

Forest Health of the Rincon Mountains, Saguaro National Park, Arizona



Results of systematic surveys, 2017

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Summary

The Rincon Mountain District of Saguaro National Park is one of the “Sky Islands” of southeast Arizona, a mountain range that rises up from the desert into pine and mixed conifer forests. Although the park has a long history of plant community research and fire effects monitoring, as well as aerial monitoring of forest health by the US Forest Service, there has never been a systematic field-based survey of the forest health of the high elevations. Because of changing fire regimes, climate change, and the fact that aerial surveys during the past 5 years have indicated a steady increase in bark beetle infestations (US Forest Service 2016), the park is concerned about long-term health of its forest ecosystem.

The purpose of this study was to create the first-ever comprehensive, field-based assessment of the forest health of the Rincons to help guide future management actions. As part of systematic surveys of natural and cultural resources on Mica Mountain (the north end of the range) we mapped forest health measures such as prevalence of dwarf mistletoe and bark beetle sign. We also trapped bark beetles using funnel traps in areas with high infestations, collected data on isolated aspen groves, and mapped indicator riparian trees such as alder, box elder, Rocky Mountain maples, and willows.

Our systematic mapping effort on Mica Mountain revealed that dwarf mistletoe is common but uneven in its distribution; it is most prevalent on ridge-top areas and west-facing slopes. We located a number of tree clusters with native bark beetles, some of which were not mapped during aerial surveys. Although we have not yet completed identification of all beetles to species, we detected pine beetles (*Dendroctonus* spp.), pine engravers (*Ips* spp.) and the Douglas fir beetle (*Dendroctonus pseudotsugae*) in low-medium numbers. Our results suggest that the forest health of the northern portion of the Rincon Mountains is generally good, with the caveat that dwarf mistletoe is widespread and that bark beetles are present and may be increasing. If funds are available we hope to continue and expand these surveys in 2018 to include areas to the south and east of Mica Mountain, and in 2019 to the southern part of the Rincons near Rincon Peak.



Figure 1. View of Rincon Peak from Mica Mountain, Saguaro National Park.

Introduction

Saguaro National Park is known for its saguaros and Sonoran Desert vegetation, yet also includes a range of vegetation communities that occur at higher elevations. The western, Tucson Mountain District of the park includes a small area of grassland and oak woodland on Wasson Peak at 4687 feet. In contrast, the eastern, Rincon Mountain District rises to nearly 8,700 feet in elevation on Mica Mountain, and includes grassland, woodland, and forest communities (Figures 1, 2).

To travel upslope through the Rincons and nearby Santa Catalina Mountains has been described as taking a journey from Mexico to Canada, as a traveler first encounters desert plants such as saguaros and ocotillos; then grassland plants such as native grasses, sotol, and agave; then woodland species like juniper, oaks, and pinyon; then finally forests of ponderosa and Arizona pine. On north slopes at high elevations occur spruce, fir and aspen trees, similar to forests in the northern Rocky Mountains.

The desert areas of Saguaro National Park face unique challenges that include urban effects from the growing city of Tucson, Arizona. The high elevation areas face similar threats, but also unique issues relating to the changing climate of the American southwest. As temperatures have increased in recent decades, the Rincons face warmer winter and summer temperatures (Gonzalez 2013); decreased snow pack; earlier springs and later winters; and potential changes in plant and animal communities.

