Grand Canyon Trust

Systematic Degradation of Mount Peale Research Natural Area by Non-native Mountain Goats

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REPORT

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Acknowledgments

We had the help of 23 volunteers in the 2017 and 2019 field work. Wild Utah Project (Allison Jones and Mary Pendergast) provided 2015 data as well as guidance on field methods. The Moab Ranger District (Manti-La Sal National Forest) provided data from the 2008 assessment and recent monitoring and suggested the use of the Rochefort and Swinney (2000) method for site condition assessments

PHOTOS IN THIS REPORT ARE BY MARC COLES-RITCHIE AND OTHER STAFF AND VOLUNTEERS OF GRAND CANYON TRUST.

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Abstract

Impacts of the non-native mountain goats in the alpine ecosystem of the Mount Peale Research Natural Area (RNA) in the La Sal Mountains of southeastern Utah are mounting. Mountain goats were introduced to the La Sal Mountains (Manti-La Sal National Forest) by the Utah Division of Wildlife Resources in 2013 and 2014. Since then, Grand Canyon Trust and others have been documenting the impacts of mountain goats in the Mount Peale RNA (10,450'-12,726') which graze and dig up alpine plants, and create large patches of bare soil (Fig. 1). In 2019 we documented 297 wallows (median size 4.5' X 3.0') within the RNA, where goats had removed the alpine turf vegetation and dug into the soil to create places to lay and kick dirt on themselves. In 2019 we also re-assessed the condition of plots in the RNA that had been previously assessed by Grand Canyon Trust and others starting in 2008. Our work, combined with previous surveys, documented that 60% of plots had declined at least one of five condition classes from 2015 to 2019. In 2015, 58% of the plots were assessed as being in pristine condition, whereas in 2019 16% of the plots remained in pristine condition. By 2019, 47% of plots were assessed to be significantly or severely different from pristine condition. The population of mountain goats has increased from the 35 introduced in 2013 and 2014 to 105 in 2019, and that number is expected to increase toward the Utah Division of Wildlife Resources goal of 200 animals. The increasing size of this population will cause increasing, potentially irreversible damage to the fragile, alpine Mount Peale Research Natural Area whose designation is supposed to result in protection by the Forest Service. We are watching and documenting the destruction of the alpine ecosystem in the Mount Peale Research Natural Area.

***Figure 1**. Field survey of plot with large goat wallow in the La Sal Mountains, Mount Peale Research Natural Area. Goat fur and scat were present in this wallow and plot. Photo was taken August 14, 2019 at 12,095 ft.*

Introduction

Non-native mountain goats (*Oreamnos americanus*) (Fig. 2) continue to damage the alpine area of the Mount Peale Research Natural Area (RNA). The introduction of mountain goats to the La Sal Mountains of southeast Utah brought a new source of physical and ecological damage to the Mount Peale RNA. Mountain goats have major effects on the fragile alpine ecosystem, rare on the Colorado Plateau, as stated by Smith (2008):

> The alpine ecosystem, with short growing seasons, shallow soils and steep slopes, is a harsh environment for plants. The subsequent long-term recovery times, limited restoration potential and specialized, endemic species make any impacts significant.

Mountain goats physically damage the alpine area by grazing and uprooting vegetation, shearing turf (Fig. 3) and digging into the soil to create bare soil where they kick dirt on themselves (Fig. 4). These bare patches are called wallows and can be the size of an individual animal or many animals since mountain goats travel in herds. This signature behavior of the mountain goats removes alpine vegetation and causes soil erosion, both of which constitute major losses in the vulnerable alpine ecosystem.

***Figure 2**. Mountain goats grazing in the Mount Peale RNA, near the Mount Tukuhnikivatz trail, on August 4, 2018 at 11,740 ft.*

This report presents data collected in 2017 and 2019 by Grand Canyon Trust staff and volunteers in the Mount Peale RNA to document the impacts of the non-native mountain goats as well as data from 2008 and 2015 assessments by others. The first objective of the 2019 work was to systematically locate and document the presence of wallows created by mountain goats within the Mount Peale RNA, building upon our previous, less comprehensive documentation of wallows in the RNA (Coles-Ritchie 2017b and Coles-Ritchie 2018). The second objective was to revisit plots that had been previously surveyed in 2008 by the Forest Service (Smith 2008), in 2015 by Wild Utah Project (Jones et al. 2015) and in 2017 by Grand Canyon Trust (Coles-Ritchie 2017a).

Background

The La Sal Mountains are a spectacular and uncommon alpine ecosystem in the Colorado Plateau (Fig. 5) high above the red rock canyons of southeastern Utah, in the Manti-La Sal National Forest. The alpine zone (above 11,000 ft) in the La Sal Mountains is 8,087 acres. The Mount Peale RNA was established by the Forest Service in 1988 to protect a portion (2,380 acres) of this high alpine ecosystem of the La Sal Mountains. This RNA ranges in elevation from 10,450 feet up to the rugged peak of Mount Peale at 12,726 feet. The RNA includes two other peaks over 12,000 ft, Mellenthin and Tukuhnikivatz, and the alpine lands between the three peaks. The land cover of the RNA is alpine turf vegetation (often mixed with rock), spruce-fir forest (including the short krummholz forest type), talus boulder fields, and small wetlands. Research Natural Areas are established by the U.S. Forest Service to "form a national network of ecological areas for research, education, and maintenance of biological diversity [and] preserve and maintain genetic diversity, including threatened, endangered, and sensitive species" (FSM 4063.02).

***Figure 3**. Alpine turf that has been sheared and damaged. Goat scat was observed in this plot. Photo taken July 16, 2019 at 12,073 ft.*

***Figure 4**. Mountain goat digging into the alpine turf and soil (left) and kicking dirt onto itself (right). Both photos are the same goats; they show laying, digging and kicking behavior. Photos taken August 18, 2017, in the Mount Peale RNA at 11,865 ft.*

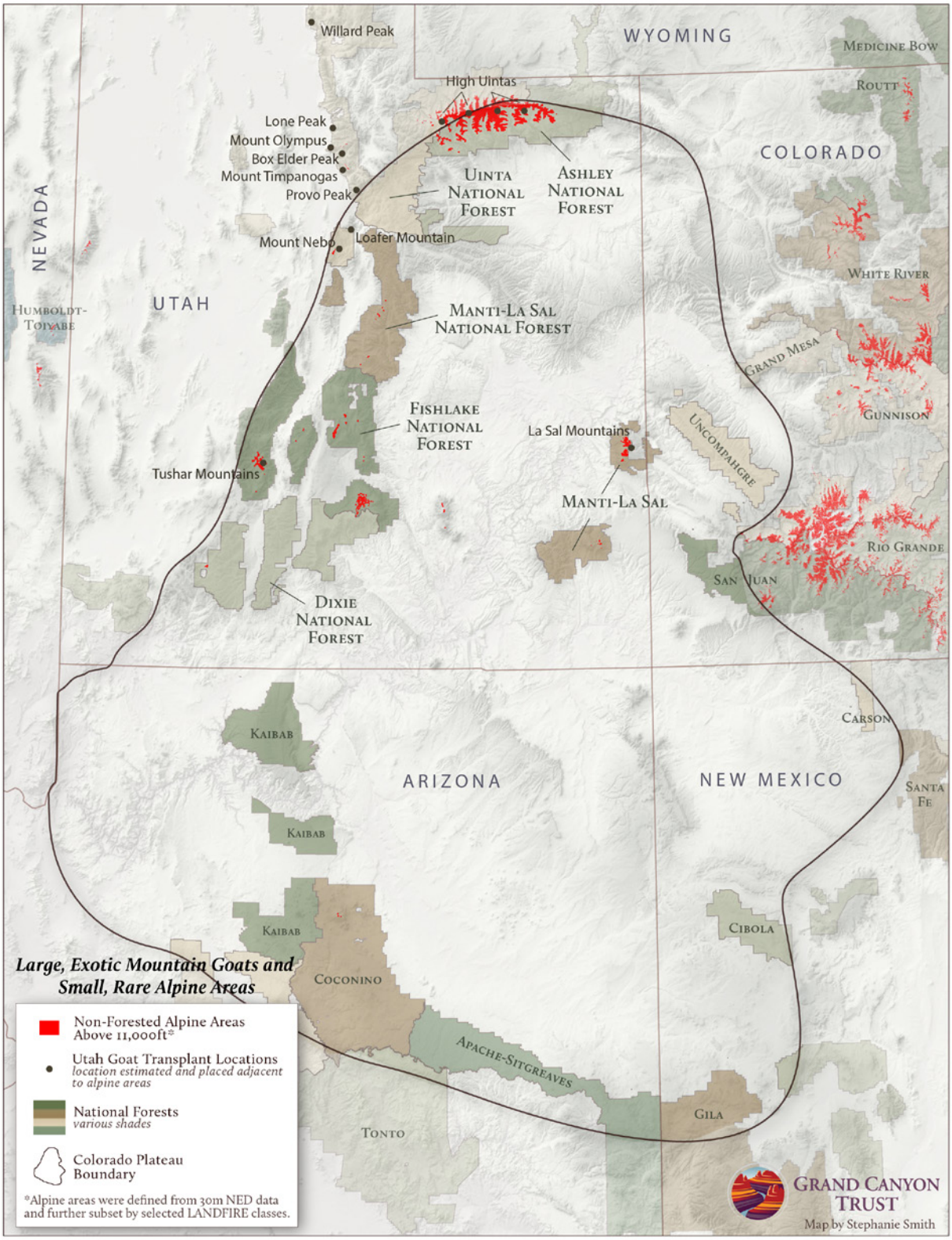

***Figure 5**. Map showing the limited amount of alpine area (shaded red) in the Colorado Plateau (bounded by black line).*

