveolens	fetid goosefoot	Chenopodiaceae	Forb	Annual/Biennial	Native
DYPA	Dyssodia papposa	fetid marigold	Asteraceae	Forb	Annual/Biennial	Native
ELEL5	Elymus elymoides	squirreltail	Poaceae	Graminoid	Perennial	Native
ELSM3	Elymus smithii	Western wheat	Poaceae	Graminoid	Perennial	Native
ELTR7	Elymus trachycaulus	slender wheatgrass	Poaceae	Graminoid	Perennial	Native
ERCA14	Erysimum capitatum	sanddune wallflower	Brassicaceae	Forb	Annual/Biennial	Native
ERCO28	Erigeron colomexicanus	running fleabane	Asteraceae	Forb	Annual/Biennial	Native
ERDI4	Erigeron divergens	spreading fleabane	Asteraceae	Forb	Annual/Biennial	Native
EREX4	Erigeron eximius	sprucefir fleabane	Asteraceae	Shrub	Perennial	Native
ERFE3	Eremogone fendleri	Fendler's sandwort	Poaeceae	Forb	Perennial	Native
ERFL	Erigeron flagellaris	trailing fleabane	Asteraceae	Forb	Annual/Biennial	Native
ERGL5	Erigeron glacialis	subalpine fleabane	Asteraceae	Forb	Perennial	Native
ERSP4	Erigeron speciosus	aspen fleabane	Asteraceae	Shrub	Perennial	Native
ERSU2	Erigeron subtrinervis	threenerve fleabane	Asteraceae	Forb	Perennial	Native
EUDA5	Euphorbia davidii	David's spurge	Euphorbiaceae	Forb	Annual/Biennial	Invasive
FEAR2	Festuca arizonica	Arizona fescue	Poaceae	Graminoid	Perennial	Native
FESA	Festuca saximontana	Rocky Mountain fescue	Poaceae	Graminoid	Perennial	Native
FRSP	Frasera speciosa	elkweed / monument plant	Gentianaceae	Forb	Perennial	Native
FRVE	Fragaria vesca	woodland strawberry	Rosaceae	Forb	Perennial	Native
GABO2	Galium boreale	northern bedstraw	Rubiaceae	Shrub	Perennial	Native
GEAC2	Gentianella acuta	little gentian	Gentianaceae	Forb	Annual/Biennial	Native
GECA3	Geranium caespitosum	pineywoods geranium	Geraniaceae	Shrub	Perennial	Native
GERI	Geranium richardsonii	Richardson's geranium	Geraniaceae	Forb	Perennial	Native
GOOB2	Goodyera oblongifolia	western rattlesnake plantain	Orchidaceae	Forb	Perennial	Native
HATR	Harbouria trachypleura	whiskbroom parsley	Apiaceae	Forb	Perennial	Native
HEAN3	Helianthus annuus	common sunflower	Asteraceae	Forb	Annual/Biennial	Native
HEMU3	Heliomeris multiflora	showy goldeneye	Asteraceae	Shrub	Perennial	Native
HEPA19	Helianthus pauciflorus	stiff sunflower	Asteraceae	Forb	Perennial	Native

Table 11. All species identified in NMFWRI's 2025 understory inventory and monitoring study (3 of 5)