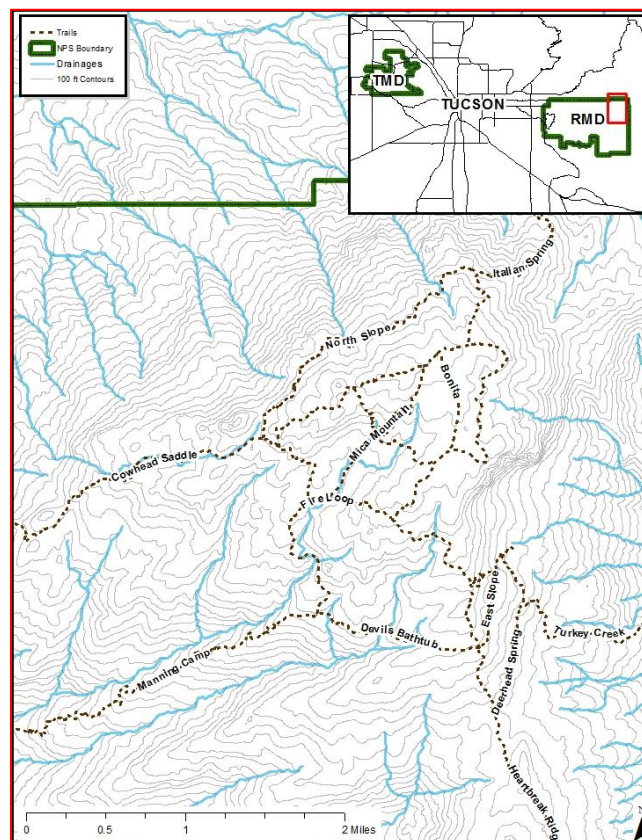


Figure 2. Location map of high elevation area in Rincon Mountain District of Saguaro National Park in southern Arizona with inset showing the two park districts in relation to Tucson.

Past assessments of the forests of the Rincon Mountains have been focused on fire management. Tree-ring studies indicate that prior to European settlement, pine and mixed conifer forests burned in low-intensity fires approximately every 6.1 years on Mica Mountain (Baisan and Swetnam 1990). As fire suppression became more successful and prevalent in the late 1800s and early 1900s, fire return intervals decreased dramatically, leading to higher tree density, increased ground fuels, and more intense fires. The park went through a period of intensive fire management during the 1970-1990s, allowing natural fires to burn and implementing use of prescribed fires. However, prescribed fire use has decreased and fire suppression has increased in the past 15 years for a variety of reasons (Pyne 2012).

Although insects and diseases of trees are natural and often caused by native species, there is ample evidence that tree mortality is increasing in parts of the estimated 363 million acres of public forests in the western US. Increases in tree mortality due to bark beetles may be the result of fire suppression and greatly increased tree density over pre-European settlement conditions (https://cals.arizona.edu/extension/fh/bb_faq.html), but may also be exacerbated by climate change, especially warming temperatures (Bentz et al. 2010). On public lands in the desert southwest (Arizona and New Mexico), it is estimated that approximately 25%, or 5.46 million acres out of 22 million acres surveyed are affected by some sort of insect or disease (USFS 2015). Major concerns in Arizona, as in other areas of the west, are several species of bark beetles and the western spruce budworm (USFS 2015). In addition, millions of forest acres are affected by root disease and dwarf mistletoe, a parasitic plant that is common in conifers such as Ponderosa pine.

Forest health assessments of the Rincons have occurred at various times in the history of Saguaro National Park, and some historic reports are archived in the NPS Western Archaeological Conservation Center in Tucson (WACC). We are not aware of any review of these documents, although it would be a great future project. The most comprehensive current assessments are the annual Insect and Disease Aerial Surveys flown each year by U.S. Forest Health personnel, which began in 2007 and have occurred each summer since. While pine mortality was nearly non-existent from 2007-20012, in 2013 it began to increase, and in 2016 over 1,200 acres were estimated to be damaged (USFS 2016). Although the damage in most areas was very light, most damage occurred on the main ridgeline of the Rincons.

The purpose of this study was to conduct baseline inventories of the forest health of the Rincon Mountains through a ground-based systematic mapping effort. This effort was part of a major initiative to survey natural and cultural resources in the Rincons in 2017 that included invasive plants, cultural resources, rare plants (Beckman et al. 2017) and water resources, especially springs (King et al. 2017). In addition to recording signs of tree mortality, bark beetles, and other insects and diseases, we also trapped bark beetles in the infested areas we discovered in an effort to identify the beetles to species and estimate relative abundance.

Finally, we ground-truthed areas covered by aerial surveys in 2017 and compared our systematic mapping with aerial survey results. We anticipate that 2017 was the first of a 3-year project that will include mapping of forest health issues in other areas on Mica Mountain as well as nearby Rincon Peak.