Mountain goats are not native to Utah (Festa-Bianchet 2008; Patterson et al. 2003); their native range is north of Utah (Fig. 6). In the 1960s, the state of Utah began introducing mountain goats from the state of Washington and subsequently transplanted mountain goats between mountain ranges within Utah (UDWR 2013b). The Utah Division of Wildlife Resources (UDWR) goal of introducing mountain goats in the mountains of Utah is to "provide high quality opportunities for hunting and viewing of mountain goats" (UDWR 2013b). In 2013 and 2014, the UDWR transported 35 mountain goats by helicopter to a patch of state land in the La Sal Mountains. As expected, the goats went up to the alpine area of the Manti-La Sal National Forest, and specifically the Mount Peale RNA. The Forest Service did not approve this introduction of a non-native species to the Manti-La Sal National Forest. The Forest Service rejected the planned introduction of mountain goats to the La Sal Mountain alpine area, indicating that the "Adverse effects from goat foraging and trampling on globally rare and Forest Service sensitive alpine plant species" in the Mt. Peale Research Natural Area "appear contrary to the establishment record for the Mount Peale RNA and inconsistent with Forest Service policy regarding management of RNAs, which includes maintaining natural conditions and protecting the integrity of ecological processes" (Rasure 2013).

Based on a UDWR aerial count in August 2019, there are now at least 105 mountain goats living in the La Sal Mountains, including the small, alpine Mount Peale RNA (personal communication with UDWR 2019). The State has a goal of 200 mountain goats in the La Sal Mountains (UDWR 2013a).

The alpine vegetation of the RNA includes five Manti-La Sal NF plant Species of Conservation Concern (SCC) (Appendix 1). SCC plants are those species ". . . for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area" (USDA-FS 2012). One of the five Manti-La Sal NF SCC plants impacted by the mountain goats is the endemic La Sal daisy (Erigeron mancus), found only in the La Sal Mountains alpine area (Figs. 7 and 8).

The national Forest Service regulations for RNAs clearly state that RNAs are to remain in "virgin or unmodified condition" (36 CFR § 251.23). The Forest Service has not developed a goat management plan for the La Sal Mountains, although in 2017 they established a joint, multi-year USFS-UDWR alpine vegetation monitoring plan for the La Sal Mountains (USDA-FS 2017b) to guide a monitoring effort that actually began in 2015. That plan is intended to address the question: "Is the Forest Service preserving and maintaining natural conditions and processes, and biological and genetic diversity, including threatened, endangered, and sensitive species in the Mt Peale RNA?" (USDA-FS 2017b). That question, however, is vague (e.g., "maintaining natural conditions and processes, and biological and genetic diversity"), does not distinguish goat impacts from climate change, and provides no quantitative thresholds that would trigger any corrective action.

In January 2016, the Utah Native Plant Society and Grand Canyon Trust filed a lawsuit in federal court (District of Utah) asserting that the Forest Service violated federal law by rejecting the Grand Canyon Trust's requests that the Forest Service require a permit for or prevent the State's goat introductions and remove all mountain goats from Manti-La Sal National Forest and Mt Peale RNA (UNPS 2017a). In March 2017 the court ruled that the Forest Service had not made a "final decision" on our requests and that there was no "final agency action" to challenge. In August 2017 the Utah Native Plant Society and Grand Canyon Trust appealed that decision to the Tenth Circuit Court of Appeals (UNPS 2017b). In May 2019 the Court rejected the appeal, agreeing that the Forest Service had not made a final decision about removing the mountain goats that could be challenged in court and concluding that the agency's decision not to require a permit for or prevent the transplants was not unlawful. The Court left open the possibility that the Forest Service could be legally required to remove the goats in the future.

***Figure 6**. The native range of mountain goats, which does not include the La Sal Mountains of Utah (red banner). Map available online.*

Figure 7*. La Sal daisy in the Mount Peale RNA amid rocks on the north side of Mount Mellenthin. Photo taken July 17, 2019 at 11,291 ft.*

Figure 8*. La Sal daisy (yellow flowers) next to ground disturbance and a clump of goat scat (arrow). Photo taken June 26, 2018 at 11,703 ft in the Mount Peale RNA.*

Methods

Wallows Survey

The purpose of the wallows survey was to systematically document places where goats had dug up plants and soil to create loose soil where they can lie and kick dirt on themselves (Fig. 4). Prior to searching for wallows, we mapped all areas within the Mount Peale RNA less than 30% slope. We wanted to avoid steep slopes which could be hazardous to traverse. We divided the RNA into grids and within each grid, we searched for wallows in vegetated areas (i.e., not rock slopes or talus) on slopes of less than 30% (Fig. 9).

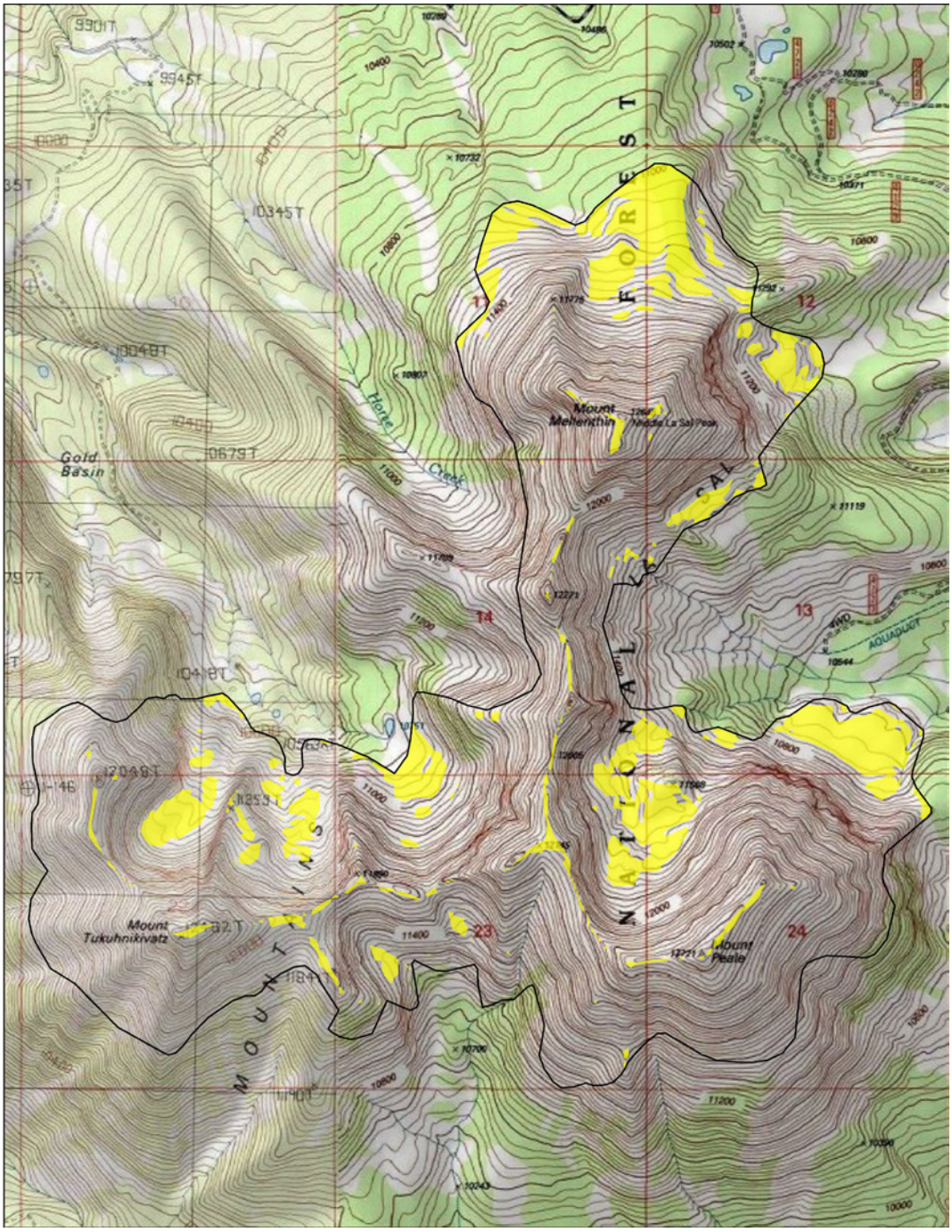

***Figure 9**. The wallow search areas (yellow) are the areas less than 30% slope in the Mount Peale RNA (black line).*

In our wallow search we looked for bare soil patches where vegetation and/or soil had been intentionally dug out and removed or displaced. The evidence that we used to confirm that these areas were created by the physical action of mountain goats is listed below with photo examples. At each wallow we took georeferenced photos, measured the length and width of the wallow, and recorded evidence of mountain goats, as well as the presence of any SCC plant.

Mountain goat fur

Fur attached to plants around wallows in which mountain goats lay and roll around (Fig. 10).

