2017 Wildfire Season: An Overview

Southwestern U.S.

MAY 2018

NORTHERN ARIZONA UNIVERSITY | Ecological Restoration Institute

SOUTHWEST FIRE SCIENCE CONSORTIUM

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Intermountain West Frequent-fire Forest Restoration

Ecological restoration is a practice that seeks to heal degraded ecosystems by reestablishing native species, structural characteristics, and ecological processes. The Society for Ecological Restoration International defines ecological restoration as "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability….Restoration attempts to return an ecosystem to its historic trajectory" (Society for Ecological Restoration International Science & Policy Working Group 2004).

Most frequent-fire forests throughout the Intermountain West have been degraded during the last 150 years. Many of these forests are now dominated by unnaturally dense thickets of small trees, and lack their once diverse understory of grasses, sedges, and forbs. Forests in this condition are highly susceptible to damaging, stand-replacing fires and increased insect and disease epidemics. Restoration of these forests centers on reintroducing frequent, low-severity surface fires—often after thinning dense stands—and reestablishing productive understory plant communities.

The Ecological Restoration Institute at Northern Arizona University is a pioneer in researching, implementing, and monitoring ecological restoration of frequent-fire forests of the Intermountain West. By allowing natural processes, such as low-severity fire, to resume self-sustaining patterns, we hope to reestablish healthy forests that provide ecosystem services, wildlife habitat, and recreational opportunities.

The Southwest Fire Science Consortium (SWFSC) is a way for managers, scientists, and policy makers to interact and share science. SWFSC's goal is to see the best available science used to make management decisions and scientists working on the questions managers need answered. The SWFSC tries to bring together localized efforts to develop scientific information and to disseminate that to practitioners on the ground through an inclusive and open process.

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Cover photo: Division Alpha Lookout keeps an eye on the Boundary Fire. Photo courtesy of the USDA Forest Service, Coconino National Forest

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Introduction

Wildfire is part of the landscape in the Southwest. It can be a threat to lives and property, but it is also crucial to maintaining healthy ecosystems. Forests in the Southwest are adapted to fire and many trees can easily survive low-intensity fires burning along the forest floor. For example, ponderosa pine forests need regular, low-severity fires to remain healthy. Over decades without fire on the landscape, fuel loads accumulated and facilitated more intense, high-severity fire. Each fire is different, and while some burn in ways that increase ecosystem resilience, others burn with greater severity than forests are adapted to, killing even the toughest trees and threatening lives and homes.

This report is the fifth in a series of annual overviews available from the Southwest Fire Science Consortium and the Ecological Restoration Institute. The goal of this overview is to provide a concise summary of the fire season and to facilitate comparison with past fire years. It follows the format of past years' overviews[1] and describes the impacts of the 11 largest fires in Arizona and New Mexico in 2017 (all fires greater than 15,000 acres in the Southwest region). As in previous overviews, this report covers: when the fire burned, fire management costs, vegetation types, previous burn footprints, management objectives, and burn severity, where available. The conclusion section summarizes these same measures for the large wildfires in the region and touches on how these fires burned in proximity to human communities.

Wildfire Management

Weather, climate, vegetation type, fuel conditions, and topography all influence how an individual wildfire burns on the landscape and whether it has beneficial effects on the landscape. Some fires will leave many unburned patches, creating a mosaic burn pattern, whereas others will burn more contiguously. Managers can approach each wildfire with multiple objectives that range from managing the wildfire for public safety to managing the fire to improve natural resources. Federal wildland fire management policy states:

> "Response to wildland fires is based on ecological, social and legal consequences of the fire. The circumstances under which a fire occurs, and the likely consequences on firefighter and public safety and welfare, natural and cultural resources, and, values to be protected, dictate the appropriate response to the fire."[2]

A full range of wildland fire response strategies may be employed to meet these objectives, including containing, confining, or suppressing the wildfire. The National Incident Management Situation Report identifies the percentage of each fire managed with a monitor, confine, point protection, or suppression strategy. This report compiles these figures to better understand how fires were managed in 2017.

Wildland fire management strategies are based on a thoughtful and systematic, risk-based approach that considers firefighter and public safety, cause of the wildfire, location, existing land management plans, availability of resources, values at risk, and social factors. Federal policy dictates that "initial action on human-caused wildfire will be to suppress the fire."[3] The same federal policy allows naturally ignited (lightning) wildfires (or parts of wildfires) to be managed for resource benefits such as mitigating fuel loads to reduce the risk of high severity, enhancing wildlife habitat, improving watershed health, and reducing risk to neighboring communities. Though multiple strategies are used to manage wildfires, it is important to note that federal agencies only recognize two types of fires: prescribed fires and wildfire.

The 2017 Fire Season

In 2017, wildfire burned 609,509 acres (Figure 1), which is nearly 90,000 acres more than in 2016 and greater than the average for the previous 10 years (593,931 acres). New Mexico had less wildfire (196,837 acres) than the 10-year average while Arizona had more (412,672 acres). Both states had more prescribed fire than the 10-year average (94,457 acres in Arizona and 86,644 acres in New Mexico).

In 2017, wildfires over 100 acres represent 82 percent of the total acreage burned by wildfire. Of the 502,295 acres for which data is available, managers used full suppression strategies on 293,042 acres and other strategies on 209,253 acres. This is a greater number of acres and a higher percentage of acres managed with full suppression strategies than in 2016 (Figure 2). However, a greater number of acres were managed with strategies other than full suppression in 2017 than in 2015, 2014, or 2013.

This overview focuses on the 11 largest fires, which includes one New Mexico fire: Corral and 10 Arizona fires: Frye, Sawmill, Hilltop, Brooklyn, Goodwin, Burro, Hyde, Boundary, Snake Ridge, and Lizard (Figure 3). The 11 largest fires in this report represent 57 percent of the acres burned by wildfire in 2017 in the Southwest region. The fires appear in this report from largest to smallest.

Regional Context

The weak La Niña of 2016–2017 ended in February of 2017 when oceanic and atmospheric indicators of the El Niño-Southern Oscillation (ENSO) returned to neutral conditions. Temperatures were above normal throughout the year. February demonstrated how variable Southwest precipitation can be. Arizona had about average precipitation, while in New Mexico a few large areas received significantly more than average precipitation. March was warmer and drier than average (except for the northeastern corner of New Mexico). April and May had above average precipitation in New Mexico and below average in Arizona. June temperatures ranged from 0 to

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[1] *2016, 2015, 2014, a*nd *2013 Wildfire Season: An Overview, Southwestern U.S.* https://cdm17192.contentdm.oclc.org/digital/collection/p17192coll1/id/877/rec/3

[2] *Guidance for Implementation of Federal Wildland Fire Management Policy* www.nifc.gov/policies/policies_documents/GIFWFMP.pdf

[3] National Interagency Coordination Center Wildland Fire Annual Reports www.predictiveservices.nifc.gov/intelligence/intelligence.htm

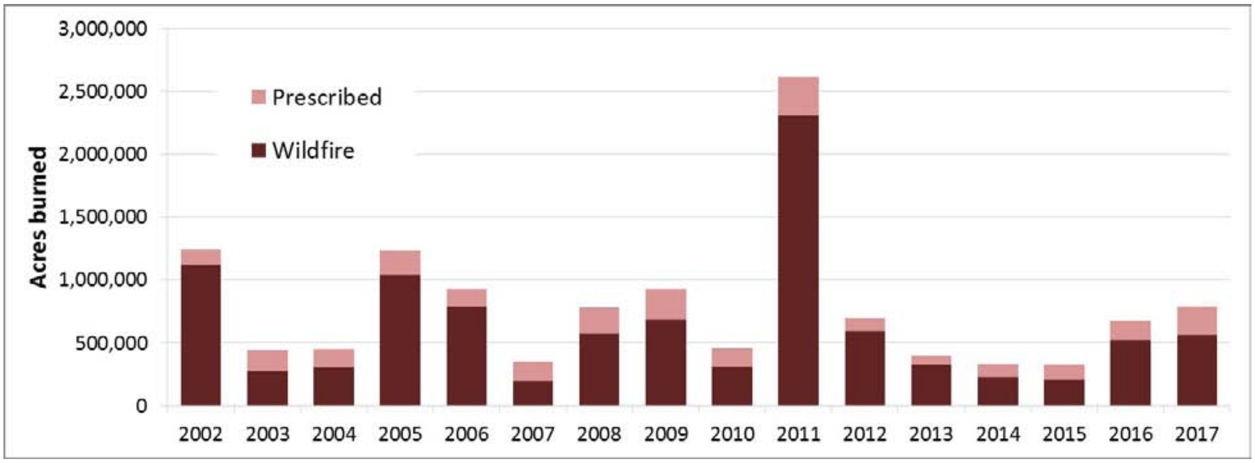

Figure 1. Wildfires and prescribed fires acres burned in Arizona and New Mexico, 2002 to 2017.[4]

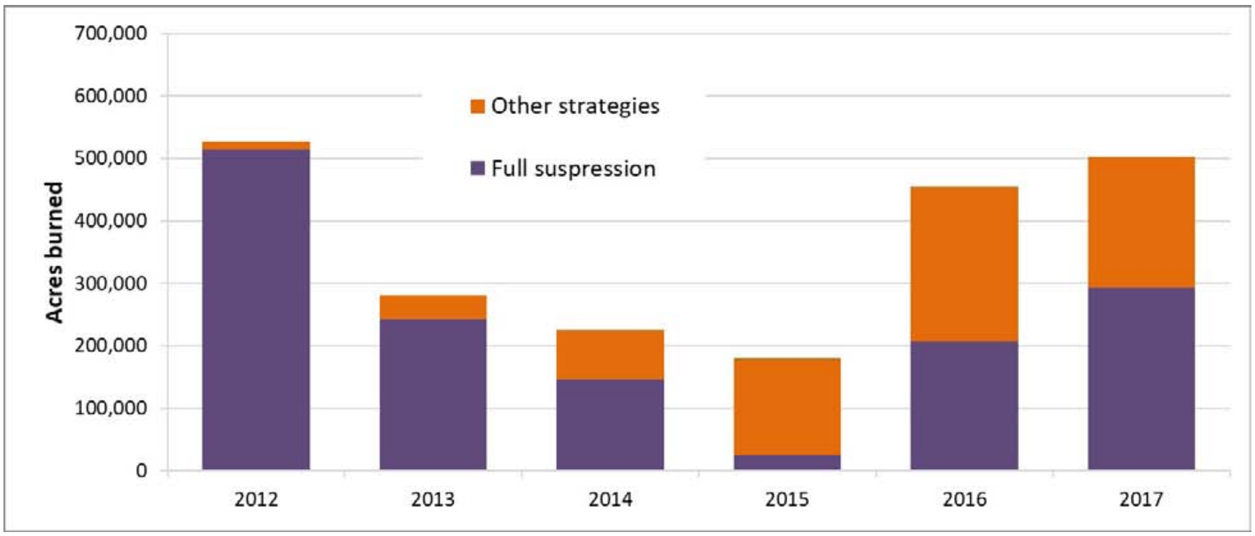

Figure 2. Acres burned by wildfires greater than 100 acres in Arizona and New Mexico, 2012 to 2017.[5]

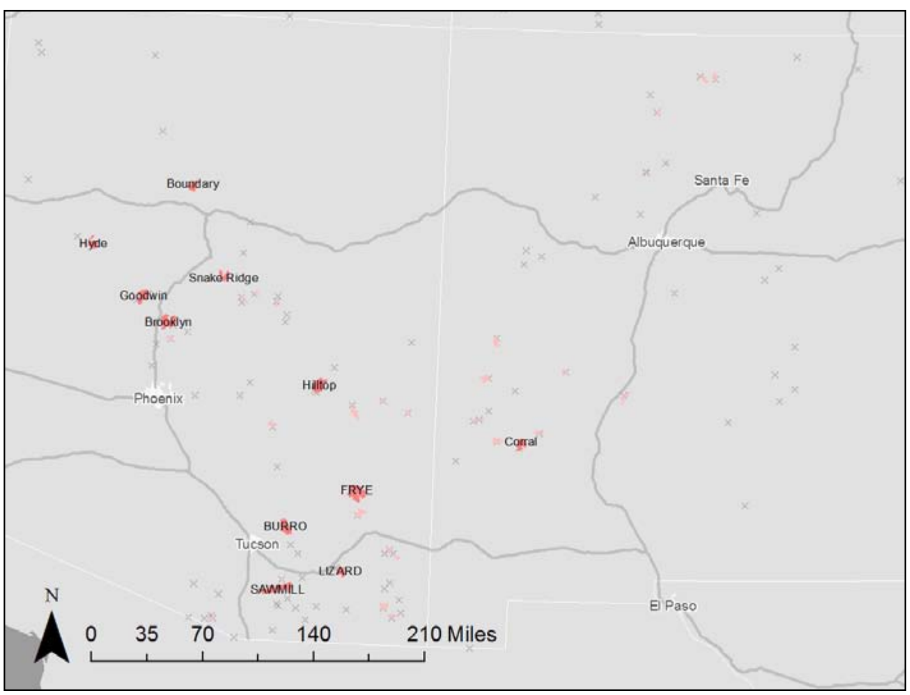

Figure 3. Map indicating the location of the 11 large fires in 2017 analyzed in this report.