Study area

Saguaro National Park is located in Pima County, AZ and consists of two disjunct districts separated by the city of Tucson (Figure 2). The park includes 37,005 ha, of which 28,694 ha (78%) are designated Wilderness. The Rincon Mountain District, the area of this study, covers a large portion of the Rincon Mountains, a northern Sky Island range adjacent and biologically connected to the Santa Catalina Mountains. The Sky Island region of the southwestern U.S. and northwestern Mexico is known for exceptional biological diversity, including species from the Sierra Madre, Rocky Mountains, Sonoran Desert, and Chihuahuan Desert biogeographic provinces. The portion of the Rincons within the park ranges in elevation from 814-2,614m (2,670-8,666 ft; Figure 2). Biotic communities include Sonoran desertscrub, semi-desert grassland, oak savannah, oak pine-oak forest and woodland, and mixed conifer forest. The Rincons also contain riparian forest and riparian woodland in canyon bottoms, scattered wet and dry meadows at higher elevations, and perennial springs and spring-fed rock pools (*tinajas*).

Methods

Systematic surveys. We recorded forest health parameters during systematic surveys of the higher elevations of Mica Mountain in the Rincon Mountain District of Saguaro National Park. Surveyors were trained park biological technicians and interns. Most but not all staff were trained in identifying forest health issues during a day-long pre-season training by USFS entomologist Amanda Grady and pathologist Nick Wilhelmi (Figure 3). In addition, we developed a training guide and provided on-site training in the Rincons so that all surveyors would be able to recognize basic forest health parameters, especially signs of bark beetle infestations including red needles, pitch tubes, and exit holes.



Figure 3. Saguaro National Park biological technicians and interns at Forest Health training on Mt. Lemmon with USFS entomologist Amanda Grady, May 2017.

Systematic surveys were conducted with surveyors following either east-west or north-south transects using a Trimble Juno GPS unit. Transects were 20 meters apart; surveyors followed a GPS coordinate and were instructed to cover areas between them and the surveyor on either side. All data was

recorded in a geodatabase (developed at SNP by Lauren Kramer) loaded into the Juno GPS unit. When diseased trees were encountered, we recorded type of infestation (bark beetles or other); signs of infection (e.g., red needles, pitch tubes, exit holes, etc.), severity of infection (low, medium, or high), tree species, and number of trees infected (Figure 4). In addition to forest health parameters, surveyors also recorded targeted rare and invasive plants, cultural resources, and water resources.



Figure 4. Intern Megan Grubbs collecting data on aspen tree using a Trimble Juno unit; Right: Intern Brittany Sandoval mapping ponderosa pine infested with bark beetles.

In addition, we also recorded certain forest characteristics at 100 meter intervals, including degree of mistletoe infection. At each location we selected the nearest mature (approximately 0.3 m DBH) ponderosa or Arizona pine to our north, and used the Hawksworth (1926) 6-class Mistletoe Rating System to determine the degree of infestation. In this system, the tree is divided into thirds, and the degree of mistletoe infection in each third is rated from 0 (no mistletoe), 1 (<50% of branches infected), or 2 (>50% of branches infected), and the ratings are totaled for the whole tree so that the tree is rated from 0-6. In addition, at these 100-m interval stops we recorded forest type, substrate (rock or soil), soil depth, and presence or absence of pocket gopher holes as an indicator of soil type and depth.

Bark beetle traps. We set traps for bark beetles in locations where we detected bark beetle infestations in >10 trees based on the characteristics described above. The locations were Four Corners, Bonita/Fire Loop Trail, Mica Mountain, and Fire Loop North in areas of ponderosa/Arizona pine and white pine. At each site we set 5 Lingren funnel traps with one bait per trap to target different forest pests. With the assistance of USFS entomologist Dr. Monica Gaylord we used five baits: alpha pinene; lanierone;

ipdsienol; Northern spruce engraver lure; and western pine bark lure. Traps were set for approximately one month and checked weekly.

Ground-check of aerial surveys. Following the completion of the 2017 US Forest Service Forest Health in August 2017 (and reception of the USFS Insect and Disease Quicknote, also in August), we compared the results of the aerial surveys with our systematic surveys, and also ground-checked the areas on Mica Mountains where infestations had been recorded by air. We obtained a shapefile from Daniel Depinte, Forest Health Specialist with the USFS, added it to our database, and hiked to areas identified as having bark beetle infestations.