Mountain goat scat

Goat droppings in a wallow or dug-out area, which indicates that a mountain goat spent time there (Fig. 11). Data gathered in 2018 from FS wildlife cameras indicated that mountain goats were observed over 30 times more than deer or elk (USDA-FS 2019). Thus, while sometimes it may be difficult to distinguish deer, elk and mountain goat scat, most if not all the scat we observed within these dug-out patches was mountain goat.

Uprooted plants

Dead, uprooted plants lying on the bare ground of a wallow or dug-out area (Fig. 12). Alpine plants are generally of low stature and are uprooted by digging, not wind or water erosion alone.

Hoofprints

Goat-sized hoofprints in the bare soil of a wallow or dug-out area indicate that mountain goats had been there relatively recently (Fig. 13).

Sheared turf

Where hoof action, digging and/or grazing results in a vertical edge of turf adjacent to a bare soil patch (Fig. 14).

***Figure 10**. Clumps of white mountain goat fur caught on plants adjacent to disturbed ground. Photo taken August 17, 2017 at 11,750 ft in the Mount Peale RNA.*

***Figure 11**. Mountain goat scat on disturbed ground. Photo taken June 26, 2018 at 11,784 in the Mount Peale RNA.*

***Figure 12**. Uprooted plant observed at a large wallow, seen in background. Photo taken August 14, 2019 at 11,813 ft.*

***Figure 13**. Hoofprint of mountain goat in bare soil (where volunteer is pointing). Photo taken September 25, 2018 at 11,714 ft in the La Sal Mountains.*

***Figure 14**. Sheared alpine turf. Photo taken September 6, 2019 at 11,985 ft in the Mount Peale RNA.*

Plot Assessments

We visited 47 plots (Fig. 15) which we had previously surveyed in 2017 (Coles-Ritchie 2017a). Of those plots, 43 (including the 13) had been assessed by Wild Utah Project in 2015 (Jones et al. 2015) and 13 had first been surveyed in 2008 by the Forest Service (Smith 2008). We used GPS points from previous field visits to revisit each plot.

In all these surveys, we used the same protocol (Rochefort and Swinney 2000) that had been used by Barb Smith (Wildlife biologist, Manti-La Sal NF) in 2008. The protocol is a qualitative assessment of physical impacts observed in a 0.1-acre circular plot (37.2 ft radius). In each plot, physical disturbance and impacts

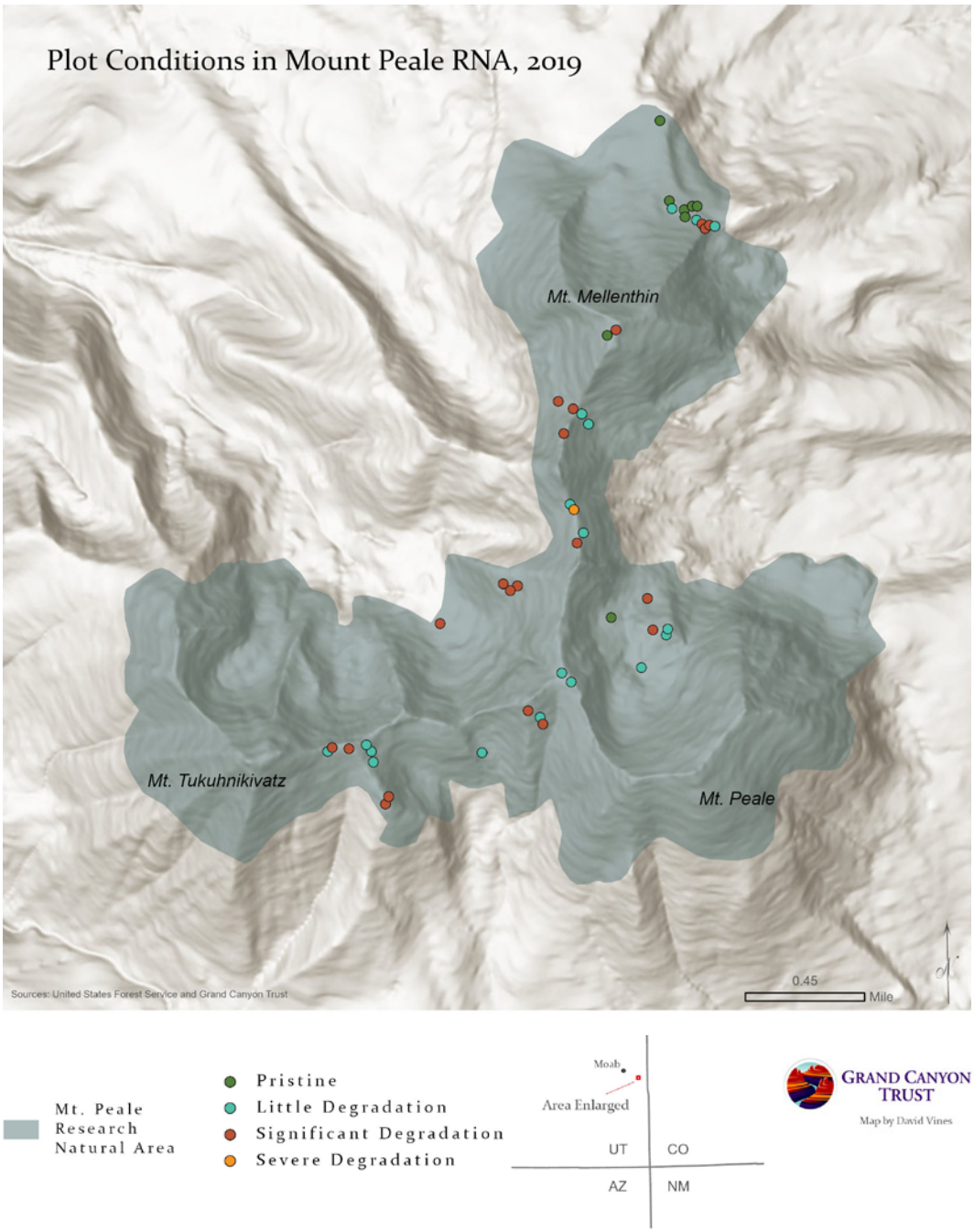

***Figure 15**. Plots (n = 47) assessed in the Mount Peale RNA in 2019 and their condition class (distinguished by dot color).*

of mountain goats were noted. We also searched for presence of five Manti-La Sal NF SCC plant species (Appendix 1), which are alpine wildflowers that are uncommon or rare in the Forest. The protocol is a qualitative site condition class assessment on a scale from 0 (pristine) to 4 (excessive change) based on written descriptions of disturbance (Appendix 2). Repeatedly judging the site condition class based on the class descriptions is a way to assess, over time, changes, if any, in the degree of physical disturbance by mountain goats that graze and trample vegetation, dig up the soil, uproot plants, and create large patches of bare ground (wallows).

Results

Wallows Survey

The 2019 wallow survey documented 297 wallows in the Mount Peale RNA, each containing at least one type of goat sign. The majority of wallows were observed on ridges and slopes just below the ridges, which are generally 11,500 to 12,200 ft in elevation (Figs. 16 and 17). Some wallows were in areas with dense turf vegetation, which required goats to dig out the plants to get to the soil (Figs. 18 and 19). In some cases goats also displaced loose gravel and rock below the turf that was removed (Figs. 20 and 21). In a few cases, it appeared that goats wallowed in dirt piles that had been created by burrowing animals (Fig. 22), but these were only counted as wallows if evidence of mountain goats was present. We also observed wallow complexes of large, nearly continuous bare soil which may have been created by groups of mountain goats (Fig. 23).

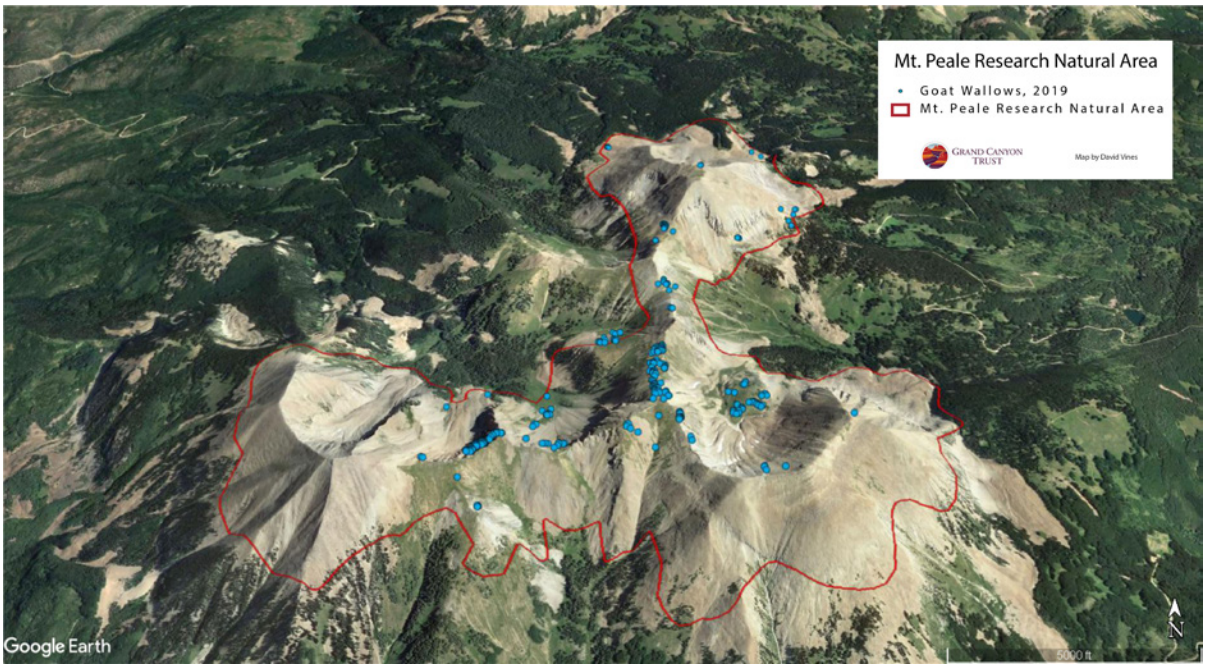

***Figure 16**. Wallow locations (blue dots) documented within the Mount Peale RNA (red line) in 2019. The 3-dimensional nature of this map shows that many of the wallows were on, or close to, ridges.*