[4] National Interagency Coordination Center Wildland Fire Annual Reports www.predictiveservices.nifc.gov/intelligence/intelligence.htm

[5] Southwest Coordinating Center ICS-209 Incidents https://gacc.nifc.gov/swcc/predictive/intelligence/Historical/Fire_Data/Historical_Fires_Acres.htm

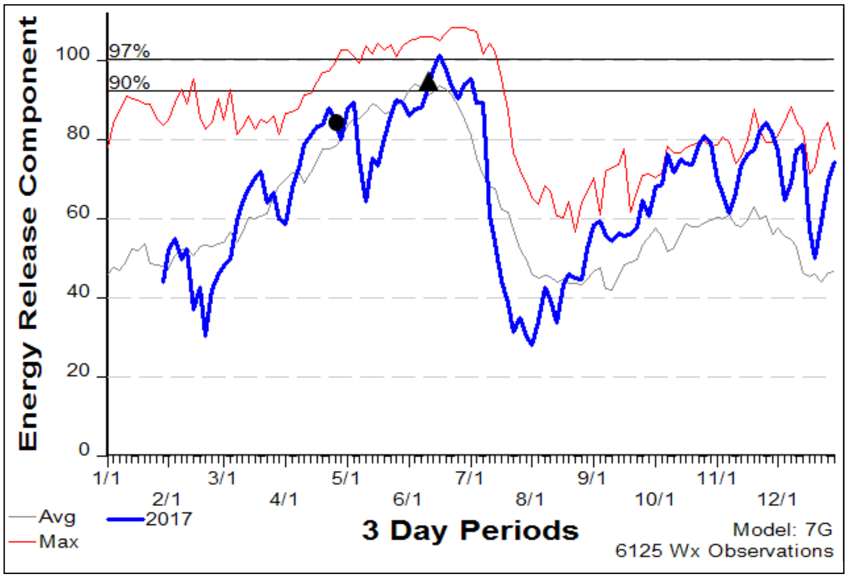

Figure 4. Energy release component (ERC) index for the 2017 fire season in the southeastern Arizona region. Note the elevated ERCs at the start of the Sawmill Fire (black circle) and around the time of the Frye Fire (black triangle).

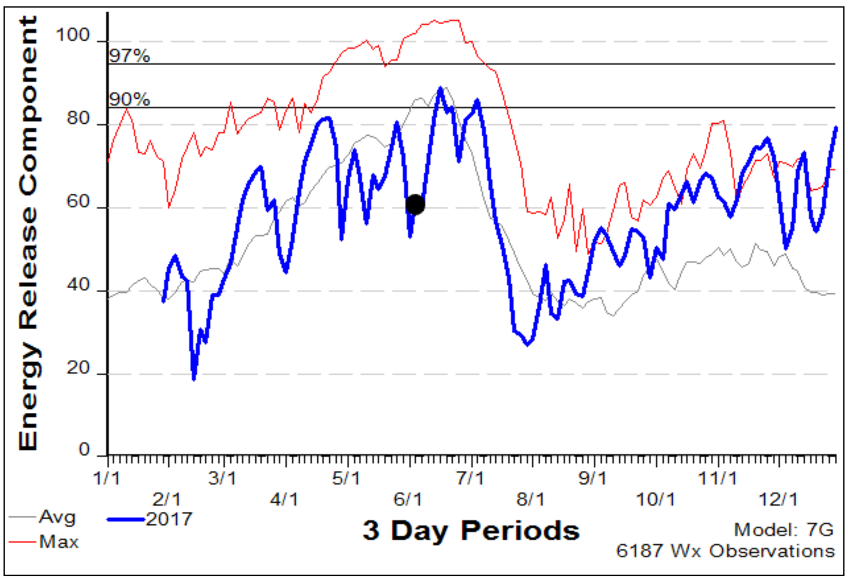

Figure 5. Energy release component (ERC) index for the 2017 fire season in the western New Mexico region. Note the low ERC values around the time of the Corral Fire started (black dot).

8 degrees Fahrenheit above normal across much of Arizona and New Mexico. By June, the 2017 precipitation totals were average or above average across much of the Southwest except southern Arizona which was below average. The monsoon came comparatively early and brought more consistent precipitation to New Mexico. The monsoon in Arizona started a little later than usual.

Weather drove at least part of the greater wildfire activity in Arizona compared to New Mexico in 2017. Arizona had below-average winter precipitation, above-average temperatures, and a later-than-average start to the monsoon. In contrast, New Mexico had average to above average spring precipitation and an early start to the monsoon season.

The Energy Release Component (ERC) is an index that estimates potential available energy released per unit area in the flaming front of a fire based on the fuel model and live and dead fuel moistures. The ERC is often used to track seasonal fire danger focused on fuel loading, woody fuel moistures, and larger fuel moistures (lighter fuels have less influence and wind speed has no influence on ERC). Graphs of ERCs for two regions show the 2017 fire season (blue line) in comparison to the 10-year average (gray line) and 10-year maximums (red line).[6] In much of the Southwest, ERCs stayed close to the 10-year average through most of the year and moved closer to the 10-year maximum in the fall (Figures 4 and 5).

Data Sources

Management, Objectives, and Cost

The InciWeb website (inciweb.nwcg.gov) provides background information on most large fires such as location and start date. InciWeb is an interagency information management system designed to provide the public with a single source of incident-related information. Because InciWeb only sporadically reports costs, Incident Status Summary (ICS-209) reports were collected to document suppression or management costs. These costs do not reflect any post-fire costs such as rehabilitation or soil stabilization. The cost data from each

[6] Graphs produced by Charles Maxwell and Jay Ellington, Predictive Services and Intelligence, Southwest Coordination Center. For more information see http://gacc.nifc.gov/swcc//predictive/fuels_fire-danger/nfdrs_charts/Areawide.htm

fire is collected in a final table at the end of the document. Incident Status Summaries also provide "strategic objectives," which briefly describe the desired outcome for the incident, high-level objectives, and in some cases strategic benefits. Though strategic objectives often change during a fire, review of the most common or persistent strategic objectives for each fire provides some insight into the overarching management goals.

Perimeters

Boundaries for each fire were taken from the Geospatial Multi-Agency Coordination (GeoMAC) archive of fire perimeter maps (rmgsc.cr.usgs.gov/outgoing/GeoMAC/). GeoMAC also provides perimeters of fires dating back to 2000, which provided a historic context for this year's fires.

Vegetation

Basic information about vegetation and topography of burned area was available from LANDFIRE (www.landfire.gov). LANDFIRE provides nationally consistent, scientifically based maps of existing vegetation as well as Vegetation Condition Class (VCC). Vegetation Condition Class was formerly referred to as Fire Regime Condition Class (FRCC). Vegetation Condition Class is a map of how existing vegetation has departed from an estimated natural or historic condition. In the Southwest, this departure is generally due to fire exclusion, past logging, and grazing and results in greater density of trees and less healthy conditions. Vegetation Condition Class is a useful metric because it integrates information on existing vegetation, historic vegetation, and fire regimes into one variable and has been used to help determine where to focus restoration efforts. The most current VCC maps (2012) were used in this report.

Soil Burn Severity

Soil burn severity maps provide Burned Area Emergency Response (BAER) teams a tool to quantify soil impacts and assess potential for post-fire erosion (https://fsapps.nwcg.gov/afm/baer/download.php). In the immediate aftermath of a fire, BAER teams perform an emergency assessment of post-fire soil conditions based on a combination of field observations and remote sensing change detection products derived from the differenced Normalized Burn Ratio (dNBR). The dNBR measures change in the ratio of near infrared reflected by healthy green vegetation to the shortwave infrared reflected by bare soil and rock. Most soil burn severity maps have four classes: high, moderate, low, and unburned; but some combine the last two categories into a "low/unchanged" category. The distribution of soil burn severity is included for those fires for which it is available both in the individual fire discussions as well as in final summary table.

Rapid Assessment of Vegetation Condition after Wildfire

Rapid Assessment of Vegetation Condition after Wildfire (RAVG) maps estimate canopy mortality (www.fs.fed.us/postfirevegcondition). The U.S. Forest Service (USFS) Remote Sensing Applications Center provides RAVG analysis as a first approximation of areas that may require reforestation treatments because of canopy killed by high-severity fire. RAVG maps are created for wildfires that burn greater than 1,000 acres of forested USFS land or for fires where it is requested. The maps are produced by measuring the change between a satellite image before and immediately after a wildfire using an algorithm called relative differenced Normalized Burn Ratio (RdNBR), which is sensitive to vegetation mortality resulting from the wildfire event. The RdNBR is derived directly from the dNBR but is more sensitive to vegetation mortality than the dNBR.

While soil burn severity maps and RAVG canopy mortality maps use similar satellite change detection methods, they measure fundamentally different forest attributes. In many areas, canopy mortality and soil burn severity patterns are similar. However, in some vegetation types, such as chaparral or grass, it is possible for a fire to cause complete canopy mortality with little effect on soils.

Wildland Urban Interface

Another geospatial dataset that helps put fires in context is the location and density of housing, often referred to as the wildland-urban interface, or WUI. The Silvis Lab at the University of Wisconsin developed a nationwide map of the WUI based on U.S. Census data (http://silvis.forest.wisc.edu/maps/wui/2010/download). The Silvis map uses fairly standard definitions of the two main WUI conditions: intermix (one or more structures per 40 acres) and interface (three or more structures per acre, with shared municipal services).

Caveats

There are important caveats for all the data used in this summary. First, the fire information presented here was taken from official sources between December 2017 and February 2018 and may not include updates or revisions. Second, the geospatial data used to generate the maps and tables is also based on the best available information, but these data have errors and uncertainties. For example, the remote sensing data used in all these datasets can include errors introduced during collection, processing, and interpretation.