Understory Plant Species List (3 of 5)						
USDA PLANTS Code	**Scientific Name**	**Common Name**	**Family**	**Growth Habit**	**Life Cycle**	**Nativity**
HEVI4	Heterotheca villosa	hairy false goldenaster	Asteraceae	Shrub	Perennial	Native
HIFE	Hieracium fendleri	yellow hawkweed	Asteraceae	Forb	Perennial	Native
HYRA2	Hymenopappus radiatus	ray hymenopappus	Asteraceae	Forb	Perennial	Native
IPAG	Ipomopsis aggregata	scarlet gilia	Polemoniaceae	Forb	Annual/Biennial	Native
IPCO2	Ipomoea costellata	crestrib morning-glory	Convolvulaceae	Forb	Annual/Biennial	Native
IRMI	Iris missouriensis	Rocky Mountain iris	Iridaceae	Forb	Perennial	Native
JUCO6	Juniperus communis	common juniper	Cupressaceae	Tree	Perennial	Native
JUIN2	Juncus interior	inland rush	Juncaceae	Graminoid	Perennial	Native
JUMO	Juniperus monosperma	oneseed juniper	Cupressaceae	Tree	Perennial	Native
JUSC2	Juniperus scopulorum	Rocky Mountain juniper	Cupressaceae	Tree	Perennial	Native
KOMA	Koeleria macrantha	prairie Junegrass	Poaceae	Graminoid	Perennial	Native
LAEU	Lathyrus eucosmus	bush vetchling	Fabaceae	Forb	Perennial	Native
LAGR3	Lathyrus graminifolius	grassleaf pea	Fabaceae	Forb	Perennial	Native
LALE2	Lathyrus leucanthus	Nevada pea	Fabaceae	Forb	Perennial	Native
LASC3	Laennecia schiedeana	pineland horseweed	Asteraceae	Forb	Annual/Biennial	Native
LASE	Lactuca serriola	prickly lettuce	Asteraceae	Forb	Annual/Biennial	Invasive
LIIN2	Lithospermum incisum	narrowleaf stoneseed	Boraginaceae	Forb	Perennial	Native
LIMU3	Lithospermum multiflorum	manyflowered stoneseed	Boraginaceae	Forb	Perennial	Native
LIPO	Ligusticum porteri	Porter's licorice-root	Apiaceae	Forb	Perennial	Native
LYSE3	Lycurus setosus	bristly wolfstail	Poaceae	Graminoid	Perennial	Native
MARA7	Maianthemum racemosum	feathery false lily of the valley	Liliaceae	Forb	Perennial	Native
MARE11	Mahonia repens	creeping barberry	Berberidaceae	Shrub	Perennial	Native
MELU	Medicago lupulina	black medick	Fabaceae	Forb	Annual/Biennial	Invasive
MEOF	Melilotus officinalis	sweetclover	Fabaceae	Forb	Annual/Biennial	Invasive
MILI3	Mirabilis linearis	narrowleaf four o'clock	Nyctaginaceae	Shrub	Perennial	Native
MOFI	Monarda fistulosa	wild bergamot	Lamiaceae	Shrub	Perennial	Native
MOHY3	Monotropa hypopithys	pinesap	Monotropaceae	Forb	Perennial	Native
MUMO	Muhlenbergia montana	mountain muhly	Poaceae	Graminoid	Perennial	Native
OEVI	Oenothera villosa	hairy evening primrose	Onagraceae	Forb	Annual/Biennial	Native
ONVI	Onobrychis viciifolia	sainfoin	Fabaceae	Forb	Perennial	Invasive
ORAS	Oryzopsis asperifolia	roughleaf ricegrass	Poaceae	Graminoid	Perennial	Native
ORPA3	Oreochrysum parryi	Parry's goldenrod	Asteraceae	Forb	Perennial	Native
ORSE	Orthilia secunda	sidebells wintergreen	Pyrolaceae	Shrub	Perennial	Native
PABU	Panicum bulbosum	bulb panicgrass	Poaceae	Graminoid	Perennial	Native
PACA6	Panicum capillare	witchgrass	Poaceae	Graminoid	Annual/Biennial	Native
PACO2	Panicum coloratum	kleingrass	Poaceae	Graminoid	Perennial	Invasive
PAFE4	Packera fendleri	Fendler's ragwort	Asteraceae	Forb	Perennial	Native
PAMY	Paxistima myrsinites	Oregon boxleaf	Celastraceae	Shrub	Perennial	Native
PANE7	Packera neomexicana	New Mexico groundsel	Asteraceae	Forb	Perennial	Native
PAST10	Packera streptanthifolia	Rocky Mountain groundsel	Asteraceae	Forb	Perennial	Native
PEBA2	Penstemon barbatus	beardlip penstemon	Scrophulariaceae	Forb	Perennial	Native
PECA	Pedicularis canadensis	Canadian lousewort	Scrophulariaceae	Shrub	Perennial	Native
PEPR7	Pedicularis procera	giant lousewort	Scrophulariaceae	Forb	Perennial	Native
PHMO4	Physocarpus monogynus	mountain ninebark	Rosaceae	Shrub	Perennial	Native
PHNA2	Phlox nana	Santa Fe phlox	Polemoniaceae	Forb	Perennial	Native
PIED	Pinus edulis	twoneedle pinyon	Pinaceae	Tree	Perennial	Native
PIFL2	Pinus flexilis	limber pine	Pinaceae	Tree	Perennial	Native
PIPO	Pinus ponderosa	ponderosa pine	Pinaceae	Tree	Perennial	Native
PIPR2	Piptochaetium pringlei	Pringle's speargrass	Poaceae	Graminoid	Perennial	Native
PIPU	Picea pungens	blue spruce	Pinaceae	Tree	Perennial	Native
PLLA	Plantago lanceolata	narrowleaf plantain	Plantaginaceae	Forb	Perennial	Invasive
POCO	Poa compressa	Canada bluegrass	Poaceae	Graminoid	Perennial	Invasive
POFE	Poa fendleriana	muttongrass	Poaceae	Graminoid	Perennial	Native