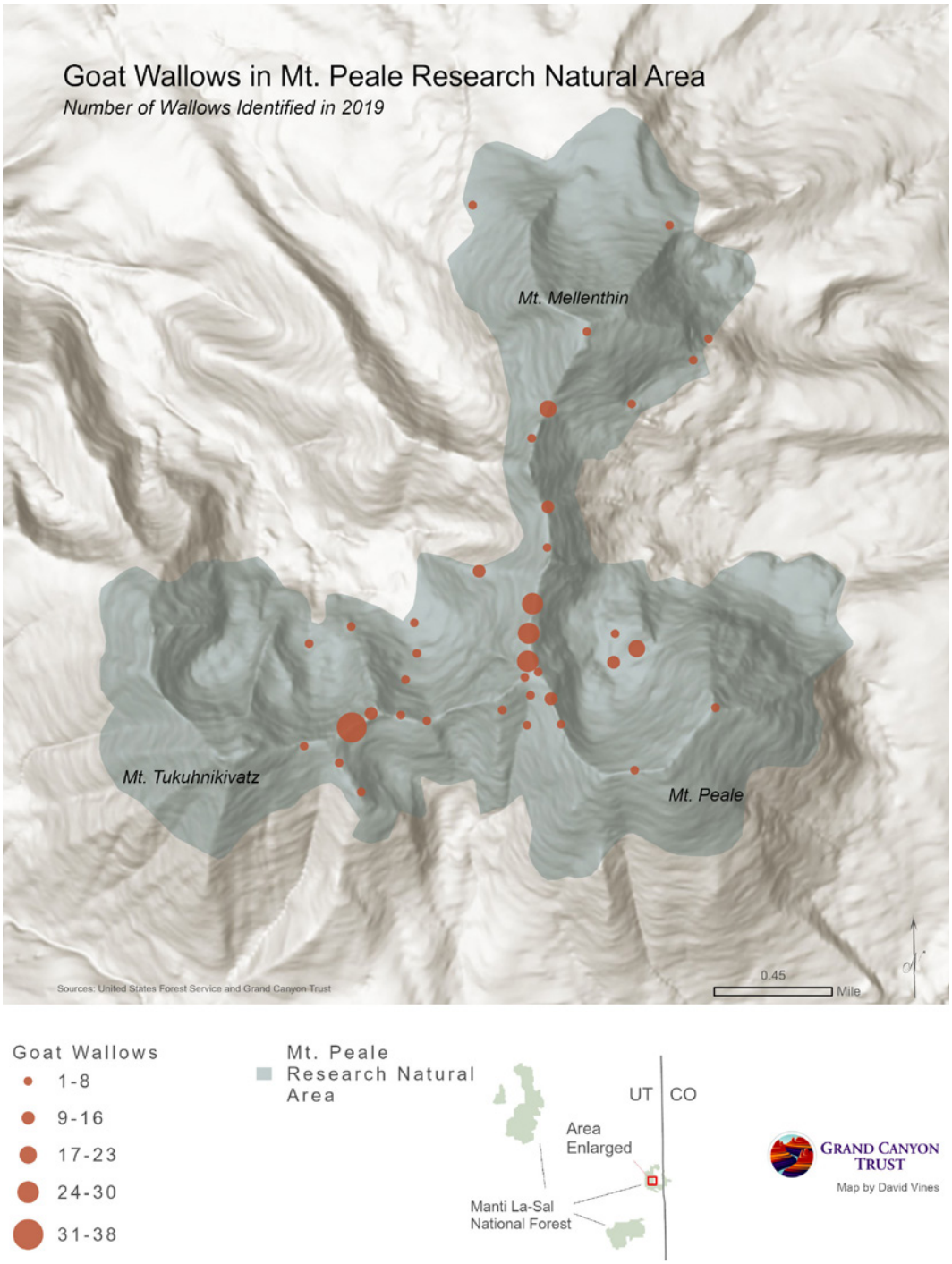

Figure 17*. Wallow locations (dots) documented in the Mount Peale RNA (shaded grey/green) in 2019. Larger dots indicate more wallows; the number of wallows is also listed.*

***Figure 18**. Wallow dug into turf, with a patch of white mountain goat fur (where the surveyor is pointing). Goat scat was nearby. Photo taken August 7, 2019 at 11,523 ft.*

***Figure 19**. Wallow dug into the turf on top of Mount Mellenthin. This wallow contained mountain goat fur and alpine plants that were grazed and uprooted. Photo taken August 29, 2019 at 12,612 ft.*

***Figure 20**. Wallow dug into turf and loose rock. A large clump of mountain goat fur is where the surveyor's pole is pointing. Photo taken July 16, 2019 at 11,987 ft.*

***Figure 21**. Wallow dug into turf and rock on steep slope. White fur (where surveyor's pole is pointing) and scat were indicators of mountain goats. The endemic (and SCC) La Sal daisy was near this wallow. Photo taken September 6, 2019 at 11,985 ft.*

Figure 22. *Piles of dirt, presumably from burrowing animals, where a mountain goat may have laid down. Left photo has imprint from an animal (possibly mountain goat) but was not counted as a wallow (taken August 7, 2019 at 11,453 ft). The right photo was counted as a wallow because white fur (by the blue pencil) and grazed plants were present (photo taken August 30, 2019 at 11,038 ft).*

Figure 23. *A large area of disturbed ground with evidence of mountain goats, including a clump of white fur where the surveyor's left pole is touching ground. This large mountain goat wallowing area is on a ridge below Mount Peale. Photo taken August 14, 2019 at 12,161 ft.*

Wallow size ranged from a few square feet to hundreds of square feet. The largest were complexes of multiple wallows. The median wallow size was 13.5 ft2, with median length and width of 4.0 ft. and 3.5 ft. The most common types of evidence indicating that mountain goats created the wallows and bare patches were sheared turf (51% of wallows) and scat (50% of wallows). Goat fur was noted at 26% of wallows, hoofprints at 22% and uprooted plants at 7% of wallows. Of the 297 wallows documented, 46% had multiple types of evidence of mountain goats. The various combinations of goat evidence are summarized in Fig. 24 and Table 1.

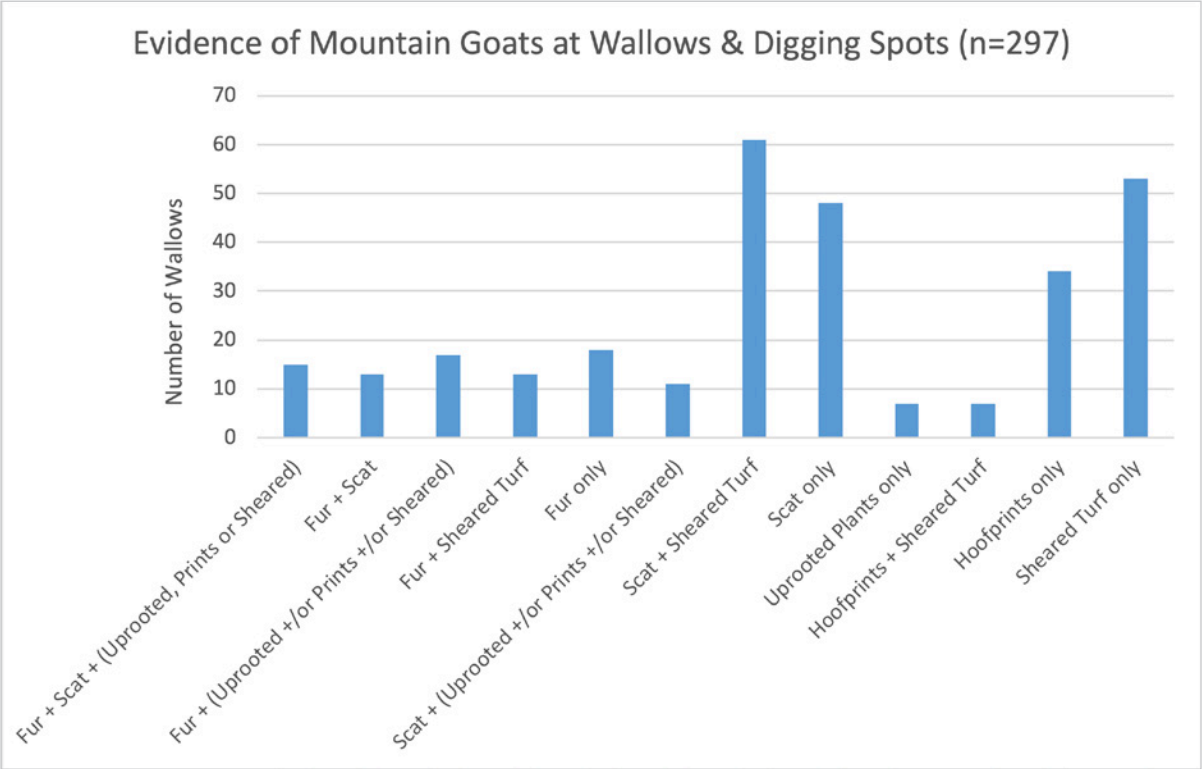

***Figure 24**. Signs of mountain goats observed at wallows and dug-out areas in the Mount Peale RNA in 2019. The wallow/digging areas on the left side of the graph contained the most abundant, definitive evidence of mountain goats, such as goat fur and goat scat, although all the signs listed were deemed to be due to mountain goats by weight of evidence. These data are also presented in Table 1.*

Table 1. Combinations of mountain goat evidence recorded at wallows in the Mount Peale RNA in 2019. The table is sorted from left to right so that the most definitive and abundant evidence of mountain goats are the top rows. These data are summarized in Fig. 24.