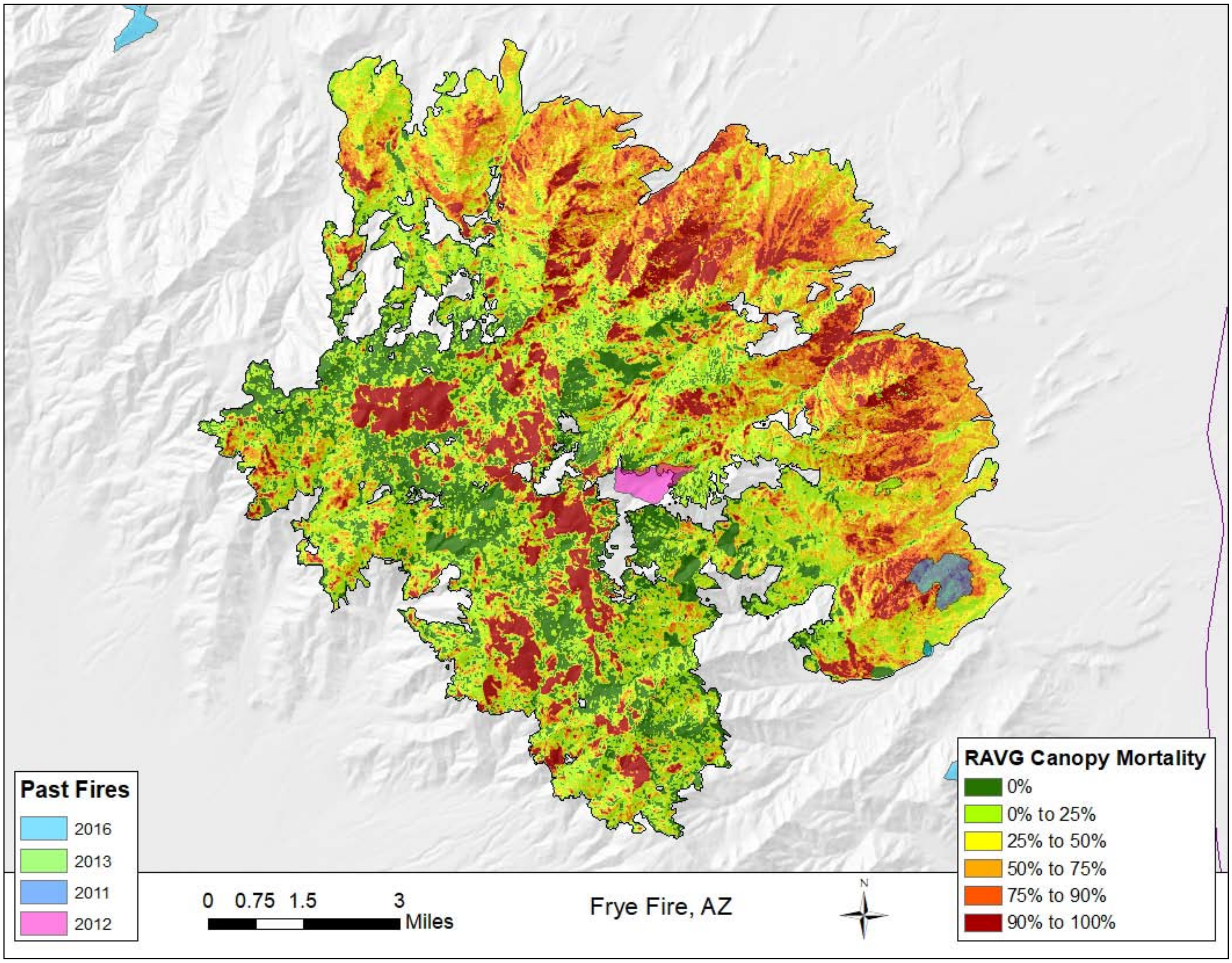

Figure 6. RAVG canopy mortality map for the Frye Fire.

Frye Fire, Arizona

Lightning ignited the Frye Fire on June 7 on Mount Graham near Safford, Arizona on the Coronado National Forest. The fire burned for 86 days covering nearly 50,000 acres. Managers working on the fire opted to use a combination of monitor (50 percent), point zone protection (30 percent), and full suppression (20 percent). No residences were affected by the Frye Fire, though some recreation areas were closed. The steep, rugged terrain, along with abundant snag hazards made firefighter access difficult and prohibitive in some areas. Responders were susceptible to heat illness due to excessive heat conditions and ground transportation of medical injuries required at least two-hours of travel time to a medical treatment facility. The vast majority of the 69-reported responder illness/injury incidents were generated from an onset of Streptococcus (strep throat) during the early days of the incident. The incident area contained historic and cultural resources and areas of tribal significance. Three minor structures were damaged or destroyed in the fire, including the Webb Peak Lookout Tower. Wildfire management cost $26 million, or about $536.71 per acre. The per-day cost of the Frye Fire was higher than any of the other fires in this review and it lasted 31 days longer than any other fire.

Vegetation and Past Fires

The Frye Fire burned through a wide range of vegetation types and a complex fuel arrangement from the lower slopes to the top of Mt. Graham in the Pinaleño Mountain Range. Elevations ranged from 4,000 to 10,000 feet. More than 15,000 acres (34 percent) were mixed conifer with piñon-juniper (17 percent), scrub (11 percent), and non-vegetated (10 percent) also making a significant amount of the area. Lower elevations transition from grass to brush to chaparral. Mid-elevation vegetation consisted of juniper, ponderosa pine, and pine/oak. Douglas-fir and spruce/fir populated the highest elevations of the mountain.

Only about one percent of the area burned by the Frye Fire had burned in the past 10 years, however, fuels in the Frye Fire included large diameter dead standing and down fuels from the 14-year-old Nuttall Fire scar. The Frye Fire perimeter contained the 2011 and 2013 Marijilda Fires, shared a small boundary with the 17-acre 2016 Noon Creek Fire, and completely encompassed the area burned by the 2012 Trap Peak fire, however only about a third of that 281-acre area reburned. Over half of the vegetation within the Frye Fire (62 percent) was not significantly different from historic conditions (i.e., low departure) according to the Vegetation Condition Class map.

Fire Severity

RAVG maps identified nearly 6,500 acres (13 percent) where the canopy had greater than 90 percent mortality. The portion of high canopy mortality by forest type was similar to the overall distribution of forest types within the fire with mixed conifer (40 percent) and piñon-juniper (18 percent) being the predominant vegetation types to lose more than 90 percent of the canopy. The soil burn severity maps showed 70 percent of the burn area in the low severity class and only 16 percent in the two highest severity classes (4 percent high, 12 percent moderate). The soil burn severity analysis showed a disproportionate (81 percent) amount of the highest severity class occurring in the mixed conifer community. Some of the differences between the RAVG and soil burn severity maps may be due to their different emphasis (i.e., canopy versus soil impacts). For example, almost none of the grass or scrub categories had high severity in the soil maps while the RAVG maps recorded over 1,000 acres of the highest severity in these vegetation types.

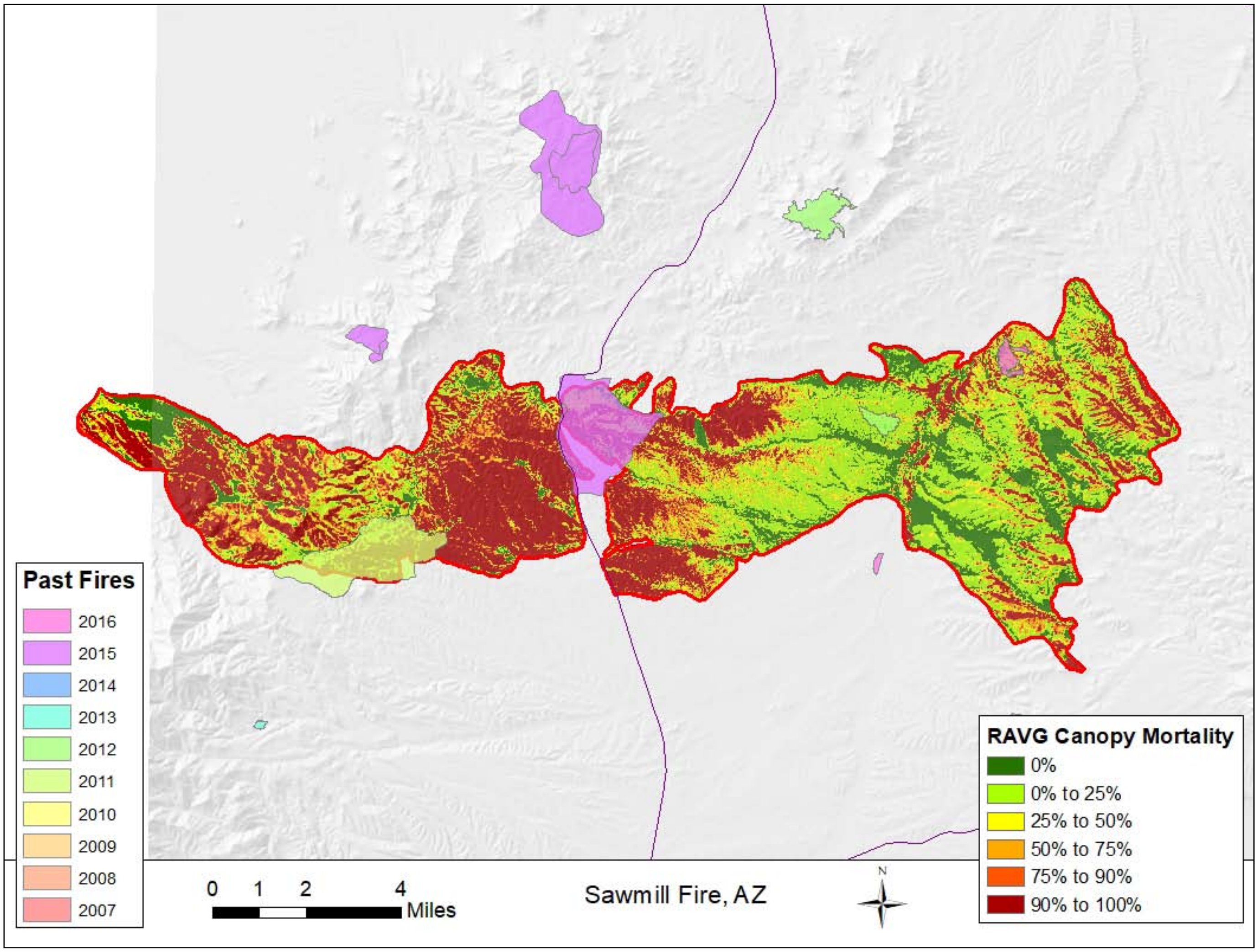

Figure 7. RAVG canopy mortality in the Sawmill Fire.

Sawmill Fire, Arizona

The Sawmill Fire is the second largest fire in this report, consuming 46,991 acres in just 11 days on lands under the jurisdiction of Arizona Department of Forestry and Fire Management, Bureau of Land Management, and the Coronado National Forest. This human-caused fire started on April 23 and burned through grass, chaparral, and oak brush 10 miles southeast of Green Valley, Arizona in Pima County. The reported cause was recreational shooting. Dry and windy conditions caused the Sawmill Fire to spread quickly. The high temperature was 98 degrees, relative humidity was between 4 and 18 percent, and wind gusts reached 30 mph. These conditions continued for much of the week.[7] A temporary area closure was issued for BLM public lands within Las Cienegas National Conservation Area and 412 citizens were evacuated from the Rain Valley area. Fire managers used direct attack tactics as part of a full suppression strategy on the wildfire. Suppression of the Sawmill Fire cost $8.2 million, or about $174.50 per acre.

Vegetation and Past Fires

The majority of the Sawmill Fire burned through grass (42 percent) and scrub (38 percent). Smaller areas of conifer-oak (10 percent) and piñon-juniper (4 percent) also burned. More than half of the vegetation within the Sawmill Fire (63 percent) had a moderate departure from historic conditions according to the Vegetation Condition Class map. The Sawmill Fire burned through an area that has seen several other fires in the last 10 years, which includes nearly all 1,800 acres affected by the 2010 Greaterville Fire. In the middle of the Sawmill Fire's hourglass shape was the 2015 Oak Tree Fire. Roughly two-thirds of this 2,000-acre fire reburned by the Sawmill Fire. The 2012 Empire and 2016 Hilton fires (148 and 163 acres) were completely within the Sawmill Fire perimeter. In total, approximately 3,000 acres reburned in the Sawmill Fire.

Fire Severity

Nearly 33 percent of the fire had greater than 90 percent mortality in the RAVG analysis. This was primarily concentrated in the western half of the burn area. The eastern half had much lower fire severity, and this is where most of the 19,500 acres (41 percent) were that experienced little to no canopy mortality (<25 percent). The highest mortality areas were generally in scrub and grass, which was consistent with the vegetation distribution of the entire fire area. Soil burn severity maps were not available for this fire.