Results

Systematic surveys. We systematically surveyed a total of 604 ha (303.5 km of transects) on Mica Mountain in the northern part of the Rincon Mountains (Figure 5). On these surveys we made 794 detections of forest health issues. The majority of forest health issues recorded were signs of bark beetles (765), and most were considered mild or intermediate. 42 detections were considered “severe” based on the number of trees affected combined with abundance of sign on the affected trees (Figure 6). Only in rare cases did we detect infestations with >15 trees exhibiting large numbers of red needles.

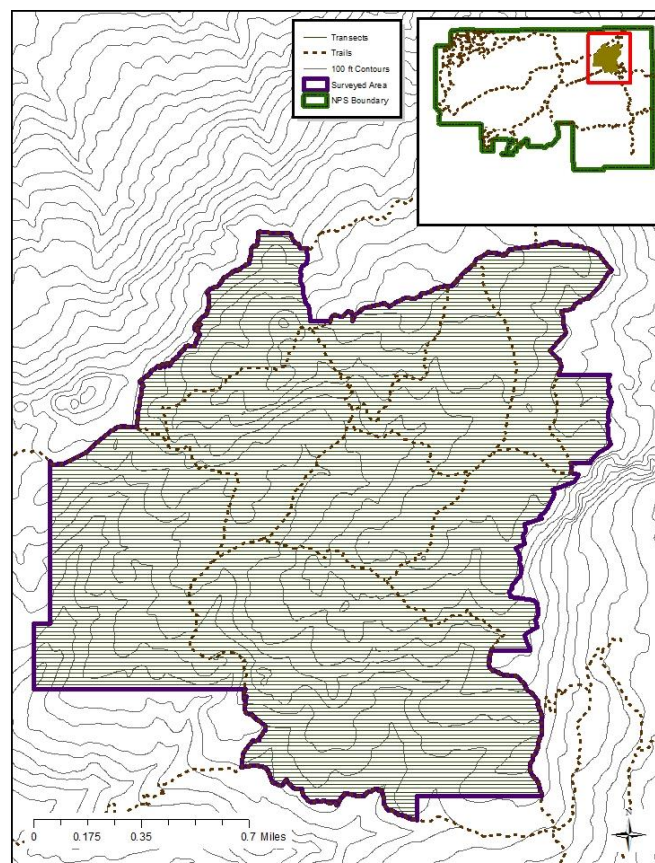


Figure 5. Locations of 2017 systematic surveys in Rincons. Surveyors walked 20 m apart, covering ground between them; this map does not show actual transects walked, which included both east-west and north-south transects.