Fur	Scat	Uprooted Plants	Hoofprints	Sheared Turf	Wallow Count
X	X	X			2
X	X		X		3
X	X			X	10
X	X				13
X		X	X		5
X		X		X	2
X		X			1
X			X	X	2
X			X		7
X				X	13
X					18
	X	X		X	1
	X	X			2
	X		X	X	1
	X		X		7
	X			X	61
	X				48
		X			7
			X	X	7
			X		34
				X	53
					297 TOTAL

Plot Assessments

At the plots assessed in 2019, 16% of the site condition classes were pristine, 37% were assessed as little changed from pristine, 44% were judged to exhibit significant change from pristine and 2% (1 plot) exhibited severe change from pristine (Figs. 15 and 25.). Evidence of mountain goats — in the form of fur, scat, hoofprints and/or wallows — was observed at 68% of plots. When any one goat sign was observed at a plot, additional signs of goat were often present.

The availability of data from previous years allowed a comparison of site condition over time. In 2015, 58% of the plots were assessed to be in pristine condition (Class 0), whereas by 2019, only 16% of the plots were in pristine condition (Fig. 26). Over time, there is a pattern of plots moving into condition classes of more disturbed condition. An exception was a 9% increase in plots in pristine condition from 2017 to 2019, within the larger decline from 2015 to the later years. Plots assessed as significantly (Class 2) or severely (Class 3) departing from pristine condition increased from 2% in 2015, to 19% in 2017, and to 47% in 2019.

Another way to characterize the changes in these plots is to compare individual plots over time. From 2015 to 2019, 60% of plots declined in condition (30% changed one class and 30% changed two classes), whereas 37% of plots had the same condition class and only 2% (one plot) improved a condition class (Fig. 27). An example of a plot that changed to a worse condition class over time is shown in Fig. 28.

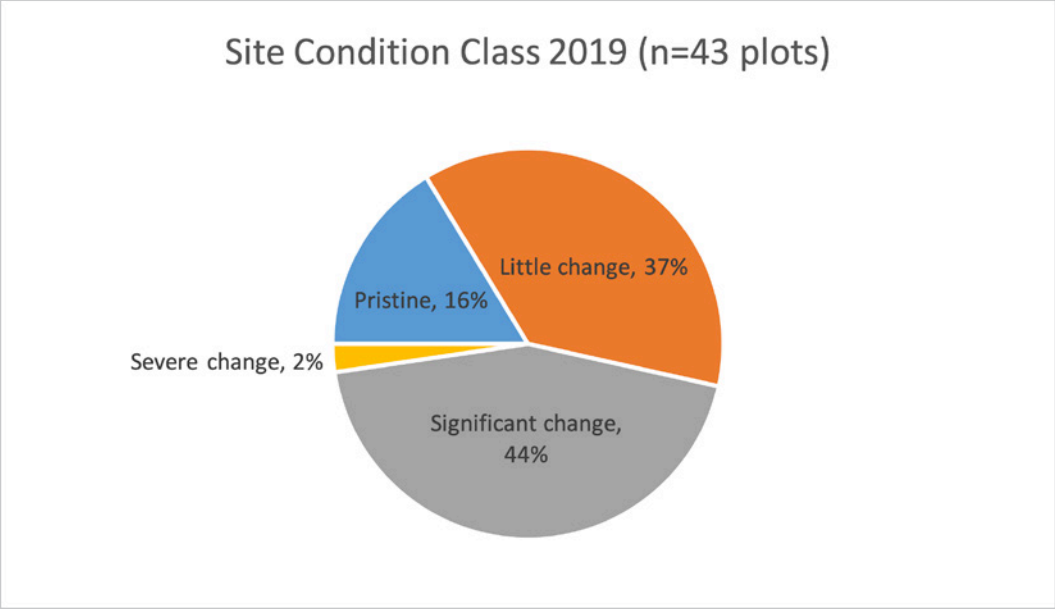

***Figure 25**. Condition classes of plots assessed in 2019.*

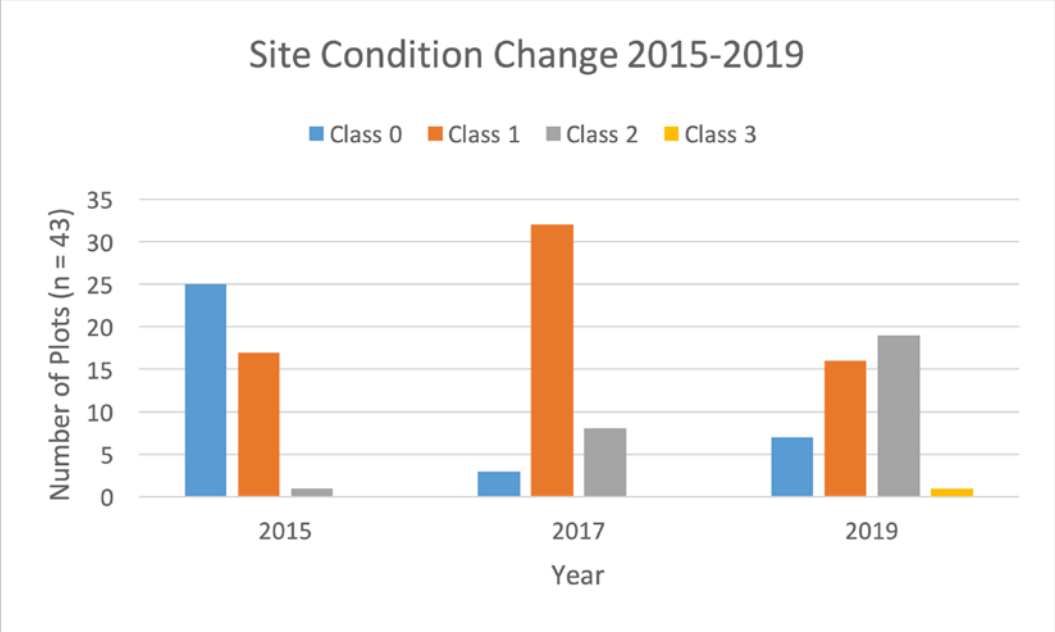

***Figure 26**. Site condition, showing a decline in condition (bar height shifts to the right) from 2015 to 2019 (see Appendix 2 for condition class descriptions).*

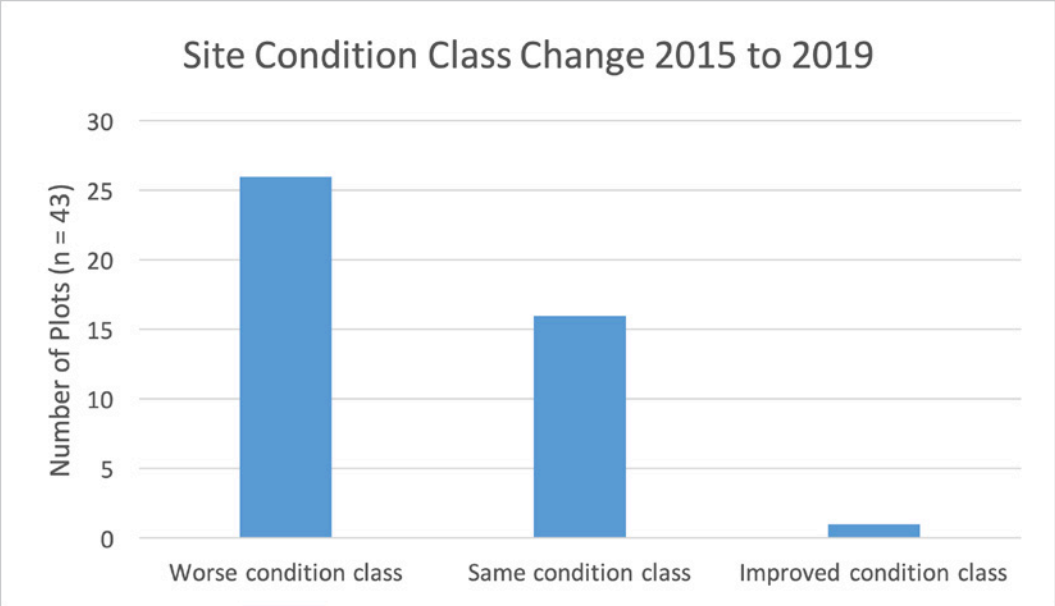

***Figure 27**. Count of plots that had different or the same condition class in 2019 compared to 2015. This summarizes the change at individual plots over time.*

***Figure 28**. Plot 120 in 2017 (left) and 2019 (right) showing the increase in bare ground, where mountain goats trail and wallow. Mountain goats were observed on the edge of this plot in 2017, including the goats in Fig. 4 which were only a few hundred feet away.*

We used a subset of the dataset described above, to determine change in the 13 plots that first had been assessed in 2008 (prior to the 2013 mountain goat introduction). This showed a decline of plots in the pristine condition class from 92% (12 of 13) in 2008 to 46% (6 of 13) in 2019 (Fig. 29). The percent of plots in the condition classes exhibiting disturbance (Class 1 and Class 2) increased from 8% in 2008 to 54% in 2019.