Table 12. All species identified in NMFWRI's 2025 understory inventory and monitoring study (4 of 5).

Understory Plant Species List (4 of 5)						
USDA PLANTS Code	**Scientific Name**	**Common Name**	**Family**	**Growth Habit**	**Life Cycle**	**Nativity**
POHI6	Potentilla hippiana	woolly cinquefoil	Rosaceae	Forb	Perennial	Native
POPR	Poa pratensis	Kentucky bluegrass	Poaceae	Graminoid	Perennial	Invasive
POTR5	Populus tremuloides	quaking aspen	Salicaceae	Tree	Perennial	Native
PRVI	Prunus virginiana	chokecherry	Rosaceae	Tree	Perennial	Native
PRVU	Prunella vulgaris	common selfheal	Lamiaceae	Forb	Perennial	Native
PSMA11	Pseudognaphalium macounii	Macoun's cudweed	Asteraceae	Forb	Annual/Biennial	Native
PSME	Pseudotsuga menziesii	Douglas-fir	Pinaceae	Tree	Perennial	Native
PSMO	Pseudocymopterus montanus	alpine false springparsley	Apiaceae	Forb	Perennial	Native
PTAQ	Pteridium aquilinum	western brackenfern	Dennstaedtiaceae	Forb	Perennial	Native
PYCH	Pyrola chlorantha	greenflowered wintergreen	Pyrolaceae	Shrub	Perennial	Native
QUERC	Quercus	oak	Fagaceae	Tree	Perennial	Native
QUGA	Quercus gambelii	Gambel oak	Fagaceae	Tree	Perennial	Native
RACO3	Ratibida columnifera	upright prairie coneflower	Asteraceae	Forb	Perennial	Native
RHTR	Rhus trilobata	skunkbush sumac	Anacardiaceae	Shrub	Perennial	Native
ROWO	Rosa woodsii	Woods' rose	Rosaceae	Shrub	Perennial	Native
RUID	Rubus idaeus	American red raspberry	Rosaceae	Shrub	Perennial	Native
RULA3	Rudbeckia laciniata	cutleaf coneflower	Asteraceae	Shrub	Perennial	Native
RUPA	Rubus parviflorus	thimbleberry	Rosaceae	Shrub	Perennial	Native
SABE2	Salix bebbiana	Bebb willow	Salicaceae	Tree	Perennial	Native
SARE3	Salvia reflexa	lanceleaf sage / mintweed	Lamiaceae	Forb	Annual/Biennial	Native
SATR12	Salsola tragus	prickly Russian thistle	Chenopodiaceae	Forb	Annual/Biennial	
SCLA6	Scorzonera laciniata	cutleaf vipergrass	Asteraceae	Forb	Perennial	Invasive
SCSC	Schizachyrium scoparium	little bluestem	Poaceae	Graminoid	Perennial	Native
SEWO	Senecio wootonii	Wooton's ragwort	Asteraceae	Shrub	Perennial	Native
SHCA	Shepherdia canadensis	russet buffaloberry	Elaeagnaceae	Shrub	Perennial	Native
SIMO2	Sisyrinchium montanum	strict blue-eyed grass	Iridaceae	Forb	Perennial	Native
