



Alpine vegetation composition and structure monitoring for Great Sand Dunes National Park and Preserve

2025 Trip Report



Bodie Spinner, Phil Krenning, Sonja Long, Maya McCain, and Elizabeth Wu work on 1x1 quadrats at 13,000+ ft on SIX, also known as Medano Peak.

NPS / LAUREN LAUGHLIN

Alpine vegetation composition and structure monitoring for Great Sand Dunes National Park and Preserve

2025 Trip Report

Lauren Laughlin¹, Katherine Zybko²

¹ Colorado Natural Heritage Program
Colorado State University
1475 Campus Delivery
Fort Collins, CO 80523

²National Park Service
Rocky Mountain Network
1201 Oakridge Dr.
Fort Collins, CO 80521

³ National Park Service
Northern Colorado Plateau Network
P.O. Box 848
Moab, UT 84532

Eliot Rendleman³, editor

Please cite this publication as:

Laughlin, L., and Zybko, K. 2026. Alpine Vegetation Composition and Structure Monitoring for Great Sand Dunes National Park and Preserve: 2025 Trip Report. National Park Service Unpublished Report. Fort Collins, Colorado. <https://irma.nps.gov/DataStore/Reference/Edit/2317200>

March 2026
U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

Contents

	Page
Figures.....	iv
Tables.....	v
Executive Summary	vi
Acknowledgments.....	vii
Introduction.....	1
Training.....	1
Camp and Site Access.....	2
Research Site.....	4
Field Sampling	7
HUK.....	9
Site Access and Set-up.....	9
Observations and Sampling Errors	9
MUD	10
Site Access and Set-up.....	10
Observations and Sampling Errors	11
PAD.....	12
Site Access and Set-up.....	12
Observations and Sampling Errors	13
SIX	13
Site Access and Set-up.....	14
Observations and Sampling Errors	15
Notes for Future Sampling.....	17
Conclusion	19
Literature Cited	20
Appendix A: US-GRSA 2025 Field Log	21
Appendix B: US-GSD 2025 Route Maps	23
Appendix C: ROMN Revisit SOP	26
General revisit tips	26

Contents (continued)

Workflow for setting up a summit site.....	26
3x3 quadrat cluster set up	27
Summit Area Section sampling tips.....	27
Quadrat cluster sampling tips.....	28

Figures

	Page
Figure 1. The parking area at Rainbow Trailhead for access to HUK, MUD, and PAD.....	2
Figure 2. The stream with the PVC pipe to gather water to the northwest of North Basecamp.	3
Figure 3. Locations of the four GLORIA peaks in Great Sand Dunes National Park and Preserve.....	5
Figure 4. U.S. Drought Monitor Map for Colorado at the time of GLORIA Great Sand Dunes sampling in 2025. Star shows the location of the GLORIA site.....	8
Figure 5. Training the crew on botany and cover estimates on HUK in Great Sand Dunes National Park and Preserve.....	10
Figure 6. Elizabeth Wu and Kati Zybko sampling quadrats on MUD in Great Sand Dunes National Park and Preserve, with a view of Crestone Peak to the northeast.	11
Figure 7. A view of the sunrise over the valley from the hike to PAD.....	12
Figure 8. Looking towards Mount Herard and SIX from PAD in Great Sand Dunes National Park and Preserve.	13
Figure 9. Surveying plots on the flank of SIX in Great Sand Dunes National Park and Preserve.	14
Figure 10. Photo showing the SIX N 3x3 plot grid and the logger location flagged near the whiteboard, outside the plot. Logger is installed to the right of the plot when looking towards the summit.....	16
Figure 11. Overview of 2025 access routes to reach trailheads in Great Sand Dunes National Park and Preserve.	23
Figure 12: Routes from the parking area to camp, HUK, MUD, and PAD in Great Sand Dunes National Park and Preserve.	24
Figure 13. Route from Medano Lake trailhead to camp and SIX in Great Sand Dunes National Park and Preserve.	25

Tables

	Page
Table 1: Name, location, elevation, and vegetation zone of the four alpine sites within the target region of GRSA.	6
Table 2. Summary of field activities and crew logistics for the 2025 GLORIA vegetation survey. ..	21

Executive Summary

The purpose of the National Park Service (NPS) Inventory & Monitoring (I&M) Program is to develop and provide scientifically credible information on the current status and long-term trends of the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. The Rocky Mountain I&M Network (ROMN) identified vegetation composition, structure, and soils as a vital sign used to better understand the condition of park ecosystems (Britten et al. 2007).