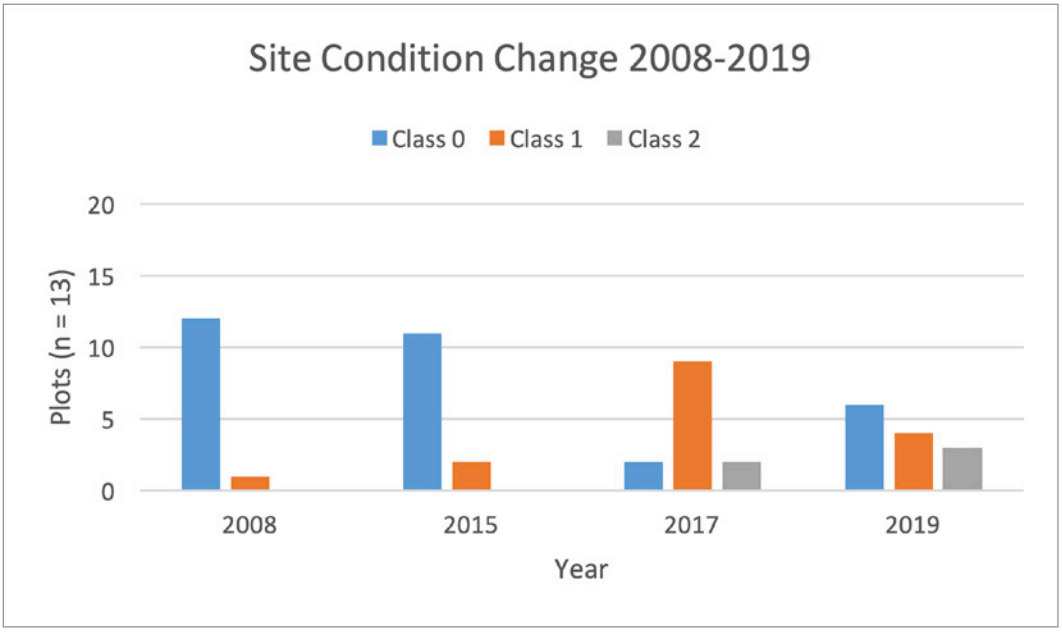

***Figure 29**. Site condition, showing a shift from mostly Class 0 "pristine" condition to Class 1 "little change from pristine" and Class 2 "significant change from pristine" over time. These 13 plots were the only plots that were assessed all four years.*

Sixty-six percent of the 47 plots assessed in 2019 contained at least one SCC plant species, and 49% contained multiple SCC species. Of the plots with SCC plants, 72% contained sign of mountain goats (as seen in Fig. 8). At the 47 plots there was a decline between 2017 and 2019 in the number of plots containing SCC plants, with the decline in presence of individual SCC plant species ranging from one to seven plots fewer in 2019 (Table 2). A comparison was not done with the 2015 data because that was done by different field crews with varying botanical knowledge and search effort, whereas the 2017 and 2019 data were collected by one of the authors (Marc Coles-Ritchie), with help from others, using consistent and professional botanical knowledge and search effort.

Table 2. Plots (of the 47 assessed) with SCC plants (Appendix 1) showing a decline from 2017 to 2019. Blackhead fleabane, the other SCC species searched for, was only observed at one plot in the two years so it is not included.

	Plots in 2017	Plots in 2019	Decline
Baker's alpineparsley	19	17	11%
Dwarf mountain ragwort	9	2	78%
La Sal daisy	23	19	17%
Sweetflower rockjasmine	21	20	5%

Discussion

The mounting evidence of negative impacts in the Mount Peale RNA that we documented would be expected given the increasing size of the resident population of mountain goats in the La Sal Mountains (35 goats in 2014; 105 in 2019). Their natural behavior of grazing, trampling, and digging in the alpine ecosystem invariably causes damage to plants and disturbs the soil. Many wallows were the size of one animal but in some locations large wallow complexes (as much as 50 ft long) were observed, with the bare areas appearing to be expanding over time (Fig. 23). We are watching the destruction of the alpine ecosystem within the Mount Peale RNA as we do these surveys. That this damage would be inevitable was known prior to the mountain goats' introduction to the La Sal Mountains and was stated by the Intermountain Regional Forester (Rasure 2013).

Research Natural Areas such as Mount Peale RNA are intended to "serve as reference areas for the study of natural ecological processes including disturbance and climate change" (FSM 4063.02). The ability to study the impacts of climate change is especially important given that there is very little alpine area in the Colorado Plateau (Fig. 5). The State of Utah (UDWR 2013a) has a goal to increase the mountain goat population in the La Sal Mountains to 200 which, as the data in this report indicate, will only lead to further destruction and accelerated loss of the native, alpine turf community in the Mount Peale RNA.

Wallows

We made a significant effort to systematically survey the Mount Peale RNA for wallows. We focused on areas less than 30% slope to minimize traverses of steep, precarious talus slopes (which we did end up traversing in some cases). It seemed likely that goats would wallow on those flatter areas (less than 30% slope) where soil and vegetation can more easily develop, and therefore it was anticipated that our search would capture many, if not most, of the wallows.

We documented 297 wallows in the Mount Peale RNA. Yet this was an undercount for two reasons. The first reason is that we relied on evidence of mountain goats (fur, scat, uprooted plants, hoofprints and sheared turf) to confirm that bare patches were created by mountain goats. When there was evidence of mountain goat activity in the bare patches we documented it as a wallow. But in some cases that evidence may have been removed by wind, water or animals, in which case we would not have counted it. We were conservative in our count and did not include any bare areas without supporting evidence that goats were the cause. There were at least 80 other spots that were originally recorded because they looked like wallows, but were not included in the final count because no evidence of goats was recorded.

The second reason our count was an underestimate of wallow numbers is because we focused on areas less than 30% slope. As we were doing the survey we sometimes encountered wallows on slopes greater than 30% and we documented those wallows when we could access them (Fig. 21), but we did not systematically survey areas greater than 30% slope.

Plot Condition

We used multiple years of data to document the increasing impacts of goats (i.e., soil erosion, uprooted plants, sheared turf, and wallows) at plots throughout the Mount Peale RNA. Our assessment using the protocol of Rochefort and Swinney (2000) showed a consistent decline in condition class from 2008 to 2019. There is a strong pattern of disturbance to vegetation and soil, hence declining conditions signaling mountain goat-related degradation of the Mount Peale RNA (Figs. 26, 27 and 29).

There are strengths and weaknesses to the Rochefort and Swinney (2000) protocol. A strength is that it involves repeated assessments of the same fixed-area, georeferenced plots. Locating plots with GPS coordinates worked well, and there was likely minimal spatial variability in the plots across years. One of the authors (Marc Coles-Ritchie) visited all of the plots in 2017 and 2019, which facilitated accurate re-location of

plots. The protocol involves searching for and recording specific conditions and disturbances (Appendix 2), which is helpful in assigning the site condition class. Observation of SCC plants is useful for documenting presence, but not abundance, of these plants at a given plot. Photos taken at each plot provide support for evaluating change and confirming the presence of SCC plants. The qualitative nature of the site condition class is a weakness of this protocol because it relies on the observers matching their observations with one of the condition classes described in the protocol. Other field crews conducted the assessments in 2008 and 2015, which would be a potential source of observer variability. Since Marc Coles-Ritchie visited all of the plots in 2017 and 2019, observer variability was reduced in those years. The qualitative nature of the protocol may have been the cause for the slight increase (9%) in sites assessed as pristine from 2017 to 2019, but there was a much larger (42%) decline in sites in pristine condition from 2015 to 2019.

Further evidence of the impacts of mountain goats is the decline in the presence of SCC plants in plots from 2017 to 2019 (Table 2). Our documentation of SCC plants, while not as intensive as the Forest Service study noted below, indicates that mountain goats are reducing the number of SCC plants in the Mount Peale RNA. Protecting rare plants was one of the purposes (but not the only one) for establishing the Mount Peale RNA (Evenden et al. 2001). We documented that 74% of plots with SCC plants had evidence of mountain goats. Also, we observed SCC plants on the margins of wallows (Fig. 21), which would indicate that goats have almost certainly removed SCC plants within those bare areas.