SIMOM	Sisyrinchium montanum var. montanum	strict blue-eyed grass	Iridaceae	Forb	Perennial	Native
SIVA4	Sisymbrium vaseyi	Las Vegas tumblemustard	Brassicaceae	Forb	Annual/Biennial	Native
SOCAL	Solidago canadensis var. lepida	Canada goldenrod	Asteraceae	Forb	Perennial	Native
SOEL	Solanum elaeagnifolium	silverleaf nightshade	Solanaceae	Shrub	Perennial	Native
SOGL6	Solidago glutinosa	Mt Albert goldenrod	Asteraceae	Forb	Perennial	Native
SOMO	Solidago mollis	velvety goldenrod	Asteraceae	Forb	Perennial	Native
SONU2	Sorghastrum nutans	Indiangrass	Poaceae	Graminoid	Perennial	Native
SOPA8	Solidago pallida	pale showy goldenrod	Asteraceae	Forb	Perennial	Native
SORI2	Solidago rigida	stiff goldenrod	Asteraceae	Forb	Perennial	Native
SOSI3	Solidago simplex	Mt. Albert goldenrod	Asteraceae	Forb	Perennial	Native
SOVE6	Solidago velutina	threenerve goldenrod	Asteraceae	Forb	Perennial	Native
SOWR	Solidago wrightii	Wright's goldenrod	Asteraceae	Forb	Perennial	Native
SPAN3	Sphaeralcea angustifolia	copper globemallow	Malvaceae	Shrub	Perennial	Native
SPCO4	Sporobolus contractus	spike dropseed	Poaceae	Graminoid	Perennial	Native
SYLA3	Symphyotrichum laeve	smooth blue aster	Asteraceae	Forb	Perennial	Native
SYRO	Symphoricarpos rotundifolius	roundleaf snowberry	Caprifoliaceae	Shrub	Perennial	Native
TAOF	Taraxacum officinale	common dandelion	Asteraceae	Forb	Perennial	Invasive
TEAC	Tetraneuris acaulis	stemless four-nerve daisy	Asteraceae	Forb	Perennial	Native
THFE	Thalictrum fendleri	Fendler's meadow-rue	Ranunculaceae	Forb	Perennial	Native
THMO6	Thermopsis montana	mountain goldenbanner	Fabaceae	Forb	Perennial	Native
TOEX	Townsendia eximia	tall Townsend daisy	Asteraceae	Forb	Perennial	Native
TRDU	Tragopogon dubius	yellow salsify	Asteraceae	Forb	Annual/Biennial	Invasive
TRMO5	Trisetum montanum	mountain oats	Poaceae	Graminoid	Perennial	Native
TRRE3	Trifolium repens	white clover	Fabaceae	Forb	Perennial	Invasive
VAMY2	Vaccinium myrtillus	whortleberry	Ericaceae	Shrub	Perennial	Native
VEMA	Verbena macdougalii	MacDougal verbena	Verbenaceae	Forb	Perennial	Native
VETH	Verbascum thapsus	common mullein	Scrophulariaceae	Forb	Annual/Biennial	Invasive

Table 13. All species identified in NMFWRI's 2025 understory inventory and monitoring study (5 of 5).