[7] http://www.climas.arizona.edu/blog/climas-sw-climate-outlook-wildfire-report-sawmill-fire

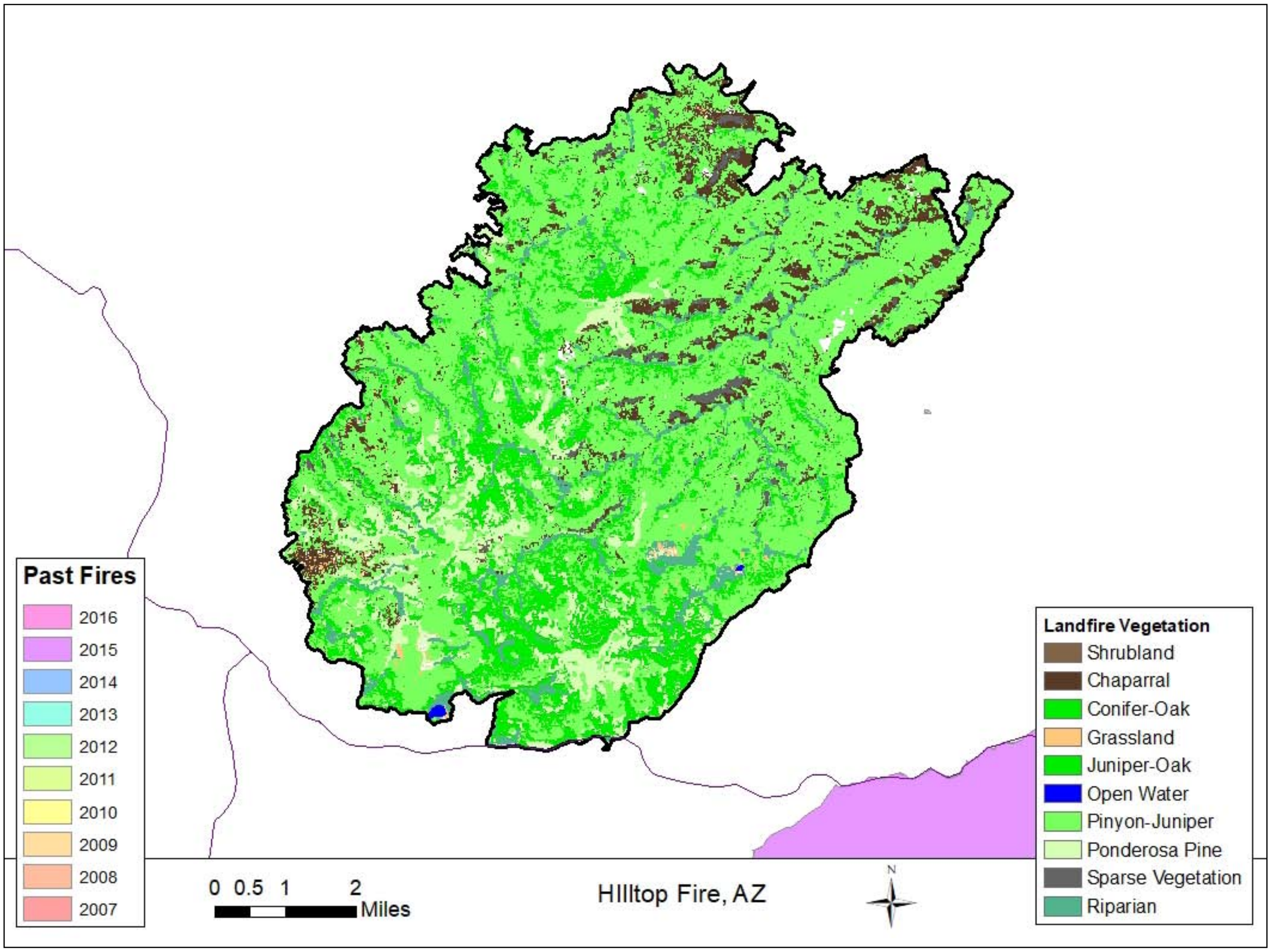

Figure 8. Vegetation in the Hilltop Fire perimeter.

Hilltop Fire, Arizona

The Hilltop Fire was a lightning-caused wildfire that burned 33,826 acres near Hilltop Lookout in Gila County, Arizona on the San Carlos Apache Nation. The fire burned from June 25 to August 18 but was declared controlled and put in monitor status by the incident command starting on July 19. A mixed suppression strategy of monitor (55 percent) and full suppression (45 percent) was used in this grass, scrub oak, juniper, and ponderosa pine area. Twelve civilians and 12 responders suffered injuries. Several monsoonal storms passed through the area bringing rain to the fire area but the potential for new starts remained high due to the high frequency of lightning in these storms. The management cost of the fire was $15 million, or about $443.45 per acre. Pre-evacuation were ordered for the Cedar Creek and Canyon Day communities, but evacuations were not required.

Vegetation and Past Fires

The Hilltop Fire mainly burned through piñon-juniper (58 percent) and conifer-oak (18 percent) forests but also affected small areas of ponderosa pine (9 percent), non-vegetated/developed (6 percent), riparian forest (5 percent), and chaparral (3 percent). Ninety-seven percent of the Hilltop Fire was identified as low departure from historic conditions according to the Vegetation Condition Class map. The area affected by the Hilltop Fire had not been burned in the last 10 years; however, the 33,000-acre Whitetail Fire burned roughly 2.5 miles south east of the Hilltop Fire in 2015.

Fire Severity

Fire severity information was not available for the Hilltop Fire.

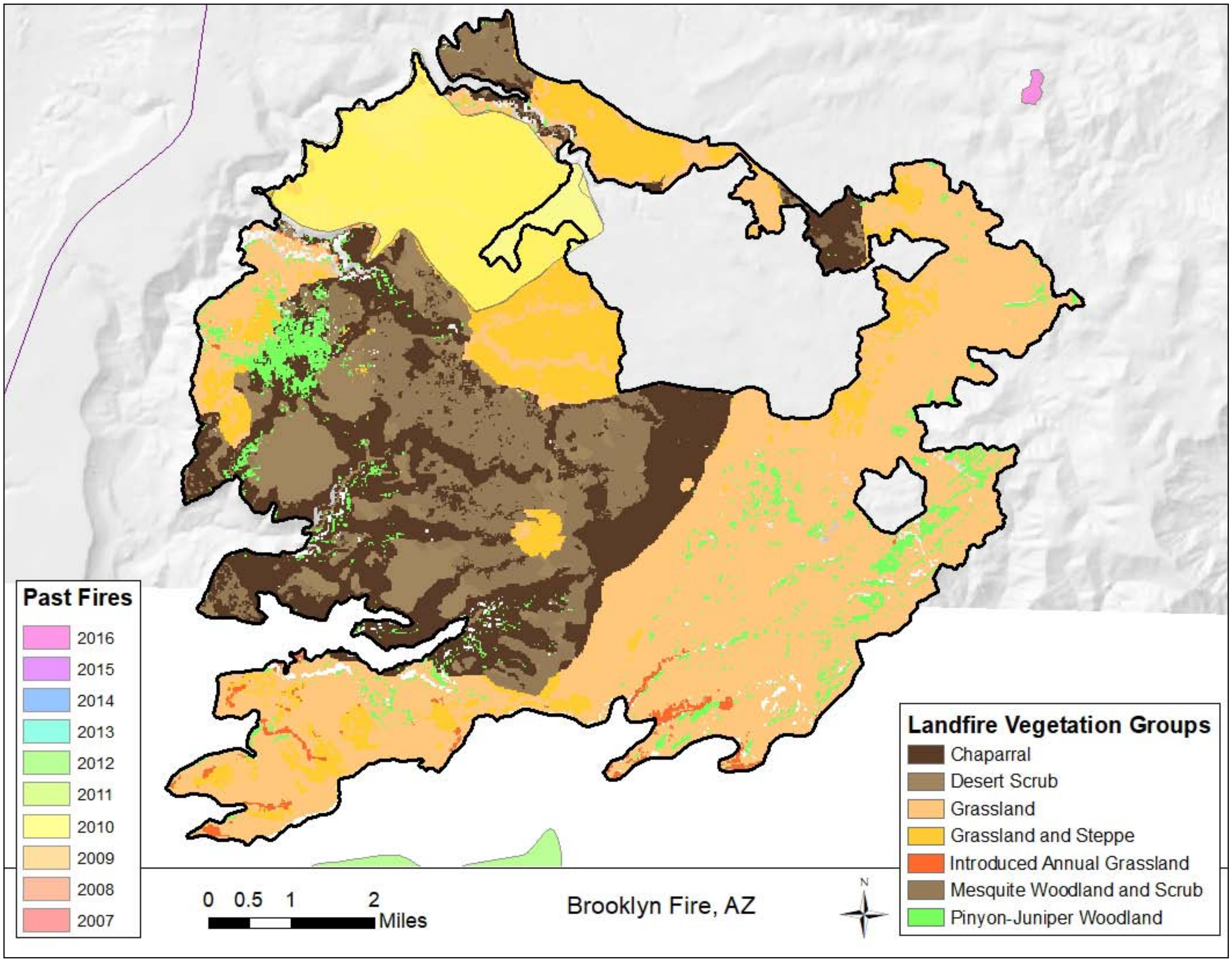

Figure 9. Vegetation in the Brooklyn Fire perimeter.

Brooklyn Fire, Arizona

The Brooklyn Fire burned for 20 days from July 7 to July 27 in Yavapai County, Arizona on the Tonto National Forest and the Agua Fria National Monument. This 33,550-acre fire was started by lightning and managers responded with a full suppression strategy. Control efforts in this grass, shrub, and juniper fuel area were aided by direct rain. No civilians were evacuated, or structures threatened, although Arizona Public Service and Western Area Power Administration (WAPA) power transmission lines, occupied range allotments, and private land in-holdings lead to the decision to use a full suppression approach in this remote, steep, and inaccessible terrain. During the second day of the fire, strong gusty winds from thunderstorms pushed it in multiple directions and made suppression difficult. Suppression cost $1.4 million, or $41.73 per acre.

Vegetation and Past Fires

The Brooklyn Fire burned primarily through grass (58 percent), scrub (18 percent), and chaparral (17 percent), with about 1,500 acres of piñon-juniper (5 percent) and not much else. Nearly all 3,600 acres that burned in the 2010 Bloody Fire were reburned in the 2017 Brooklyn Fire. The area that reburned was nearly entirely grassland. Eighty-six percent of the Brooklyn Fire was identified as low departure from historic conditions according to the Vegetation Condition Class map.

Fire Severity

The Soil Burn Severity data for the Brooklyn Fire indicated that all but 141 acres were either low severity (90 percent) or unburned/undetected (9 percent).

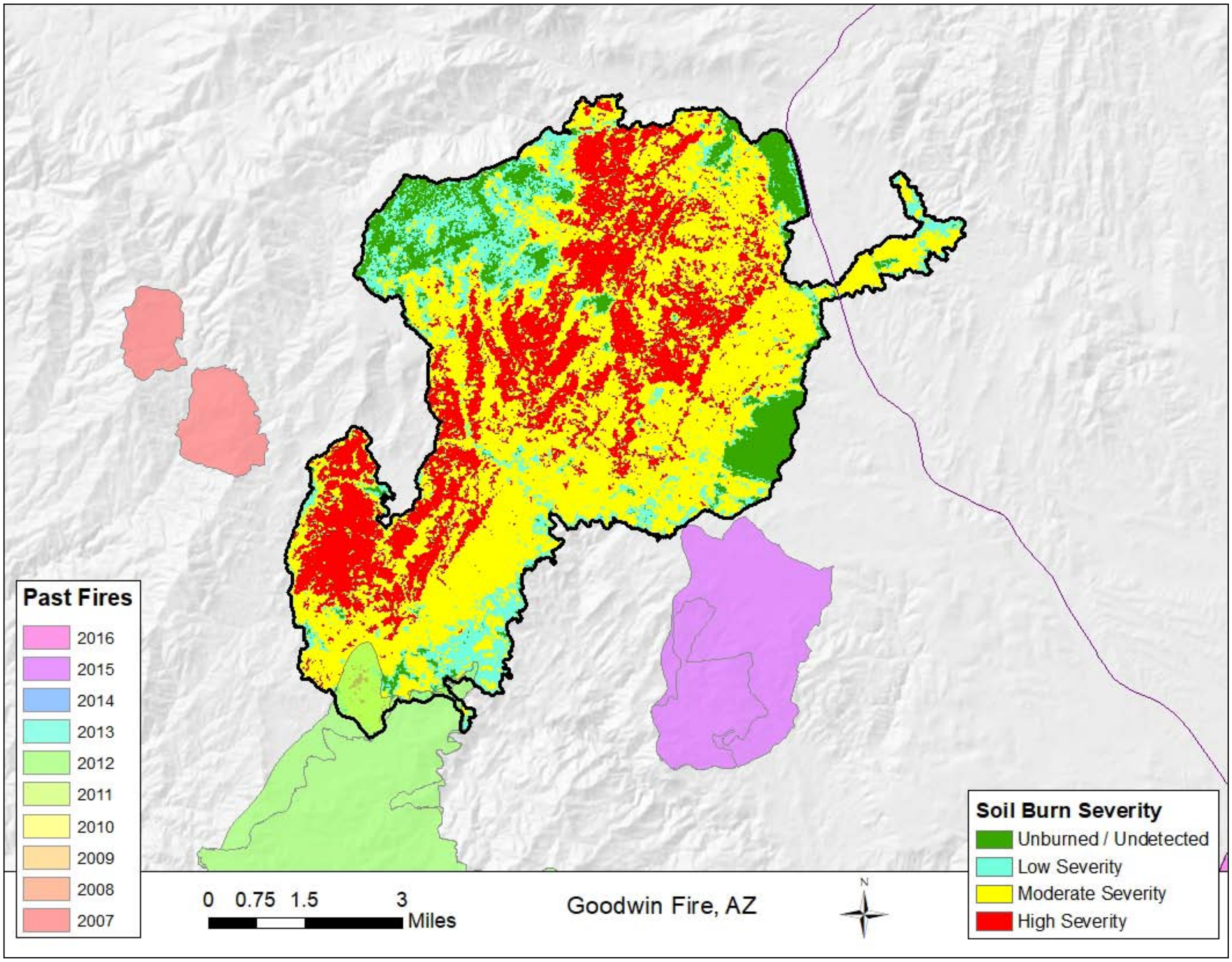

Figure 10. Soil burn severity map for the Goodwin Fire.