Recreation Impacts

It could be postulated that hikers are the cause of the ground disturbance in the Mount Peale RNA. But 100% of the wallow/dug-out areas has evidence of mountain goats, and 68% of the 47 assessment plots we assessed in 2019 had evidence of mountain goats. The 32% of assessed plots may also have been impacted by mountain goats, but we did not document clear evidence of goats in the form of fur, scat, hoofprints or wallows. While there is evidence of trails from hikers, especially on the ridges that are routes between the peaks, wallows are not being dug by hikers or the occasional cow, elk or deer whose activities have been captured by Forest Service wildlife cameras in the alpine area of the La Sal Mountains. There are more goats than hikers in the La Sal Mountains, as documented by wildlife cameras that the Forest Service placed in the alpine area (above 11,000 ft) in the La Sal Mountains (USDA-FS 2019). In the part of the La Sal Mountains where the RNA is located, those cameras documented 1.8 to 5.1 times (for different cameras) more goats than recreationists (hikers). In other parts of the La Sal Mountains (outside the RNA, but still above 11,000 ft) their data indicated 30 times more goats than hikers. Mountain goats are known to dig in areas where people have urinated (USDOI-NPS 2018) but if goats were not present on the mountain, urination sites would not be disturbed.

Cumulative Impacts

The impacts of mountain goats that graze and dig in the alpine turf ecosystem, are cumulative with other, generally smaller, physical disturbances from hikers, the occasional ungulate other than mountain goats (deer, elk, cattle) and pocket gophers. In this small and fragile alpine ecosystem the effects of these impacts add up, with mountain goats providing the most dispersed, widespread, and inevitable destruction of the alpine vegetation.

Climate change is causing earlier snowmelt in Utah (Gillies et al. 2012), exposing the alpine vegetation and soil for longer portions of the year to mountain goats, other animals and humans. Drought exacerbates the impacts as plants that experience grazing are also water-stressed and regeneration where plants have been uprooted may be less likely. The extreme drought conditions of 2018, the third worst since 1900 (NOAA), may have been the reason there were cattle droppings (Fig. 30) in at least six locations in the RNA (over 11,000 ft) in 2019. We had not seen cattle droppings in the RNA the previous two years. The extreme drought of 2018 likely caused cattle to go up to the alpine area in late 2018 when forage was less available at lower elevations. With documentation (Gillies et al. 2012) and predictions (Lukas et al. 2014) of increasing temperatures and earlier snowmelt in the region and the ongoing impacts from mountain goats, climate change is a cumulative stressor for alpine plants in the Mount Peale RNA.

***Figure 30**. Cattle dropping in the Mount Peale RNA, at 11,774 ft. The tallest peak in the background is Mount Peale. Photo taken August 13, 2019.*

Forest Service Study

Beginning in 2015 (i.e., two years after the mountain goat introduction) the Forest Service began a study of conditions within the alpine area of the La Sal Mountains. That study is intended to answer the question "Is the Forest Service preserving and maintaining natural conditions and processes, and biological and genetic diversity, including threatened, endangered, and sensitive species in the Mt Peale Research Natural Area and the La Sal Mountains?" (USDA-FS 2017b). The study involves quantitative monitoring of the abundance of four SCC forb (wildflower) species in 93 plots across the La Sal Mountains, including the RNA. Species composition (all species) is being documented at eight sites. This monitoring is intended to help the Forest Service "identify management action triggers . . . and management options for mountain goats and/or recreation in La Sal Mountain alpine communities and the Mount Peale RNA" (USDA-FS 2017b). To our knowledge, the Manti-La Sal has not identified management triggers or management options for mountain goats. Forest Service analysis in 2019 (USDA-FS 2019; undated document in "RMRS" folder obtained through FOIA) indicated that evidence of ungulates (primarily mountain goats in the La Sal Mountain alpine setting) was increasing and that forb and graminoid cover were decreasing during 2015-2018. They concluded that there was no statistical evidence that La Sal daisy or sweetflower rockjasmine were declining, but "there was some indication that ungulate grazing had a negative effect on Erigeron [La Sal daisy] population abundance in 2018" (USDA-FS 2019; undated doc in "RMRS" folder obtained through FOIA). The Forest Service analysis indicated that the low abundance of dwarf mountain ragwort (*Senecio fremontii var. inexpectatus*) in the La Sal Mountains alpine area made it "not possible to estimate trends for Senecio" (USDA-FS 2019). But it is noteworthy that 10 of 11 Forest Service plots with dwarf mountain ragwort had a decline in cover from 2015 to 2018 and the average decline was 13% (USDA-FS 2019). That is consistent with our data which showed a decrease in the number of plots where dwarf mountain ragwort was observed from nine plots in 2017 to two plots in 2019 (Table 2). This plant that is "critically imperiled" (NatureServe and USDA-FS Rare Plant Profiles) typically grows on rocky slopes that are often unstable, making it vulnerable to disturbance from mountain goats that walk or dig on those slopes.

The Forest Service also has wildlife camera data that indicate the numbers and usage patterns of large animals (elk, deer and mountain goats) in the alpine area. Data from 11 wildlife cameras deployed in 2016 across the La Sal Mountains above 11,000 ft (not just the RNA) documented many more mountain goats than other animals: 63% mountain goats, 21% deer and 16% elk (USDA-FS 2016). Subsequent data in 2018 in the area of the Mount Peale RNA, detected 34 to 157 times (for different cameras) more goats than deer or elk (USDA-FS 2019). With the mountain goat population increasing from 35 animals in 2014 to 105 goats in 2019, it would be expected that mountain goats would be an increasing percentage of the animals detected by the wildlife cameras. The increasing number of mountain goats will increasingly disturb this alpine ecosystem.

Other Areas with Introduced Mountain Goats

Impacts from introduced mountain goats have also been documented in Olympic National Park where "mountain goats cause soil erosion, impact native plant communities, and occupy habitat for native species" (USDOI-NPS 2018, Executive Summary). As a result, Olympic National Park is taking the dramatic step of removing all mountain goats, which are not native to the Park. Removal began in 2018, and as of September 2019, about half the population had been removed, with 275 mountain goats translocated to their native range in the Cascade Mountains, 16 transferred to zoos, and 35 animals dead or killed (USDOI-NPS 2019a).

Similarly, Grand Teton National Park is concerned about the impacts of mountain goats, which are not native there. That Park has developed a plan to remove the non-native mountain goats to "...1) aid in the conservation of a native population of Rocky Mountain bighorn sheep whose status is tenuous; and 2) protect other park resources and values from the rapidly growing non-native mountain goat population" (USDOI-NPS 2019b). The removal of mountain goats from Grand Teton National Park is expected to begin in 2020.

Conclusion

This study documents the declining condition of the alpine ecosystem in the 2,380-acre Mount Peale RNA since introduction of non-native mountain goats to the La Sal Mountains in 2013. There are major impacts from mountain goats on soil and vegetation, including in areas with SCC plants such as the endemic La Sal daisy (found only in the La Sal Mountains alpine area) and dwarf mountain ragwort (a critically imperiled plant). We documented over 297 wallows where mountain goats have uprooted alpine vegetation and dug into the soil, creating bare patches that result in vegetation loss and soil erosion in a rugged alpine environment where soil development and vegetation growth are slow. As the number of non-native mountain goats continues to increase toward the DWR goal of 200 animals, the damage to the alpine vegetation and soil can only increase. The increasing temperature associated with climate change, which will continue to shorten the season of snow cover in the La Sal Mountains, will lead to even more mountain goat damage to vegetation and soil in the Mount Peale RNA. Recovery from this disturbance, particularly the removal of plants and soil, will be very slow if not impossible, due to the challenging conditions (short growing season, shallow soil and steep slopes) of this rugged alpine environment. It is ironic and discouraging that this RNA, expressly established to protect native biota, is being subjected to large non-native ungulates for sport hunting (UDWR 2020; hunting guidebook with mountain goat on cover) and recreational viewing.

References

[CFR] Code of Federal Regulations 36 § 251.23. https://www.law.cornell.edu/cfr/text/36/251.23 (accessed January 28, 2020).

Coles-Ritchie, M. 2017a. Modified by Mountain Goats. Grand Canyon Trust. https://www.grandcanyontrust.org/modified-mountain-goats (accessed January 28, 2020).

Coles-Ritchie, M. 2017b. Kicking the Alpine Plants Out: Mountain Goat Wallows In Mount Peale Research Natural Area (La Sal Mountains, Utah). https://www.grandcanyontrust.org/plots/default/files/resources/Utah_forests_wallows_Mount_Peale_RNA_report_2017_11_21.pdf (accessed January 28, 2020).

Coles-Ritchie, M. 2018. Ongoing Damage by Mountain Goats to the Mount Peale Research Natural Area. Grand Canyon Trust. https://www.grandcanyontrust.org/sites/default/files/resources/Utah_Forests_Goat_Damage_Mt_Peale_7_7_2018.pdf (accessed January 28, 2020).

Evenden, A. G.; M. Moeur.; J.S. Shelly.; S.F. Kimball; C.A. Wellner. 2001. Research Natural Areas on National Forest System lands in Idaho, Montana, Nevada, Utah, and Western Wyoming: A guidebook for scientists, managers, and educators. Gen. Tech. Rep. RMRS-GTR-69. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 84 p.

Festa-Bianchet, M. 2008. *Oreamnos americanus*. The IUCN Red List of Threatened Species 2008: e. T42680A10727959. https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T42680A10727959.en. (accessed on January 23, 2020).

[FSM] Forest Service Manual 4063.02. Research and Development Chapter 4060, National Headquarters (WO), Washington DC. Effective date September 11, 2019.