Understory Plant Species List (5 of 5)						
USDA PLANTS Code	**Scientific Name**	**Common Name**	**Family**	**Growth Habit**	**Life Cycle**	**Nativity**
VIAM	Vicia americana	American vetch	Fabaceae	Forb	Perennial	Native
VICA4	Viola canadensis	Canadian white violet	Violaceae	Forb	Perennial	Native
VIPU2	Vicia pulchella	sweetclover vetch	Fabaceae	Forb	Perennial	Native
VIVI	Vicia villosa	winter vetch	Fabaceae	Forb	Annual/Biennial	Invasive

B: Acronyms & Abbreviations

Table 14. Acronyms, abbreviations, and other terms used by NMFWRI in this report.

Acronym/Abbreviation/Term	Definition as used by NMFWRI
ASL	Above Sea Level
CFRI	Colorado Forest Restoration Institute
CFRP	Collaborative Forest Restoration Program
DBH	Diameter at breast height (4.5 feet)
ERI	Ecological Restoration Institute
FFI	FEAT/FIREMON Integrated
FEAT	Fire Ecology Assessment Tool
FIREMON	Fire Effects Monitoring and Inventory System
HPCC	Hermit's Peak-Calf Canyon Wildfire
HU	Highlands University
LPI	Line-Point-Intercept
NMDA	New Mexico Department of Agriculture
NMFWRI	New Mexico Forest and Watershed Restoration Institute
QMD	Quadratic Mean Diameter
USFS	United States Forest Service
Sapling	Height > 4.5 feet & DBH < 1 inch
Seedling	Height < 4.5 feet
SWERI	Southwest Ecological Restoration Institute
TPA	Trees per acre (trees/acre)
Tree	Height > 4.5 feet & DBH > 1 inch
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey

C: Metrics Across Time

The data represented in this report is compiled from one of three monitoring periods from the 2025 growing season (see *Monitoring Methods*). The highest cover of vegetation, as well as the highest number of unique species were recorded in all plots in August (Figures 18-19), which is the peak of the growing season in the southwest. This month's data is the only sample represented in this report

because the goal of this study was to best represent the diversity and structure of the understory plant communities.

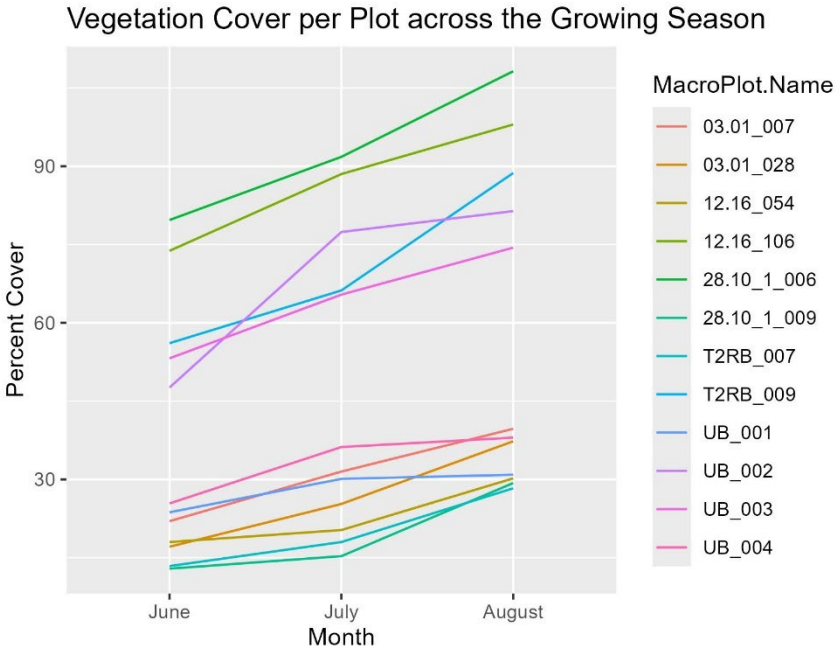


Figure 18. Aerial cover of vegetation across the growing season, from June to August, for all plots.