Goodwin Fire, Arizona

The Goodwin Fire burned 28,516 acres of dense chaparral and ponderosa pine in 16 days between June 24 and July 10 on the Prescott National Forest. The cause of this Yavapai County fire was not determined. Managers used a full suppression strategy because the fire threatened 1,400 residences and necessitated the evacuation of 9,000 citizens. Ultimately 17 residences were damaged or destroyed along with 19 minor structures. Strategic objectives were to protect and minimize threats to infrastructure, developed recreational sites, cultural resources, threatened and endangered species habitats, and structural range improvements. The wildfire cost $15 million to manage, or $526.02 per acre.

An unofficial drone flown over the burn area caused the grounding of firefighting air craft on the fifth day of the fire. Grounding of aircraft was significant because of the important role they played on this fire. Three Very Large Air Tankers (VLATs), heavy air tankers, and helicopters worked to reduce fire intensity around endangered structures.

Vegetation and Past Fires

The Goodwin Fire burned 2,400 acres of ponderosa pine (8 percent) but was primarily in chaparral (60 percent) and piñon-juniper (15 percent). The Goodwin Fire reburned 45 acres of the 2012 Gladiator Fire. It also shared a small boundary with the 2015 SA Hill Fire. Most of the Goodwin Fire was identified as close to historic conditions (93 percent) in the Vegetation Condition Class Map.

Fire Severity

RAVG maps identified nearly 16,000 acres (56 percent) where the canopy had greater than 90 percent mortality. The proportion of high canopy mortality by forest type was similar to the overall distribution of forest types in the fire: chaparral (64 percent), piñon-juniper (20 percent) ponderosa pine (4 percent), and scrub (4 percent). The soil burn severity maps showed 74 percent of the burn area in the two highest severity classes (24 percent high, 50 percent moderate) and only 11 percent in the unchanged category. The distribution of forest types within the high soil burn severity analysis was similar to the RAVG maps.

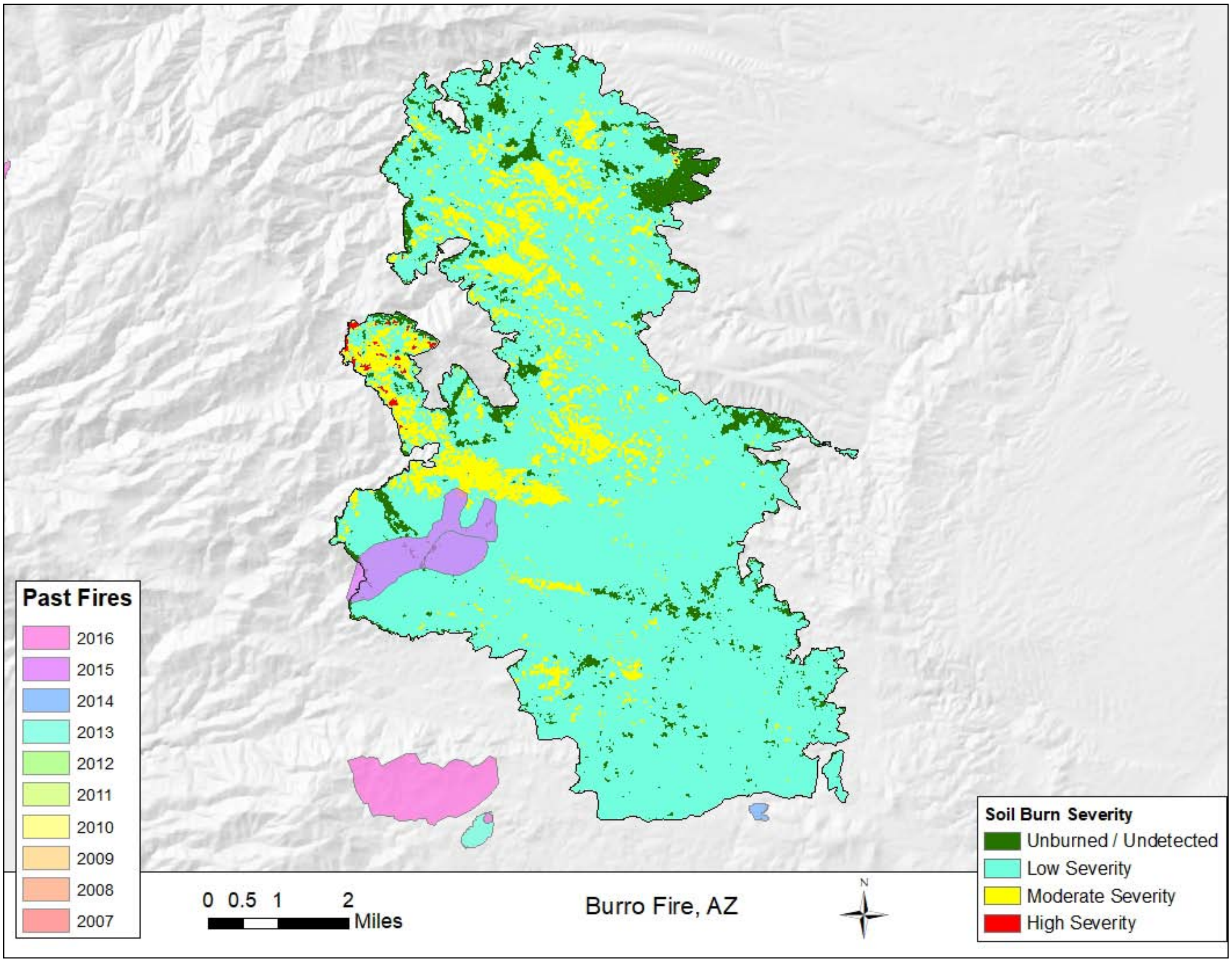

Figure 11. Soil burn severity map for the Burro Fire.

Burro Fire, Arizona

The Burro Fire started by an unknown cause on June 30 eight miles northeast of Tucson, Arizona on Coronado National Forest, state, and private lands. Fire managers chose to evacuate 350 citizens along the Catalina highway and use a 100 percent monitor approach to the Burro Fire. Operational challenges included the remote location, lack of road access to the majority of the fire, extreme weather conditions, and elevated public concerns due to proximity of communities. The strategic approach was to protect public, commercial, and recreational sites along the Catalina Highway and the communities of Summerhaven and Willow Creek until the arrival of a fire-season-ending rain event. Planning utilized the onset of monsoons and on July 9, rain fell on approximately 80 percent of the fire. Lighting from the storms also ignited spot fires, which crews suppressed. The wildfire was fully contained after burning 27,238 acres in 18 days. Management of the wildfire cost $8.95 million, or $328.59 per acre.

Vegetation and Past Fires

The Burro Fire burned through a relatively balanced distribution of conifer-oak (28 percent), grass (28 percent), scrub (22 percent), and piñon-juniper (19 percent) communities with a small amount of riparian forest (2 percent). The Burro Fire perimeter contained nearly all of the 785-acre 2015 Woods Tanker Fire. The remaining 26,500 acres had not burned in the previous 10 years.

Fire Severity

Fire severity was generally low in the Burro Fire. RAVG maps identified only 658 acres (2 percent) where the canopy had greater than 90 percent mortality. About half of these acres were in the conifer-oak community. Eighty-eight percent of the burn area caused less than 25 percent canopy mortality. The soil burn severity maps showed a similar result with nearly 24,000 (88 percent) in the lowest two severity classes. The soil burn severity maps only identified 46 acres as high severity and all of these were in a western lobe of the fire.

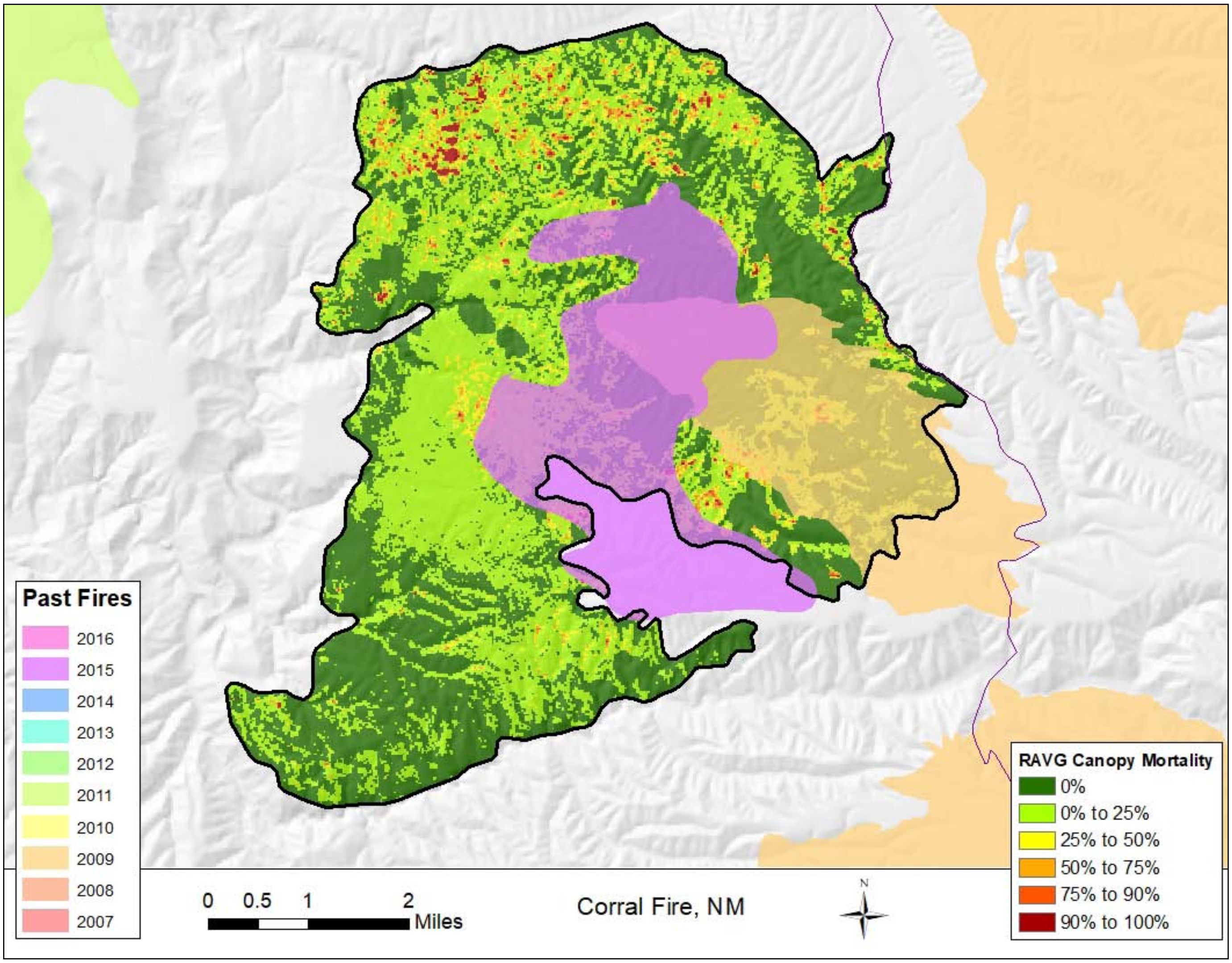

Figure 12. RAVG canopy mortality for the Corral Fire.