Gillies, R., S. Wang, and M. Booth. 2012. Observational and Synoptic Analyses of the Winter Precipitation Regime Change over Utah. *Journal of Climate*. 25. 4679-4698. 10.1175/JCLI-D-11-00084.1.

Jones, A., B. Hansen, and M. Moyano. 2015. Impacts of Non-Native Mountain Goats in Introduction Areas of the West: A Review of the Literature. Wild Utah Project, Salt Lake City, Utah. https://static1.squarespace.com/static/57c5f6aa579fb31d71581457/t/58bb585da5790a1de0c40d4a/1488672862793/Goat+Lit+Review+summary+Nov+2015.pdf (accessed January 28, 2020).

Lukas, J., J. Barsugli, N. Doesken, I. Rangwala, K. Wolter. 2014. Climate Change in Colorado A Synthesis to Support Water Resources Management and Adaptation Second Edition. A Report for the Colorado Water Conservation Board Western Water Assessment, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder. https://wwa.colorado.edu/climate/co2014report/Climate_Change_CO_Report_2014_FINAL.pdf (accessed February 19, 2020).

NatureServe. http://explorer.natureserve.org/ (accessed January 28, 2020).

[NOAA] National Centers for Environmental information, Climate at a Glance: Divisional Time Series, https://www.ncdc.noaa.gov/cag/ (accessed February 19, 2020).

Patterson, B.D., G. Ceballos, W. Sechrest, M.F. Tognelli, T. Brooks, L. Luna, P. Ortega, I. Salazar, and B.E. Young. 2003. Digital Distribution Maps of the Mammals of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA. (accessed via NatureServe.org January 28, 2020).

Rasure, N. August 21, 2013. Letter to Gregory Sheehan, Executive Secretary, Division Director, Wildlife Division Board, Utah Division of Wildlife Resources. File Code 2600/2680.

Rochefort, R.M. and D.D. Swinney. 2000. Human impact surveys in Mount Rainier National Park: past, present, and future. In: Cole, David N.; McCool, Stephen F.; Borrie, William T.; O'Loughlin, Jennifer, comps. 2000. Wilderness Science in a Time of Change Conference—Volume 5: Wilderness Ecosystems, Threats, and Management; 1999 May 23– 27; Missoula, MT. Proceedings RMRS-P-15-VOL-5. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Smith, B. 2008. Mt. Peale Research Natural Area Alpine Vegetation Impact Assessment Final Report. U.S. Department of Agriculture, Forest Service, Manti-La Sal National Forest.

[UDWR] Utah Division of Wildlife Resources. 2013a (unpublished document). Mountain Goat Herd Unit Management Plan. Wildlife Management Unit #13, La Sal Mountains, June 2013.

[UDWR] Utah Division of Wildlife Resources. 2013b. Utah Mountain Goat Statewide Management Plan. Utah Department of Natural Resources. https://wildlife.utah.gov/pdf/bg/mtn_goat_plan.pdf (accessed January 30, 2020).

[UDWR] Utah Division of Wildlife Resources. 2020. Big Game Application Guidebook. Utah Department of Natural Resources. https://wildlife.utah.gov/guidebooks/2020_biggameapp.pdf (accessed February 19, 2020).

[UNPS] Utah Native Plant Society. 2016. The Utah Native Plant Society Rare Plant List: Version 2. By Jason Alexander, in Calochortiana. Number 3. http://www.unps.org/Calochortiana/CalochortianaMay2016Num3.pdf (accessed Jan. 28, 2020).

[UNPS] Utah Native Plant Society. 2017a. Opening brief on August 9, 2017 for Case No. 17-4074, Utah Native Plant Society and Grand Canyon Trust v. U.S. Forest Service and Tom Tidwell. https://www.grandcanyontrust.org/sites/default/files/resources/uf_La_Sal_goats_opening_brief_8_9_17.pdf (accessed January 28, 2020).

[UNPS] Utah Native Plant Society. 2017b. Legal appeal on December 19, 2017 for Case No. 17-4074, Utah Native Plant Society and Grand Canyon Trust v. U.S. Forest Service and Tom Tidwell. https://www.grandcanyontrust.org/la-sal-goats-reply-brief (accessed January 28, 2020).

[USDA-FS] U.S. Department of Agriculture, Forest Service. 2012. National Forest System Land Management Planning 36 CFR 219.9(b)(2)(ii)(c). https://www.gpo.gov/fdsys/pkg/CFR-2017-title36-vol2/xml/CFR-2017-title36-vol2-part219.xml#seqnum219.9 (accessed January 28, 2020).

[USDA-FS] U.S. Department of Agriculture, Forest Service. 2016. 2016 La Sal Alpine Vegetation Monitoring Project, Trail camera videos. Internal report of the Manti-La Sal National Forest (author not listed). File name: "2016LaSalAlpineVegMonitoringPrj_trailCameras3pg."

[USDA-FS] U.S. Department of Agriculture, Forest Service. 2017a. Identification of the Manti-La Sal National Forest Plant Species of Conservation Concern (memo by Nora B. Rasure, Regional Forester, dated Sept 8, 2017). Intermountain Region, Ogden, Utah.

[USDA-FS] U.S. Department of Agriculture, Forest Service. 2017b. Alpine Vegetation Monitoring Plan: La Sal Mountains and Mt. Peale Research Natural Area. Manti-La Sal National Forest and Utah Division of Wildlife Resources.

[USDA-FS] U.S. Department of Agriculture, Forest Service. 2019 Manti-La Sal National Forest. Freedom of Information Act FOIA 2019-FS-R4-04424-F to Manti-La Sal National Forest, from Grand Canyon Trust, July 3, 2019.

[USDA-FS] U.S. Department of Agriculture, Forest Service. Rare Plant Profiles. *Senecio fremontii* var. *inexpectatus*, La Sal Mountains groundsel. https://www.fs.fed.us/wildflowers/Rare_Plants/profiles/Critically_Imperiled/senecio_fremontii_var_inexpectatus/index.shtml (Accessed February 19, 2020).

[USDOI-NPS] United States Department of Interior - National Park Service. 2018. Final Mountain Goat Management Plan / Environmental Impact Statement. Olympic National Park. https://parkplanning.nps.gov/document.cfm?parkID=329&projectID=49246&documentID=87542 (accessed January 28, 2020).

[USDOI-NPS] United States Department of Interior - National Park Service. 2019a. News Release September 12, 2019: August Capture and Translocation Activities Moved 101 Mountain Goats to Northern Cascades Mountains. https://www.nps.gov/olym/learn/news/august-capture-and-translocation-activities-moved-101-mountain-goats-to-northern-cascades-mountains.htm (accessed January 28, 2020).

[USDOI-NPS] United States Department of Interior - National Park Service. 2019b. Grand Teton National Park and John D. Rockefeller Jr. Memorial Parkway, Finding of No Significant Impact, Mountain Goat Management Plan Environmental Assessment. https://parkplanning.nps.gov/document.cfm?parkID=68&projectID=47959&documentID=99126 (accessed January 28, 2020).

Appendix 1
Species of Conservation Concern

Five alpine plant Species of Conservation Concern (SCC) in the Manti-La Sal National Forest, which were searched for and recorded during field surveys in the La Sal Mountains.

Species	Conservation Status
Baker's alpineparsley (*Oreoxis bakeri*)	Species of conservation concern (USDA-FS 2017a); High conservation priority (UNPS 2016); Critically imperiled status in Utah (NatureServe).
Blackhead fleabane (*Erigeron melanocephalus*)	Species of conservation concern (USDA-FS 2017a); Watch list (UNPS 2016); Critically imperiled status in Utah (NatureServe).
Dwarf mountain ragwort or La Sal Mountains groundsel (*Senecio fremontii* var. *inexpectatus*)	Species of conservation concern (USDA-FS 2017a); High conservation priority (UNPS 2016); Critically imperiled status (NatureServe); Only found in La Sal Mountains (Utah) and San Juan Mountains (Colorado).
La Sal daisy (*Erigeron mancus*)	Species of conservation concern (USDA-FS 2017a); High conservation priority (UNPS 2016); Critically imperiled status (NatureServe); Endemic to La Sal Mountains (found nowhere else).
Sweetflower rockjasmine (*Androsace chamaejasme subsp. lehmanniana [Syn. Androsace chamaejasme* var. *carinata*]	Species of conservation concern (USDA-FS 2017a).

Appendix 2
Site Condition Class

The Site Condition Classes from Rochefort and Swinney (2000) are presented below.

Class	Short Description	Long Description
0	pristine	No signs of human or ungulate use of the area.
1	little change	Small and temporary indications of use caused by people or animals, such as litter, trampled vegetation, scuffed soil, foot/hoofprints, light grazing but no lasting damage such as plant loss, erosion or broken stems.
2	significant change	Human impacts easily recognizable but limited in severity or distribution; examples include uprooted plants, clearing of forest litter creating a trail or campsite, clearing of pebbles or rocks in fellfields, compacted soil, but not erosion; impacts from animals include digging and goat wallows, area of individual impacts should be small (< 1 ft in diameter) and covering a small portion of the sample area (<10-15%).
3	severe change	Few severe impacts or many moderate impacts with an extensive distribution so that the sample area is fragmented; severe impacts include construction of rock walls, eroded social trails (greater than 1" deep), very large compacted sites; extensive, moderate impacts could cover up to 50% of the sample area.
4	excessive change	This level of impact is reached when 50% or more of the site is covered by permanent impacts such as plant or soil loss or erosion.