The Great Sand Dunes National Park and Preserve (GRSA) Global Observation Research Initiative in Alpine Environments (GLORIA) alpine monitoring site was established by ROMN in 2009 to study the impacts of climate change on alpine vegetation composition and soils over time. The timeline for activities at this site includes the following events:

- In 2008, an alpine monitoring site was selected, and some reconnaissance measurements were taken at GRSA following GLORIA guidance.
- In 2009 and 2010, four sentinel sites were established and sampled on four unnamed peaks on the ridge extending north from Mount Herard (referred to as MUD, HUK, PAD, and SIX; Ashton 2010). The peaks range in elevation from 3,550 to 4,000 meters.
- In 2015, 2020, and 2025, CNHP crews fully surveyed the four sentinel sites, including all 1x1 m quadrat clusters and summit area sections. All soil data loggers were collected and replaced at each peak in 2024. Soil samples were scheduled to be collected in 2025 but were not, since the ROMN network is downsizing protocols and soil chemistry is not part of the official GLORIA protocol.
- In 2025, the crew had two 8-day hitches scheduled on the calendar as a buffer for weather and other unknowns. The crew was able to sample all four peaks over two hitches: the first a 6-day hitch (including travel) and the second a 3-day hitch (including travel).

GLORIA sites are typically surveyed every five years for vegetation composition, structure, and soils. Site establishment and baseline monitoring were carried out in 2009. Due to logistical challenges and concurrent GLORIA resampling at Rocky Mountain National Park, the first revisit occurred in 2015 and the second in 2020. In 2025, sites were fully surveyed again, following guidance from NPS and GLORIA protocols. The purpose of this report is to outline the basic timeline of sampling, any irregularities or errors in surveying, and logistical details that may be beneficial for future survey crews.

Acknowledgments

We would like to thank all who assisted with field work, training, and preparation, and who provided knowledge and insight necessary for the GLORIA study. We are grateful for our undergraduate interns Rebecca Fries, Liam Bauer, and Maya McCain, who hit the ground running and were excited to learn the protocol and alpine plants. We also would like to acknowledge Phil Krenning, Ed Brett, Mila Garelle-Essam, and Grant Pottash, who volunteered their time to help with the fieldwork. Special thanks to staff at the Rocky Mountain I&M Network and Great Sand Dunes National Park and Preserve for helping with pre-season field coordination, field sampling, and coordinating safety check-ins and aiding us with our backcountry itinerary.

Introduction

The Rocky Mountain I&M Network (ROMN) adapted an alpine monitoring protocol from the Global Observation Research Initiative in Alpine Environments (GLORIA), an international monitoring network established in 2001, to assess and predict biodiversity and temperature changes in alpine communities in response to drivers such as climate change (Pauli et al. 2004). The goals of the GLORIA program are to provide a global baseline for vegetation monitoring in alpine environments and to assess the risks of biodiversity loss and ecosystem instability from climate change. The methodology is extended by cooperators such as the ROMN and the Colorado Natural Heritage Program (CNHP), to create a long-term monitoring network at the global scale. In 2025, all four sentinel sites were sampled following the GLORIA protocol and the ROMN protocol to sample disturbance.

In 2025, a field crew of 10 people—three volunteers (Ed Brett, Mila Garelle-Essam, and Grant Pottash), two NPS botanists (Kati Zybko and Elizabeth Wu), two CNHP botanists (Lauren Laughlin and Clark Hollenberg), a CNHP field technician (Sonja Long) and two interns (Rebecca Fries and Liam Bauer)—sampled HUK, MUD and PAD over the course of five field days. A field crew of eight people—one volunteer botanist from BLM (Phil Krenning), three interns (Rebecca Fries, Liam Bauer and Maya McCain), two CNHP botanists (Lauren Laughlin and Bodie Spinner), a CNHP field technician (Sonja Long), and one NPS botanist (Elizabeth Wu)—sampled SIX in one day. In total, all four peaks were sampled in eight days, including travel days. Appendix A outlines daily activities, including the time spent at each peak, how long it took to hike to the peak, and who was present during sampling. The following summary outlines key information about how the site was sampled and lessons learned that may be applied to future sampling events.

Training

Typically, it is advised for crew members unfamiliar with GLORIA protocol and alpine botany to train at Trail Ridge Road in Rocky Mountain National Park (RMNP) before sampling the peaks, since many of the common alpine plants there are also present on the peaks in GRSA, and RMNP is easily accessible as a day trip from Fort Collins. However, with 13 different crew members across two hitches, it was not possible to find a day that aligned with schedules mid-season. Instead, the crew reviewed the general protocol, setup at basecamp the first day, learned the basic botany, and calibrated on top-cover the first sampling day. With the understanding that the crew members had varying degrees of plant knowledge, a less experienced botanist was paired with a more experienced botanist whenever possible. Additionally, crew members had green pin flags that they used to mark unknown plants in plots that could be reviewed by a more knowledgeable botanist when available.