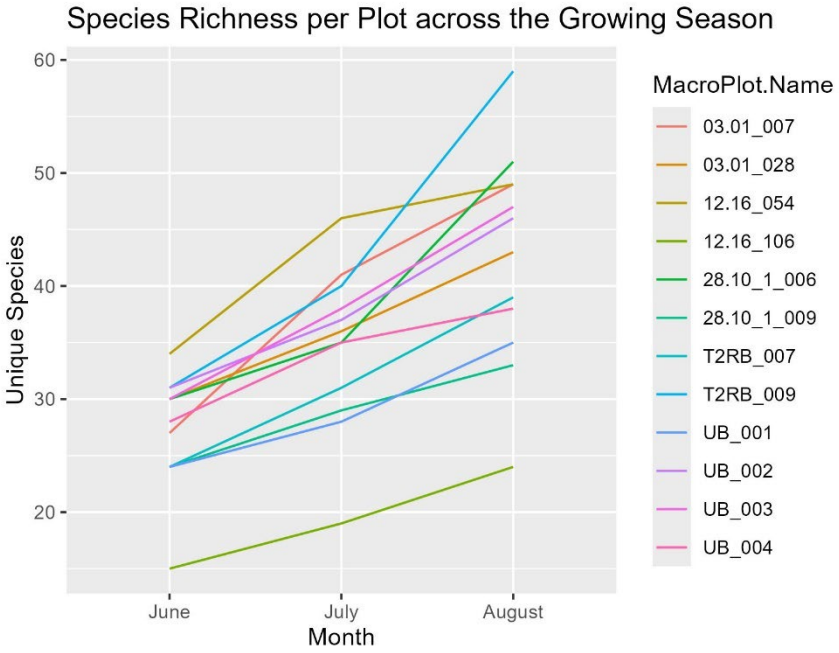


Figure 19. Species richness across the growing season, from June to August, for all plots.

D: LPI vs Ocular Estimation

Ninety-four percent of all LPI observations of species across the three sample periods were an overestimation when compared with the ocular estimation method (Table 13). On average, cover was over-estimated by 3.9%, but ranged up to 23.6%. Six percent of all LPI observations were underestimations, on average -3.8%. The largest underestimation was -12.7%.

Table 15. Summary of the differences in methods of vegetation cover estimation.

Difference between Cover Estimation Methods (LPI minus Ocular Estimate)			
Mean 3.4%			
Positive (overestimation)		*Negative (underestimation)*	
n	354	n	22
Mean	3.9%	Mean	-3.8%
Minimum	0.06%	Minimum	-0.42%
Maximum	23.6%	Maximum	-12.7%