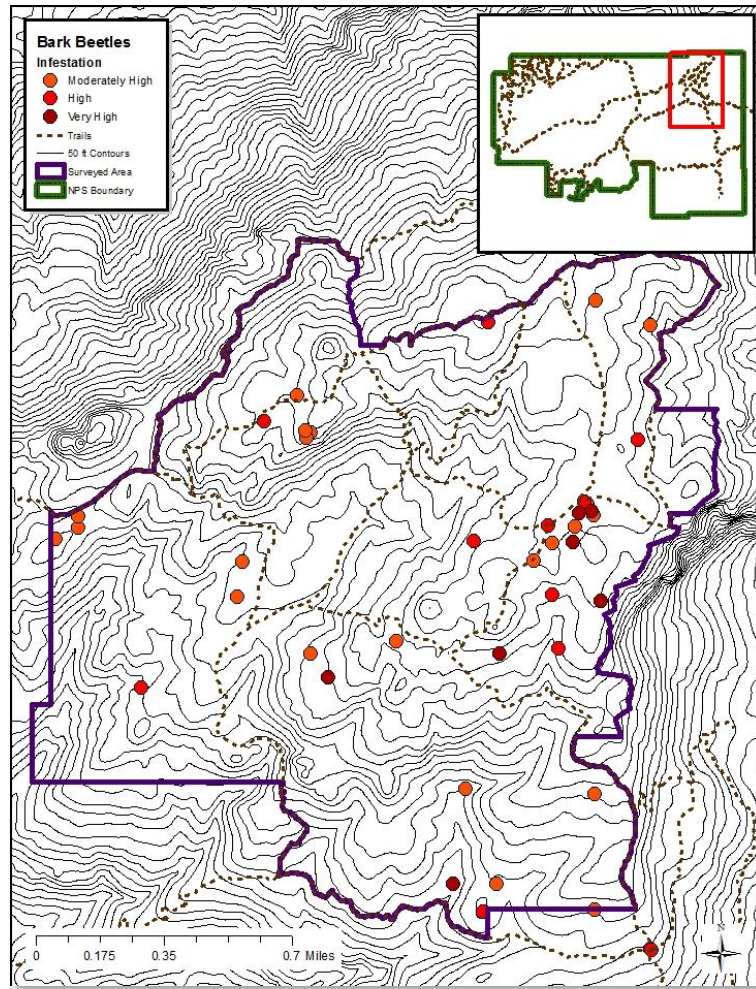


Figure 6. Bark beetle infestations in Rincon Mountains, 2017. Darker red dots indicate locations of very high severity, with lighter red high or moderately high.

Infestations of dwarf mistletoe are common in ponderosa and Arizona pine in the Rincon Mountains (Figure 7). On our transects where we mapped mistletoe at regular intervals we found severe signs of mistletoe infection (5-6 on Hawksworth Scale) on 47 out of 575 sites. We did not distinguish between the two species of pine hosts.

To our surprise, we found definite “hotspots” where mistletoe infestations were very common, and other areas where it was quite rare (Figure 8). Mistletoe hotspots were north and east of Manning Camp and also southeast of Manning Camp, whereas areas with less mistletoe occurred in the Devil’s Bathtub area, especially south of Devil’s Bathtub trail, and in valley areas of Madrona and Chimenea Creeks. Consistent with patterns in previous research (Hawksworth 1961), we found the most severe mistletoe infestations associated with ridgelines (Figure 8). Although it occurred on all slopes, it appeared to be more common on west-facing slopes. When mistletoe occurred in large amounts, it was often found in both younger and older trees.



Figure 7. Southwestern dwarf mistletoe (*Arceuthobium vaginatum subsp. cryptopodeum*).