Corral Fire, New Mexico

The Corral Fire was the only fire more than 15,000 acres in New Mexico and therefore the only one highlighted in this report. This fire started with a lightning strike on June 4 and covered 20,350 acres in Grant County before it was considered 100 percent contained 39 days later. This low-intensity fire on the Gila National Forest was managed with a monitoring approach as it worked through grass and juniper on the ridge tops with ponderosa pine in the drainage bottoms. The strategic objective of this fire was to allow the fire to play its natural role in a fire-adapted ecosystem. The cost to manage the fire was $750,000, or about $36.86 per acre.

Vegetation and Past Fires

The Corral Fire primarily burned through piñon-juniper (47 percent) and ponderosa pine (29 percent) with conifer-oak (8 percent) and grass (7 percent) also making up significant acreage. The two largest fires to affect the Corral Fire area in the last 10 years were the 2009 and 2015 Moore Fires, both were approximately 4,000 acres. One 800-acre area in the center of the Corral Fire was burned by all three fires. The unburned notch in the south western edge of the Corral Fire was likely associated with the 2015 Moore Fire perimeter. Most of the Corral Fire was identified as close to historic conditions (85 percent) in the Vegetation Condition Class map.

Fire Severity

Fire severity was generally low in the Corral Fire. RAVG maps identified less than 250 acres (1 percent) where the canopy had greater than 75 percent mortality. Similar, to the burn area as a whole, these limited acres of high severity were predominantly in piñon-juniper and ponderosa pine communities. The soil burn severity data also showed a relatively low-severity fire with zero acres designated as high severity and only 311 (2 percent) identified as moderate severity.

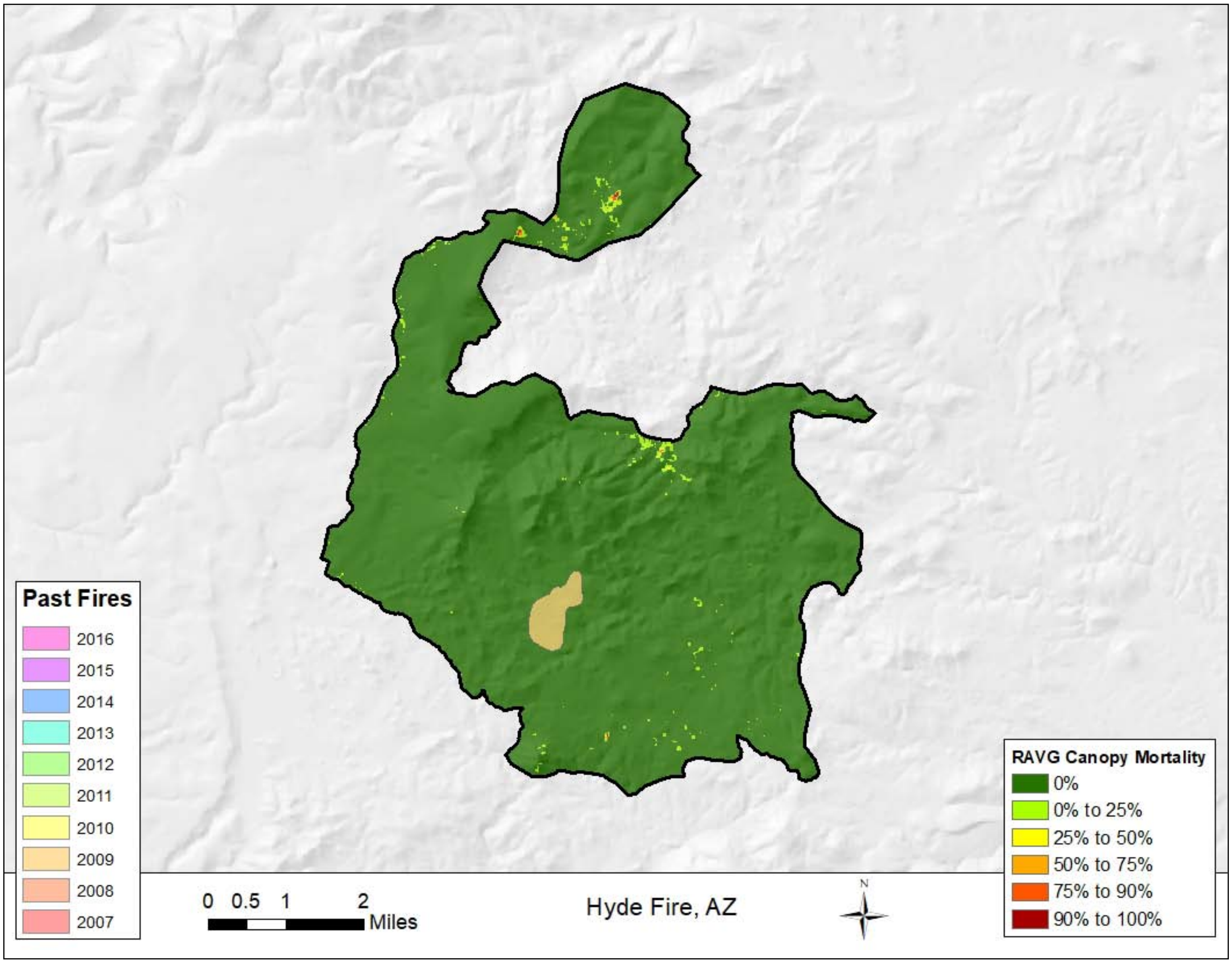

Figure 13. RAVG canopy mortality map for the Hyde Fire.

Hyde Fire, Arizona

A lightning strike started the Hyde Fire on July 11 in the Prescott National Forest near Williamson Valley, Arizona. After 30 days, it encompassed 18,072 acres. A monitoring strategy was used to approach this fire allowing management for multiple resource objectives. This decision was made in part because the Hyde Fire burned in a remote area and started at a time when intermittent rains are more common. Other fires that were treated with a more aggressive approach started earlier in summer and burned during the hottest and driest periods of the year or were immediately adjacent to communities. There were no evacuations or structures affected by the fire. The cost for managing the Hyde Fire was $500,000, or about $27.67 per acre.

Vegetation and Past Fires

The Hyde Fire mainly burned through piñon-juniper (58 percent), ponderosa pine (19 percent), and conifer-oak (10 percent) forests but also affected small areas of chaparral, grass, riparian forest, and scrub. Eighty-eight percent of the Hyde Fire was mapped as low departure from historic conditions. The only fire to burn this area in the last 10 years was a 235-acre fire in 2009 also named Hyde.

Fire Severity

More than 99 percent of the 18,000-acre fire exhibited little to no canopy mortality. Only 23 acres had more than 25 percent canopy mortality in the RAVG map. Those acres were almost all in the piñon-juniper community. Soil burn severity maps were not available for this fire.

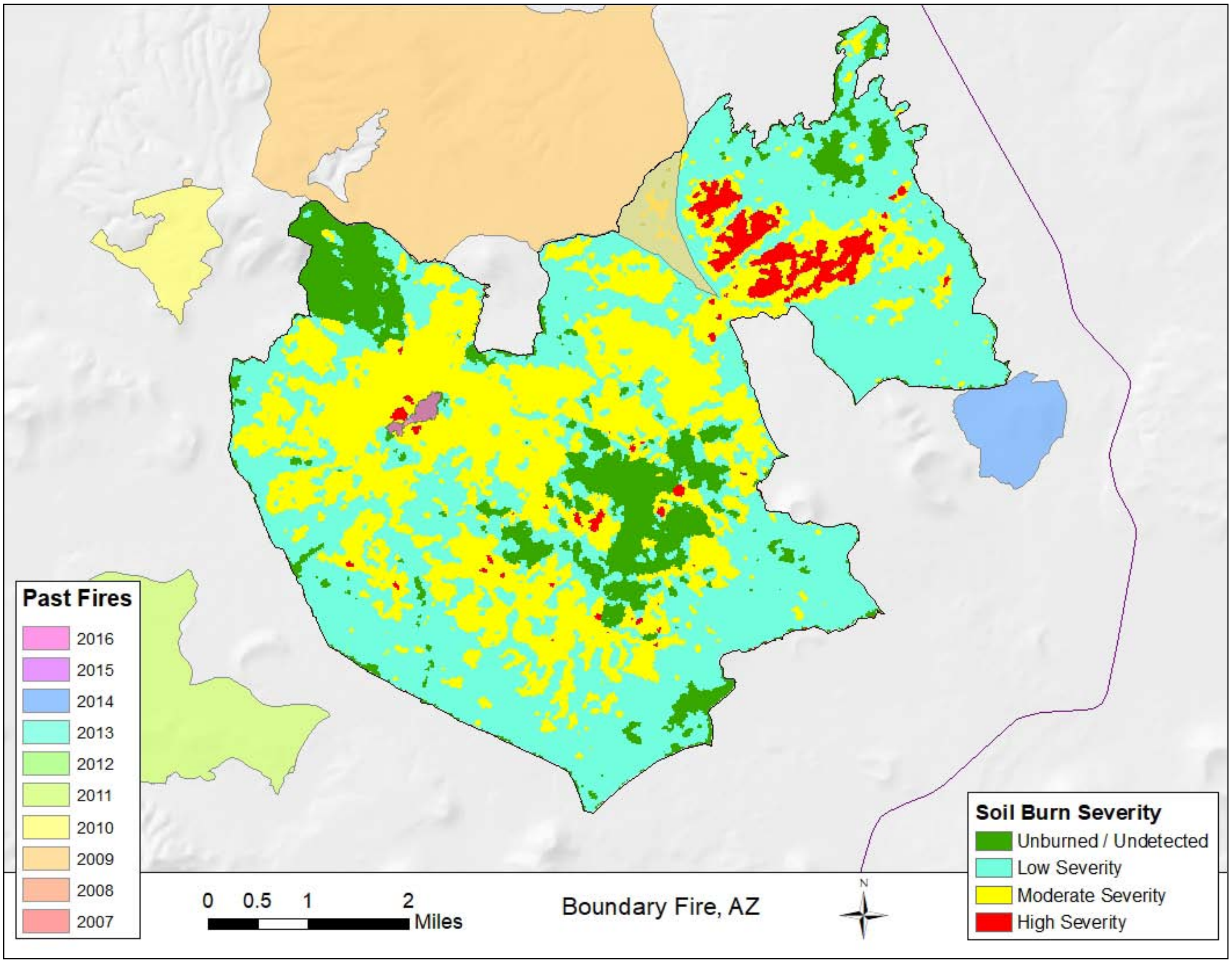

Figure 14. Soil burn severity map of the Boundary Fire.

Boundary Fire, Arizona

The Boundary Fire burned for 32 days, from June 1 to July 3, and covered 17,788 acres in Coconino County, Arizona on the Kaibab and Coconino national forests. This fire was caused by a lightning strike and was managed with a combination of monitor (5 percent), confine (35 percent), point zone protection (25 percent) and suppression (35 percent) strategies. The Boundary Fire was partially within the Kendrick Mountain Wilderness, which features steep, rugged terrain and presented considerable firefighter safety concerns due to topography, fuels, and the potential for rapid fire growth. Primary fuels included: timber (litter and understory), short grass (1 foot), and heavy logging slash. Some areas featured heavy dead and down debris from the Pumpkin Fire in 2000.