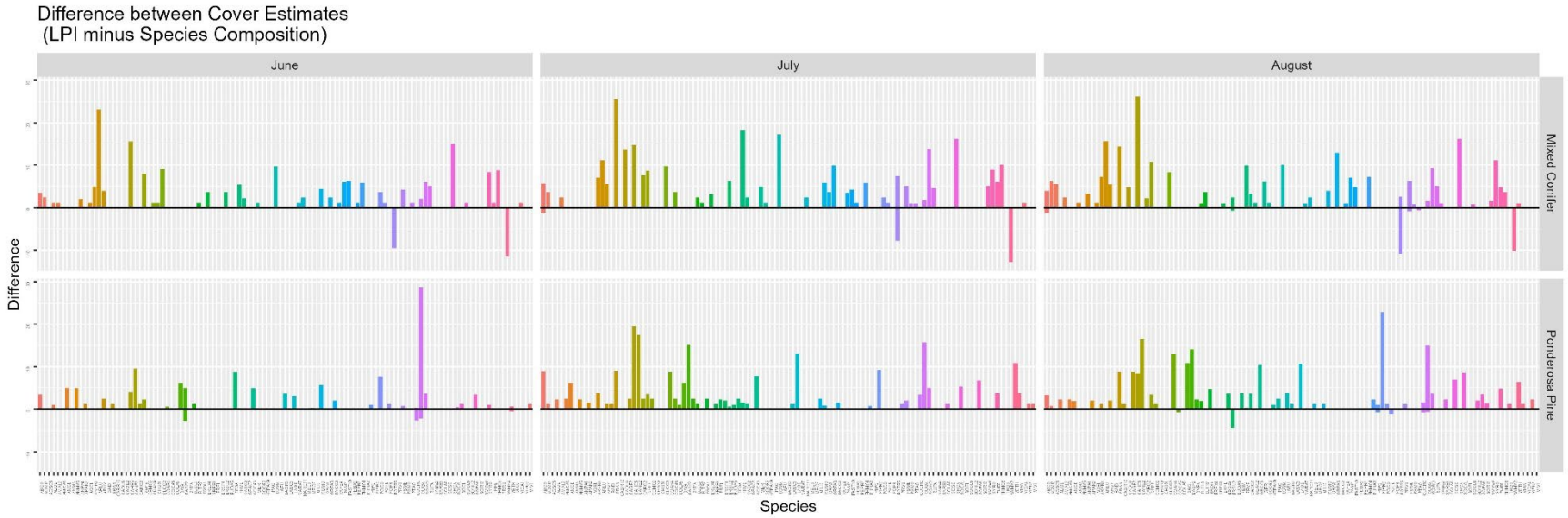


Figure 20. The difference between cover estimation methods across all species recorded, stratified by month and forest type.

E: Notable Species and Functional Groups

Nitrogen Fixers

Nitrogen is a vital nutrient for plant growth, but most of this nutrient occurs in the air, in a form that plants cannot utilize. There are plants, however, that are able to take Nitrogen from the air and transform it into a form that is usable for other species. They do not do this themselves, but through *Rhizombium* bacteria, which live in small nodules on the roots of these plants. Most nitrogen-fixing plants are members of the family Fabacaeae. Twelve unique species of plants in the family Fabaceae were found across all understory monitoring plots. This is encouraging for the status of the soil within the burn scar. In some areas, the soil became hot enough to potentially kill off all microbial life, including the valuable *Rhizombium* bacteria. See the publication below for more information on Nitrogen-fixing plants.

American vetch (*Vicia americana*). Photo by Emily Yannayon.

Evers, G. W. (n. d.). Nitrogen Fixation. *Texas A&M AgriLife Research & Extension Center at Overton.* https://overton.tamu.edu/faculty-staff/gerald-wayne-evers/cool-season-legumes/nitrogen-fixation/

The Life of Fire

Penstemon barbatus (beardlip penstemon, scarlet penstemon, fire-on-the-mountain). Photo by Emily Yannayon

Fire is usually viewed as a destructive force, and it indeed often is. However, this report shows that fire can be restorative, and offer new opportunities for many plants and animals. What is not known by many, and indeed is not often studied, is the direct, positive effects the flames may have on some plant species. High soil temperatures and exposure to smoke may stimulate the germination of seeds of multiple species of plants observed at NMFWRI monitoring plots. This includes, but is not limited to: *Arctostaphylos* spp., *Ceanothus fendleri*, and *Penstemon* spp. There are also many species, especially woody species, that are able to survive high temperatures by a large underground network of rhizomes or rootstocks. This includes quaking aspen (*Populus tremuloides*), oaks (*Quercus* spp.), maples (*Acer* spp.), serviceberry (*Amelanchier alnifolia*), and some willows (*Salix* spp.).

Brown, N. A. C. & van Staden, J. (1997). Smoke as a germination cue: a review. *Plant Growth Regulation*. 22. 115-124. https://doi.org/10.1023/A:1005852018644

Fornwalt, P. J. (2015). Does smoke promote seed germination in 10 Interior West *Penstemon* species? *Native Plants Journal.* 16(1). https://doi.org/10.3368/npj.16.1.5

Moir, W. H.; Benoit, M. A.; & Scurlock, D. (1997). Chapter 1 Ecology of Southwestern Ponderosa Pine Forests. Gen. Tech. Rep. RMRS-GTR-292. U.S. Department of Agriculture, Forest Service.