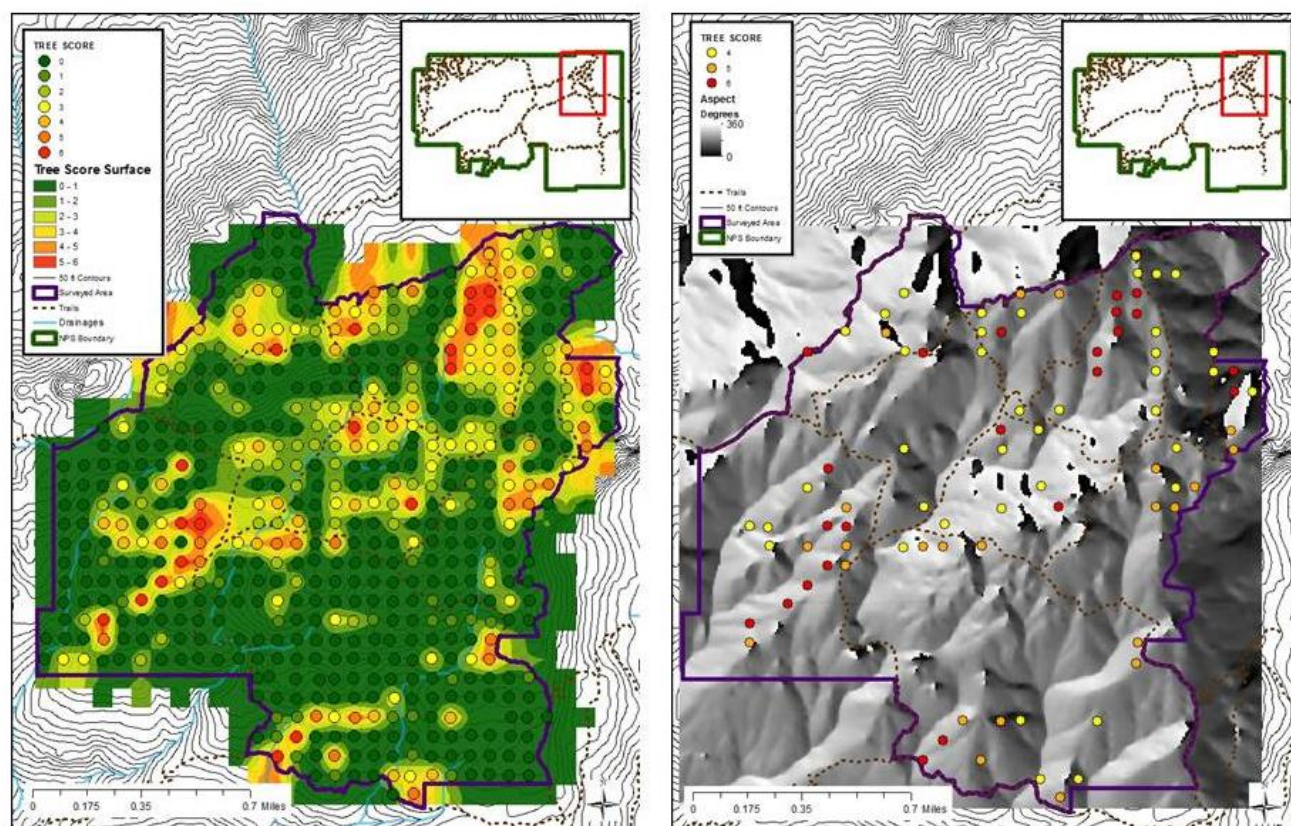


Figure 8. Left: Map of mistletoe and mistletoe surface projection based on the scores we gave trees on our 100m grid. The surface map was created using an inverse distance weighted model that calculates the surface based on the values of the 12 points closest to that area. Right: map of mistletoe (4-6 on Haworth scale) correlated with aspect.

Not surprisingly, we observed a large number of other different types of tree insects and diseases in the Rincons. Although we did not record these observations systematically, they included what we believe are black leaf spot (*Marssonina populi*) on aspen leaves (Figure 9), which were observed in many aspens trees, heartrot (*Phellinus everhartii*) in oak trees (Figure 9), witches broom rust in southwestern white pine, and defoliation from alder flea beetles (*Macrohaltica ambiens*) in Arizona alders. In addition we observed a rust identified by USFS forest pathologist Nick Wilhelmi as Coronado limb rust (*Cronartium arizonicum*), and collected specimens for K.A. Leddy, a graduate student at Colorado State University who is studying native rust fungi in the western U.S (Figure 10).



Figure 9. Left: Fungi (potentially heartrot, *Phellinus everhartii*) on Gambel oak. Right: black leaf spot (probably *Marssonina populi*) on aspen leaf.



Figure 10. Botany intern Dan Beckman collecting Coronado limb rust (*Cronartium arizonicum*).

Bark beetle traps. We trapped bark beetles at all four trap locations (Figure 11). So far, we have only identified the beetles to genus, but plan to identify them to species over the winter (Figure 12). The most common genus in the traps were *Dendroctonus* spp, presumably western, mountain, or roundheaded bark beetles. The second most common genus were pine engravers (*Ips* spp.). The number of beetles and engravers captured varied among sites, with Four Corners being high; the Fire Loop/North Slope site being medium; and fairly low numbers at Bonita/Fire Loop and Mica Mountain.

Ground-check of aerial surveys. In comparing our results to the bark beetle infestations mapped aerially by the US Forest Service in August 2017, we found strong agreement, although aerial mapping included the whole mountain range, so several sites were outside of our surveyed areas. Ground visits to these sites confirmed that there were multiple trees with more severe infestations at all of the locations