The described strategy was to utilize a values-driven approach that incorporated a mix of tactics (point protection, direct and indirect) when and where the probability of success was high and the risk is acceptable in relationship to the values. The planned end-state was that the fire burned in ponderosa pine, dry mixed-conifer, aspen and pinyon-juniper with mixed severity, including areas of moderate to high severity. The goal was to protect private land and infrastructure from fire and post-fire impacts. Noted considerations included 1) lower average fuel loading in the Kendrick Mountain area; 2) maintain habitat for the Mexican spotted owl, peregrine falcon, and other wildlife; and 3) minimize impacts on private property, cultural and historic resources, wilderness character, aspen enclosures, and livestock forage. Managers used aerial ignitions to protect values at risk and increase the amount of backing fire.

No structures were damaged during the Boundary Fire; however, 13 civilians were evacuated, four of which had injuries. The cost for managing the Boundary Fire was $9.4 million, or about $528.45 per acre. Two reasons the Boundary Fire may have had a high per-acre cost were its long duration (32 days) and aerial ignitions.

Vegetation and Past Fires

The most common vegetation type within the Boundary Fire footprint was ponderosa pine (56 percent), with mixed conifer (26 percent) also accounting for a significant portion of the area. Based on the Vegetation Condition Class map, nearly two-thirds (65 percent) of the vegetation within the Boundary Fire was significantly different from historic conditions (i.e., high departure). The Boundary Fire shared two boundaries with the 2009 Wildhorse Complex Fire equaling roughly three total miles. The fire expanded past the Wildhorse Complex Fire perimeter on the longer of the two shared boundaries and lead to about 315 acres reburning. The Boundary Fire also shared a half-mile border with the 2015 Kendrick Fire on the east. Despite the roughly 3.5 miles of shared boundaries, only about 2 percent of the Boundary Fire had been burned in the last 10 years.

Fire Severity

The soil burn severity maps showed only 3 percent of the burn area in the highest severity class. Sixty-three percent of the area was in low (51 percent) or unchanged (12 percent) category. The RAVG data indicated even lower fire severity with more than 75 percent of the burn area having less than 25 percent canopy mortality. According to the RAVG data, around 1,500 acres (8 percent) showed greater than 90 percent canopy mortality. Ponderosa pine was the dominant vegetation type (56 percent) in the Boundary Fire but it made up a disproportionate amount of the highest canopy mortality (84 percent).

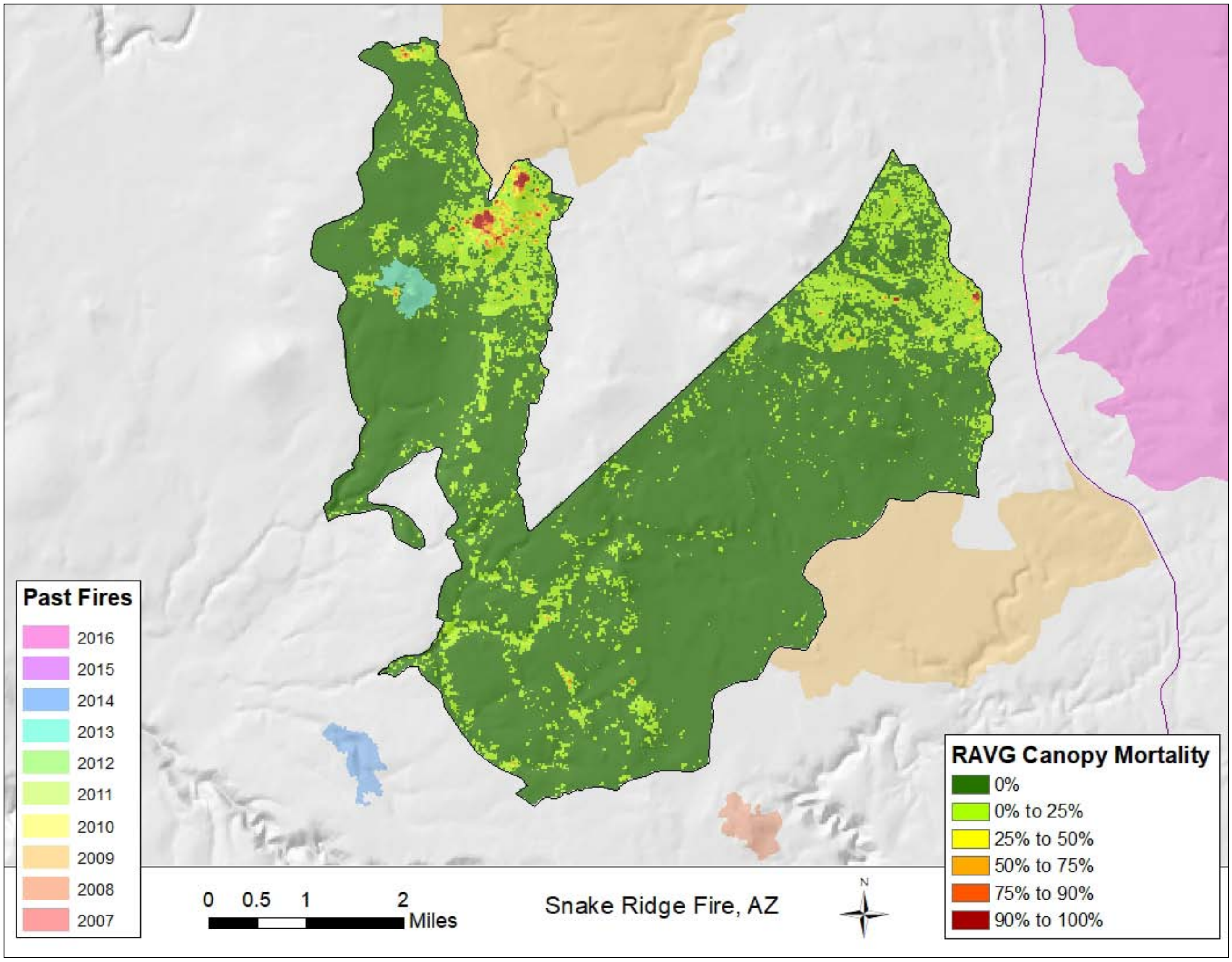

Figure 15. RAVG canopy mortality in the Snake Ridge Fire.

Snake Ridge Fire, Arizona

Lightning started the Snake Ridge Fire on May 19 and it continued to burn until July 13. During those 55 days, it burned 15,333 acres on the Coconino National Forest. This fire was managed with a combination of monitor (25 percent), confine (25 percent), point zone protection (25 percent) and full suppression (25 percent) strategies. After preparing a perimeter to contain the wildfire, managers used ignitions to secure the perimeter, reduce long-term smoke impacts, and minimize adverse fire effects to Western Area Power Administration power lines, critical wildlife habitat, and soil, watershed, and cultural resources. The overarching strategic objective from ICS-209 was to use fire to reduce fuel accumulations, reduce future risks, reintroduce fire back into the planning area, and improve ecosystem health. Managers worked to keep wildfire out of timber sales and private property while also minimizing smoke impacts to highways and residence in Verde Valley. The management cost of the wildfire was $1 million, or $65.22 per acre.

Vegetation and Past Fires

The Snake Ridge Fire burned through an area that was 86 percent ponderosa pine. Riparian forest (7 percent) and grassland (3 percent) were the only other vegetation types accounting for more than 250 acres. Based on the Vegetation Condition Class map, most of the vegetation within the Snake Ridge Fire (78 percent) was significantly different from historic conditions (i.e., high departure). The Snake Ridge Fire shared boundaries with two 2009 fires. It shared a 3.4-mile perimeter with the 4,000-acre Brady Fire and a 2.2-mile perimeter with the 3,000-acre Bow Fire. Despite the lengthy shared perimeters, less than 1 percent of the Snake Ridge Fire had been burned in the last 10 years. The Snake Ridge Fire contained all of the 100-acre 2013 Wild Horse Fire.

Fire Severity

Fire severity was generally very low in the Snake Ridge Fire. RAVG maps identified less than 250 acres (2 percent) where the canopy had greater than 25 percent mortality. Nearly all this canopy mortality was in ponderosa pine communities in the northern lobe of the fire. Eighty-three percent of the area showed no canopy mortality. Soil burn severity data was not available for this fire.

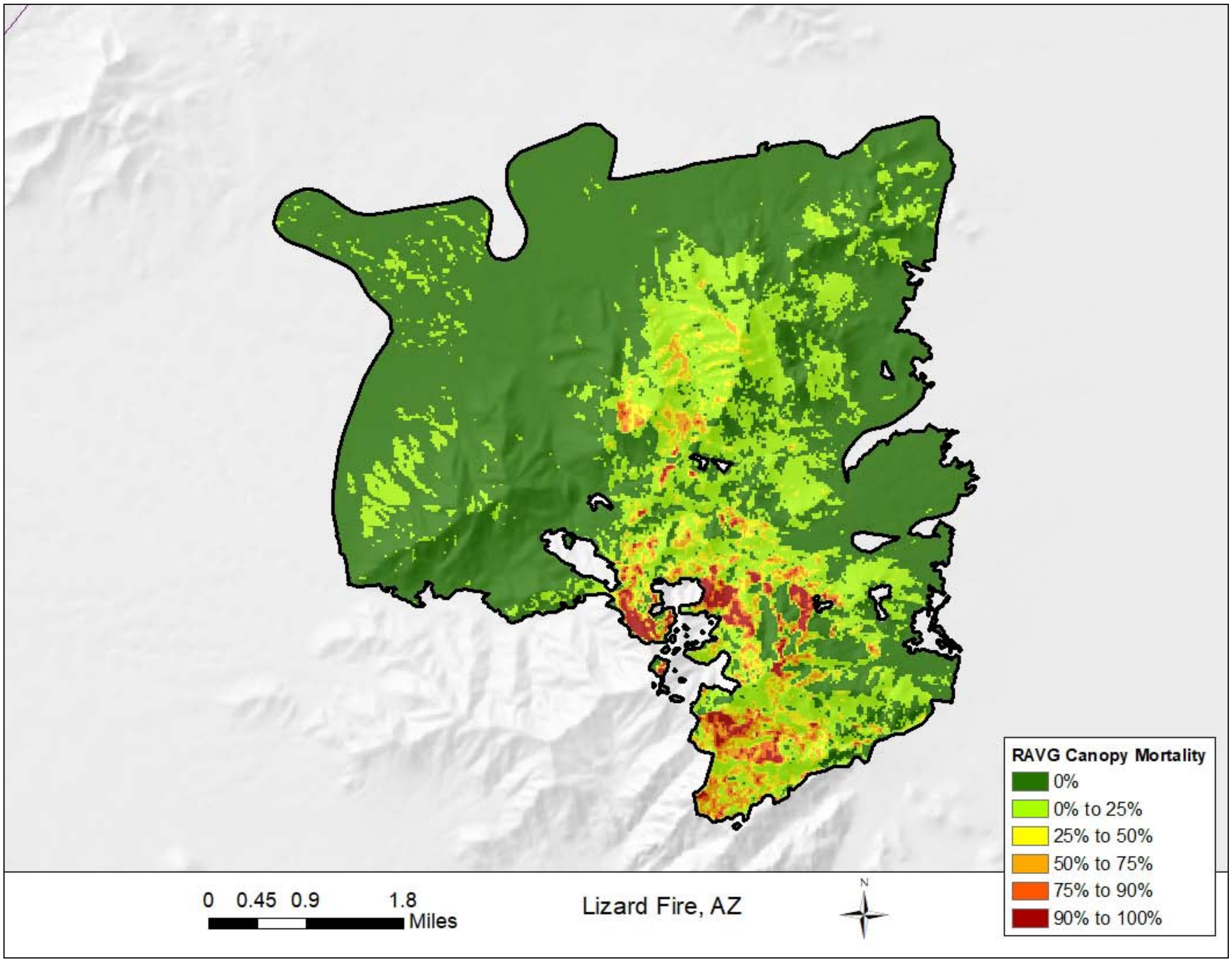

Figure 16. Canopy mortality map for the Lizard Fire.

Lizard Fire, Arizona

The Lizard Fire was reported on June 7 near Dragoon, Arizona. This fire predominantly burned through short grass and brush on the Coronado National Forest. This area features rough terrain on the south and limited access on the west side. Fifty citizens were evacuated as the fire burned north and west toward homes, and fire managers responded with a full suppression strategy. The wildfire burned for 15 days and covered 15,230 acres. The wildfire cost $5.876 million to manage, or about $385.82 per acre.