Zuloaga-Aguilar, S.; Briones, O.; & Orozco-Segovia, A. (2011). Seed germination of montane forest species in response to ash, smoke, and heat shock in Mexico. *Acta Oecologica*. 37 (2011). 256 262. http://dx.doi.org/10.1016/j.actao.2011.02.009

Oaks

A gall, formed by a Jewel Oak Gall Wasp (*Acraspis quercushirta).* This is one of a myriad of insect species that are dependent on oaks for their life cycle. Photo by Emily Yannayon

There are approximately 90 species of *Quercus* in North America, and at least 15 species occur in New Mexico. They are often recognized as keystone species of their environments. The species of oak found in our monitoring plots, *Q. gambelli* (Gambel oak) does not often grow large enough to be utilized for timber or other wood products, this tree can provide much, much more to its surrounding ecosystem. The dense thickets the plant can form are utilized by large herbivores such as deer or elk for browsing and to provide shelter. Acorns are a valuable food resource that is high in fats and proteins, and is utilized by many wildlife, including woodpeckers, turkey, elk, deer, squirrels, and rabbits. In an average moisture year, Gambel oak is expected to produce 500-625 pounds of acorns per acre, and may make up a majority of these animals' diets (Harper et al, 1985). Acorns have also been a staple of the diets of Native Americans and other residents of the Americas. Oaks also play host to hundreds of species of insects, some of which feed *only* on oaks. Insects are, in turn, the main dietary component for many birds during nesting season. In addition, the ability of oaks to re-sprout rapidly following disturbance, such as wildfire, allow them to play a critical role in soil stabilization and nutrient input.

Harper, K. T.; Wagstaff, F. J.; & Kunzler, L. M. (1985) Biology and management of the Gambel oak vegetative type: a literature Review. General Technical Report INT-179. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

National Park Service. (2025). Species Spotlight – Oaks. Accessed February 25, 2026. https://www.nps.gov/articles/species-spotlight-oaks.htm

Tallamy, D. W. (2021). *The Nature of Oaks: The Rich Ecology of Our Most Essential Native Trees.* Hachette Book Group.

United States Department of Agriculture, United States Forest Service. (2000). Quercus gambelii. Fire Effects Information System. https://www.fs.usda.gov/database/feis/plants/tree/quegam/all.html

The Fungus Eaters

Some plants have no chlorophyll – the pigment essential for photosynthesis. They are achlorophyllous. Without this pigment, how do these plants procure energy and nutrients? Many achlorophyllous plants are parasites of the mycorrhizal fungi associated with trees. This is known as mycoheterotrophy – the "fungus eaters." The presence of mycoheterotrophs in a forest indicates a robust and relatively undisturbed soil ecosystem. It takes time for fungal networks to develop. The

Pinesap (*Monotropa hypopitys*) is parasitic on the mycorrhizal fungi of trees, often conifers, but sometimes deciduous trees such as oaks. Photo by Emily Yannayon

mycelium must seek out and establish partnerships by forming connections with tree roots. The fungi must also have time to decompose the litter produced by their arboreal partners, in order to produce energy, but also to recycle nutrients back into the trees. Highly disturbed forests, such as clear-cuts, lack this vital fungal organ.

Only once there is a healthy fungal support network, can mycoheterotrophs establish themselves. Mycoheterotroph may be a misnomer, however. This topic is difficult to study, but some findings have suggested that these plants are not *true* parasites. The definition of a parasite is an organism that takes advantage of another, while providing nothing in return, often causing harm to its host. Research suggests mycoheterotrophs may provide a service for their host: they may be able to transform or free up certain types of nutrients that the fungi cannot, or perhaps they have another effect entirely.

Two species of mycoheterotrophs were recorded in the understory monitoring plots: Pinesap (*Hypopitys monotropa*) and spring coralroot (*Corallorhiza wisteriana*). These were only observed in the unburned plots, which is consistent with the aforementioned knowledge that these species are indicative of late-seral forests.

Merckx, V.; Bidartondo, M. I.; & Hynson, N. A. (2009). Myco-heterotrophy: when fungi host plants. *Annals of Botany*. 104(7). 1255-1261. https://doi.org/10.1093/aob/mcp235