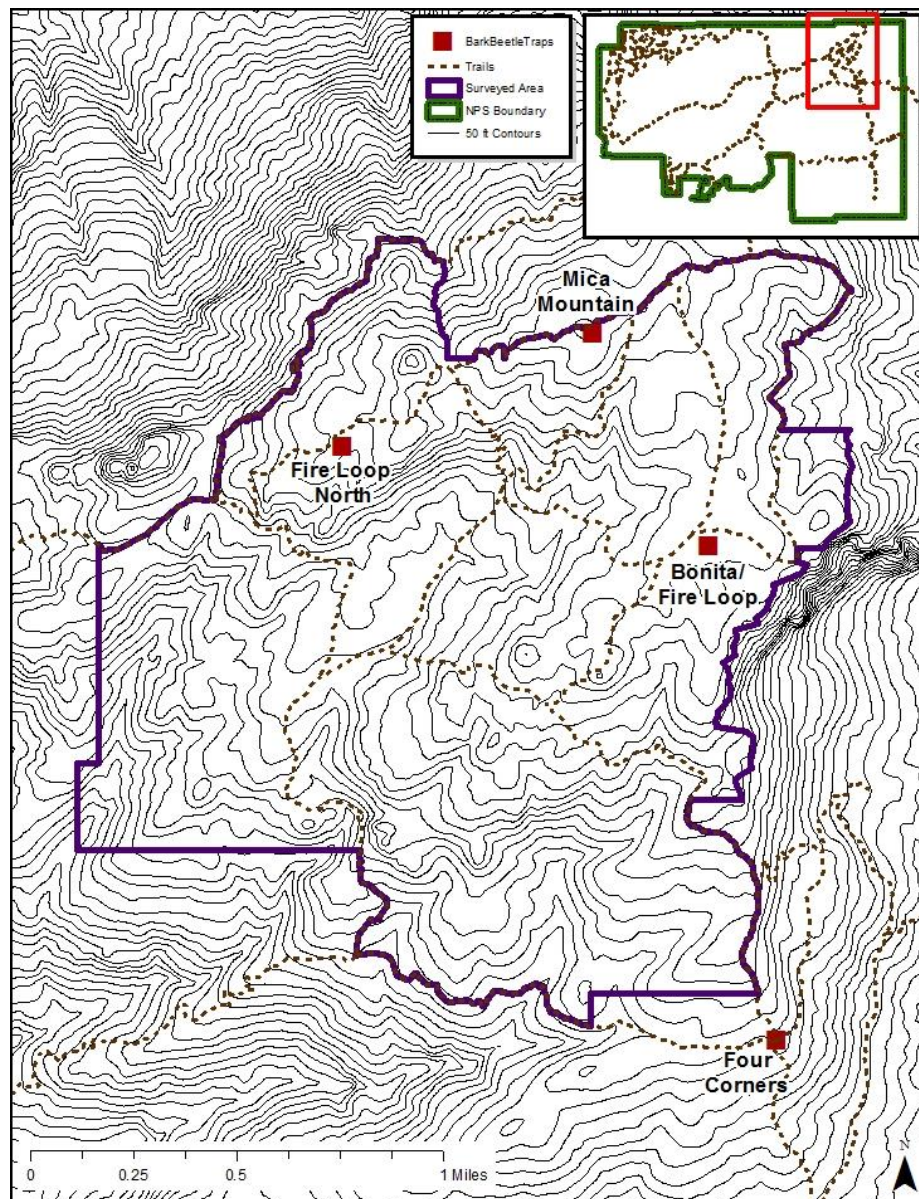


Figure 11. Location of bark beetle traps.



Figure 12. Left: ponderosa pine tree infested with bark beetles. Right: Tony Palmer, Manning Camp ranger and entomologist, with bark beetles and other insects collected in traps.

determined to have bark beetle infestations based on the aerial survey (Figure 13). Within our survey area, two of the three areas where we considered bark beetle activity to be so high that we placed traps were also mapped as bark beetle infestations on the aerial surveys (compare Figures 11 and 13). With the exception of Mica Mountain, the aerial survey locations of beetles within our survey area strongly corresponded with our survey results (compare Figures 6 and 13). Our surveys did locate more trees and additional areas that were not mapped aerially, which is to be expected because our ground-based surveys were more intensive, and were also able to detect bark beetle damage to smaller trees that might be hidden by the canopy.

Discussion

Forest health surveys by NPS biological technicians and interns this summer were extremely valuable in revealing information about the forest health of the Rincon Mountain District of Saguaro National Park. Our mapping reveals that dwarf mistletoe is widespread in the Rincons, and some areas are heavily infested with this plant. However, this species is not evenly-distributed: although we did not do a detailed geospatial analysis, it appears to occur more commonly on ridgelines and west-facing slopes. This information will be very valuable for fire managers in planning future burns to reduce the prevalence of dwarf mistletoe in the park.