Vegetation and Past Fires

The area burned by the Lizard Fire had not been burned by any other fires in the previous 10 years. The majority of the Lizard Fire was scrub (26 percent), conifer oak (26 percent), grass (22 percent), or piñon-juniper (15 percent) with portions of chaparral (5 percent). Roughly half (47 percent) of the Lizard Fire showed low departure from historic vegetation and most of the rest (49 percent) was classified as moderate departure.

Fire Severity

The RAVG maps indicate that nearly 91 percent of the fire burned with little impact on the overstory canopy (less than 25 percent mortality). Canopy damage was most significant in the southern and central portion of the Lizard Fire, with approximately 200 acres having greater than 90 percent canopy mortality. Soil burn severity maps were not available for this fire.

Conclusion

This report covers the 11 largest wildfires of 2017 and half of the acreage burned in the Southwest. Piñon-juniper was the most commonly burned vegetation type and made up 21 percent of the area analyzed in this report (Figure 17). Fewer acres of ponderosa pine burned in the largest wildfires of 2017, while more acres of chaparral, scrub, and grassland burn burned in 2017 compared to the largest wildfires of the previous four years.

Soil burn severity maps analyzed in this report account for only 28 percent of the total acres burned in 2017 (56 percent of the 11 largest fires). For the six fires in this report with soil burn severity maps, 77 percent of the the acres burned with low or very low soil burn severity (Figure 18). Roughly 10,000 acres (6 percent) of this area experienced high soil burn severity. More than 70 percent of the high soil burn severity acres in this report were from the Goodwin Fire.

RAVG maps were available for nine fires in this analysis and show the majority (63 percent) of acres analyzed were less than 25 percent canopy mortality (Figure 19). Seventeen percent of the area analyzed burned with greater than 90 percent canopy mortality. The Goodwin and Sawmill fires account for 78 percent of the highest canopy mortality areas. It is worth noting that these two fires mainly burned in low-stature vegetation (grass, scrub, chaparral), so canopy mortality is likely less ecologically significant.

Only 13 percent of the area in this analysis was highly departed from historic conditions based on the LANDFIRE vegetation condition class maps (Figure 20). It is reasonable to assume that the high proportions of wildfires burning with low severity and the high portion of the area burned close to the historic condition are related. The Boundary and Snake Ridge fires make up 57 percent of the area burned that was highly departed from historic conditions. The Sawmill Fire had the third most highly departed acres and featured more than 15,500 acres with greater than 90 percent canopy mortality.

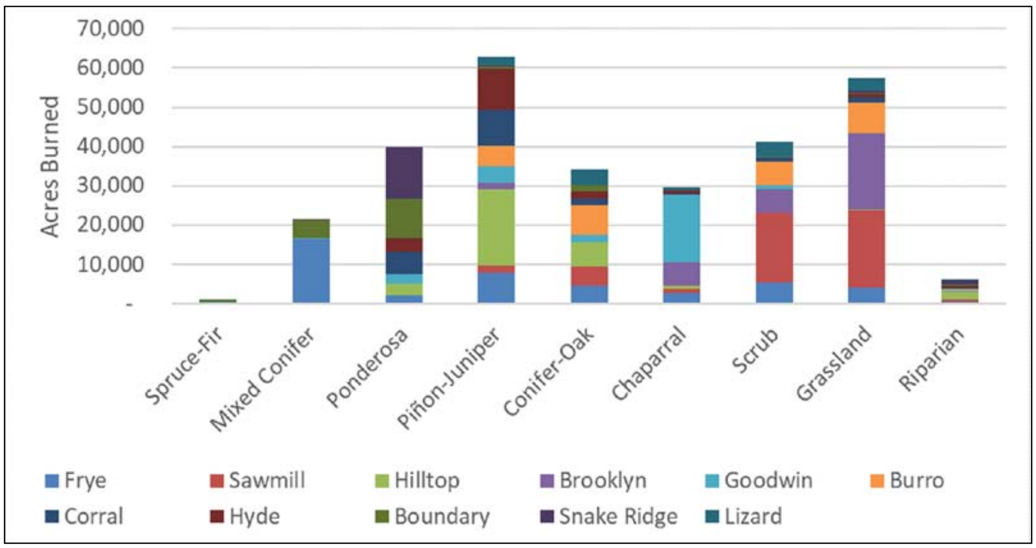

Figure 17. Summary of acres burned by vegetation type.

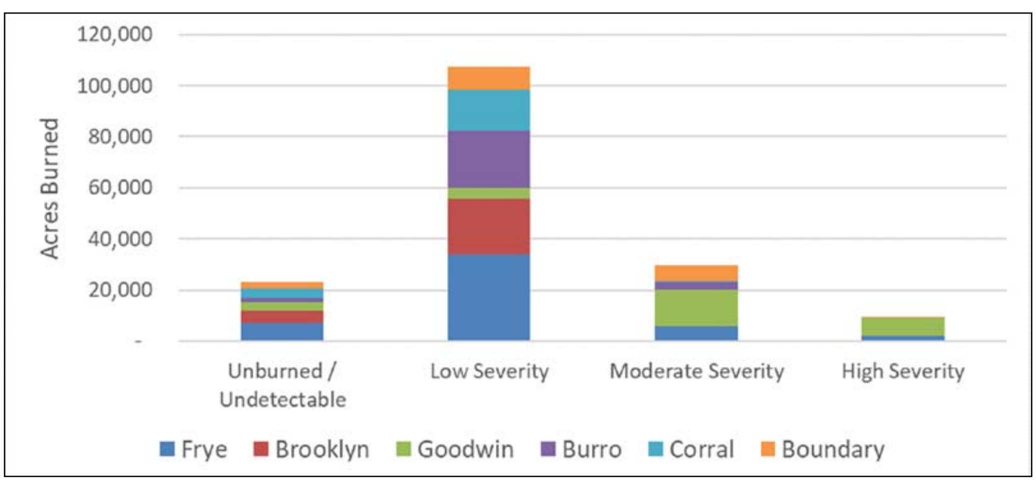

Figure 18. Summary of acres burned by soil burn severity class.

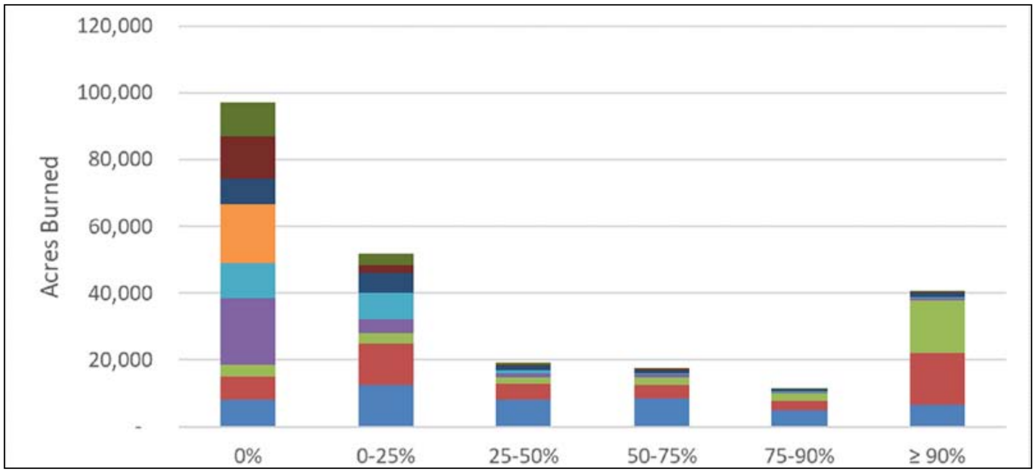

Figure 19. Summary of acres burned by canopy mortality class.

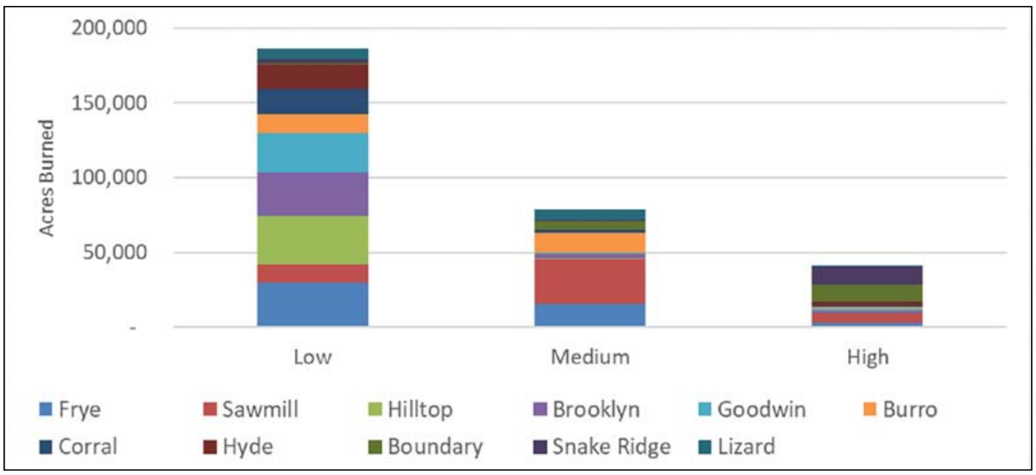

Figure 20. Summary of acres burned by vegetation condition class.

Three structures were damaged in the Frye Fire, while 17 residences were damaged or destroyed along with 19 minor structures in the Goodwin Fire. Evacuations were required for the Sawmill, Goodwin, Burro, Boundary, and the Lizard Fire. Pre-evacuations were called for Hilltop, but no evacuation was necessary.

Past fires played a role in most fires in this analysis except the Hilltop and Lizard Fires. However, in many cases the area reburned within 10 years was small (e.g., 1 percent in the Frye Fire).

The 11 fires in this analysis cost more than $92 million dollars to manage (with a range of strategies) for an average of $302 per acre. As noted above, managers identify the most appropriate strategy for each part of a wildfire to minimize threats and maximize positive outcomes. Using the percentage of strategies reported in the ICS-209 forms allows a portioning of acres and costs by the strategy used. In 2017, managers used full suppression strategies on 58 percent of the acres burned in fires over 100 acres and other strategies on remaining 42 percent of the acres.

Appendix 1. Fire Statistics

Area and Cost				Vegetation Departure		
Name	**Acres**	**Cost**	**cost/ac**	**Low**	**Medium**	**High**
Frye	48,443	$26,000,000	$536.71	62%	32%	6%
Sawmill	46,991	$8,200,000	$174.50	25%	63%	13%
Hilltop	33,826	$15,000,000	$443.45	97%	2%	1%
Brooklyn	33,550	$1,400,000	$41.73	86%	10%	4%
Goodwin	28,516	$15,000,000	$526.02	93%	3%	4%
Burro	27,238	$8,950,000	$328.59	45%	49%	6%
Corral	20,350	$750,000	$36.86	85%	10%	6%
Hyde	18,072	$500,000	$27.67	88%	1%	12%
Boundary	17,788	$9,400,000	$528.45	4%	31%	65%
Snake Ridge	15,333	$1,000,000	$65.22	19%	2%	78%
Lizard	15,230	$5,876,000	$385.82	47%	49%	4%

	Soil Burn Severity				RAVG canopy mortality					
Name	Unburned	Low	Moderate	High	0%	< 25%	< 50%	< 75%	< 90%	≥ 90%
Frye	14%	70%	12%	4%	16%	26%	16%	18%	10%	13%
Sawmill	N/A	N/A	N/A	N/A	15%	26%	11%	9%	6%	33%
Hilltop	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Brooklyn	12%	51%	34%	3%	N/A	N/A	N/A	N/A	N/A	N/A
Goodwin	11%	15%	50%	24%	12%	11%	6%	8%	8%	56%
Burro	7%	81%	11%	0%	73%	15%	5%	3%	2%	2%
Corral	18%	80%	2%	0%	53%	40%	5%	2%	1%	1%
Hyde	N/A	N/A	N/A	N/A	99%	1%	0%	0%	0%	0%
Boundary	12%	51%	34%	3%	42%	33%	8%	6%	3%	8%
Snake Ridge	N/A	N/A	N/A	N/A	83%	16%	1%	0%	0%	0%
Lizard	N/A	N/A	N/A	N/A	68%	22%	4%	3%	1%	1%

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