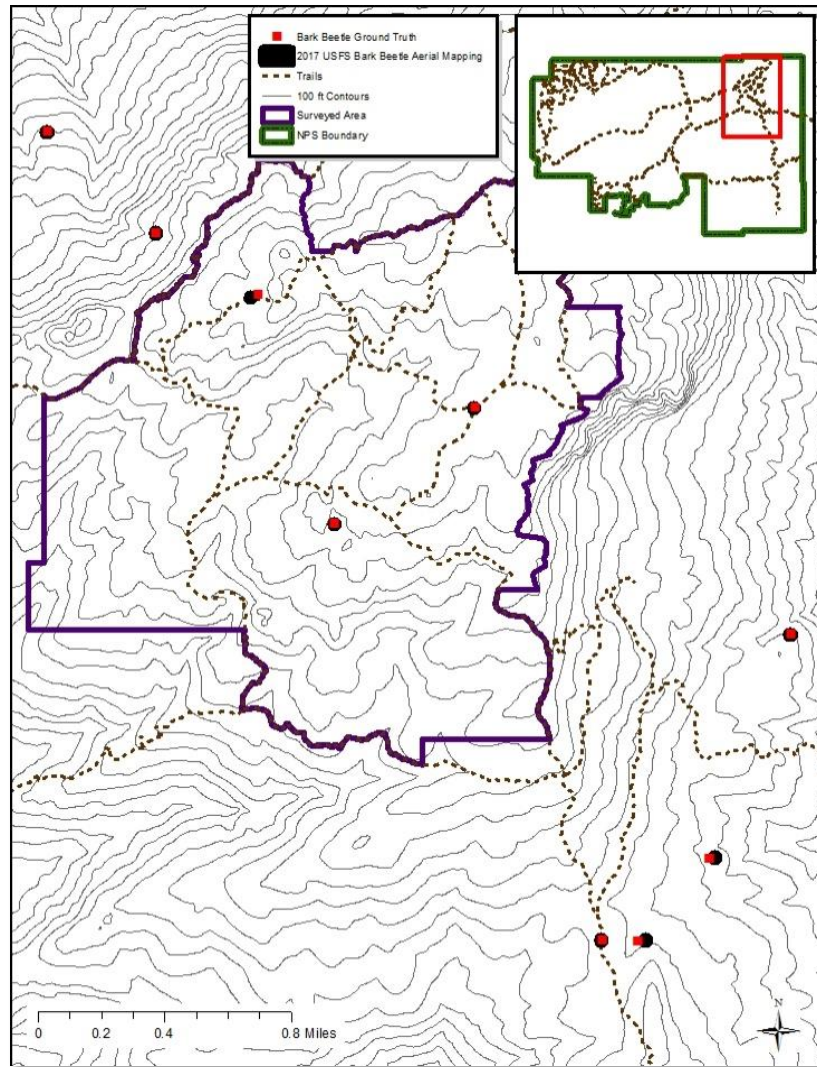


Figure 13. Results of ground visits to areas determined to be of high bark beetle infestations based on US Forest Service aerial surveys. Red dots indicate ground surveys and green areas indicate aerial mapping. We confirmed bark beetle activity at all areas mapped by air.

We found large numbers of bark beetles in our traps, and also many trees that exhibited signs of bark beetle infestation such as pitch tubes, red needles, and exit holes. There also appear to be hotspots of beetle activity, such as on the northern part of the Fire Loop Trail, at Four Corners, Mica Mountain, near the Bonita Trail, and other areas. However, these hotspots tend to be small, typically involving clusters of small numbers (<10 trees). Our results corroborated the results of the US Forest Service aerial surveys. In general, we found fewer and smaller areas of bark beetle infestations in the park than we expected, which was encouraging.

A great benefit of this project is that it focused attention on forest health issues in the Rincons, something that we have seen as a lack of focus in our Resource Management program for a long time. Although the high elevation forests of the Rincons are extremely important to Saguaro National Park,

they receive relatively few visitors because they are in a roadless wilderness, and staff also tend to focus their work on the desert areas and cactus forests. The entire resource crew had an opportunity to learn about forest health issues this summer, most of us for the first time. We are really appreciative of the support we received from forest health experts from the US Forest Service for their help in training, materials, aerial surveys, and expert advice throughout the project.

As mentioned at the beginning of this report, we hope that this is the first of at least 3 years of surveys of the forest health of the Rincons. If we can obtain sufficient funds we hope to complete the survey in the northern part of the range this summer, and then do additional surveys in the southern part of the range in 2019. The results should also suggest what our concerns are moving forward, and how we can most effectively and efficiently work with partners, especially USFS, in monitoring the health of our Sky Island forests in the future.

Acknowledgments

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