Given the frequency of lightning storms in the Sangre de Cristo Mountains, the crew reviewed weather and lightning safety procedures along with other general safety protocols. It was agreed that anyone on the crew could “call stop” if they felt unsafe due to impending weather or other conditions, and the crew would gather to briefly discuss safety concerns, assess potential actions, and act as needed to maintain group safety. Crew members regularly communicated about morale and

how they felt at altitude as well, and they were encouraged to speak up if they were concerned about weather or health.

Camp and Site Access

The crew met in Westcliffe, Colorado, to top off vehicle fuel before driving to the first trail to access the GRSA summits on the east side of the Sangre de Cristo Mountain Range. From Westcliffe, the crew headed south on CO-69S to a right turn on County Road (CR) 559 and followed CR 559 for 9 miles (Appendix B). The crew continued straight on CR 559.1 and turned right to stay on CR 559.1 at approximately 1.8 miles. From this point, the crew followed the road (marked as Forest Road 412) for another 0.75 miles to a pull-off where the “Muddy Creek Trailhead” sign indicated that the road was restricted to vehicles less than 50 inches wide. There is good and sufficient parking here. Note: the access road (Pass Peak Rd.) used in 2015 is now closed to the public, and the entrance off CO-69S is blocked by a fence. Be sure to follow the above driving instructions; navigating to the parking spot in Google Maps will look faster but routes through private property.



Figure 1. The parking area at Rainbow Trailhead for access to HUK, MUD, and PAD.
NPS / KATI ZYBKO

A backcountry campsite (13S 0458693E 4193744N, WGS84)—near the site referred to as “North Basecamp” by the 2015 crew—was utilized for access to MUD, HUK, and PAD (Appendix B). The crew was able to follow an overgrown road (part of the Rainbow Trail) and a faint human/game trail for most of the hike to the campsite, which took the crew approximately two hours to reach from the trailhead. Some slope erosion obscured the trail on the way to the campsite and resulted in some overland travel, but the crew was able to follow the trail for almost the entire way out. The campsite was reasonably flat, with a short hike to a stream north of camp for water. The stream barely had enough water for standard water-filtration pumps in 2020, potentially due to the drought. In 2025, the crew found a PVC pipe near the stream, which could be situated in a way that better allowed the crew to collect water into filtration bags despite a lighter flow. While the National Park Service does not require bear canisters in Great Sand Dunes National Park and Preserve, the crew brought bear canisters as well as bags and cord to hang food to prevent wildlife access.



Figure 2. The stream with the PVC pipe to gather water to the northwest of North Basecamp.
NPS / KATI ZYBKO

There are no defined trails to the summits of HUK, MUD, and PAD, but the crew found abundant old hunting trails and game trails to follow for easier hiking through forested areas and slopes leading to the summits. A topographic map with the “North Basecamp” and routes used to access all three summits is included in Appendix B.

To access SIX during the second field hitch, the crew camped at a backcountry site in the vicinity of Medano Lake, located approximately 3 miles up the Medano Lake trail. The crew accessed the trailhead with various vehicles: two Jeeps, a Ram 1500, and a Chevy Tahoe. All vehicles were able to navigate easily up the road with no issues. Crews in future years should try to get road conditions from the National Park Service ahead of time, but a high-clearance vehicle, careful driving, and some spotting are needed to access the trailhead. At the track, there is a very small parking lot. The crew fit all four vehicles in the parking lot with room for one more vehicle. There is additional space to park vehicles a bit farther away from the trailhead if the parking lot is full. Future crews should be mindful of this and try to park close together. Additionally, the crew accessed the trailhead on a Tuesday, which is much less busy than a weekend, and this helped with parking availability at the trailhead. If

possible, a future crew should aim to photograph the parking lot at Medano Lake Trailhead to aid future crews in planning, like Figure 1 above.

At the Medano Lake campsite, the crew was able to filter water from a stream immediately adjacent to the campsite. It is worth noting that future crews may want to scout the trail to the summit ridge for SIX during daylight hours. The 2020 crew used a well-traveled climbing trail, which differed slightly from the GPS tracks from the 2015 GLORIA crew, particularly around the willow carr surrounding the lake (the climber's trail diverges and heads slightly uphill of the trail used by the 2015 crew). In 2025, the crew took a direct route to the summit once up the saddle, which was steep and slow going. The 2025 crew took the ridge saddle down, and while distance-wise it was a bit longer, it is a better route. This ridge route is marked sporadically with cairns, since climbers use it to summit the peak.

Research Site

GLORIA sites are established on the tops of peaks (summits), and the summits vary from just above treeline to the highest life zones of vegetation. Within one region, all four summits share qualitatively similar geology, climate, disturbance, and land-use history, leaving vegetation differences among the summits to be driven primarily by elevation. The four summits chosen within Great Sand Dunes National Park and Preserve are in close proximity to one another (all within ~4 km) on a ridgeline extending north from Mount Herard (Figure 3).

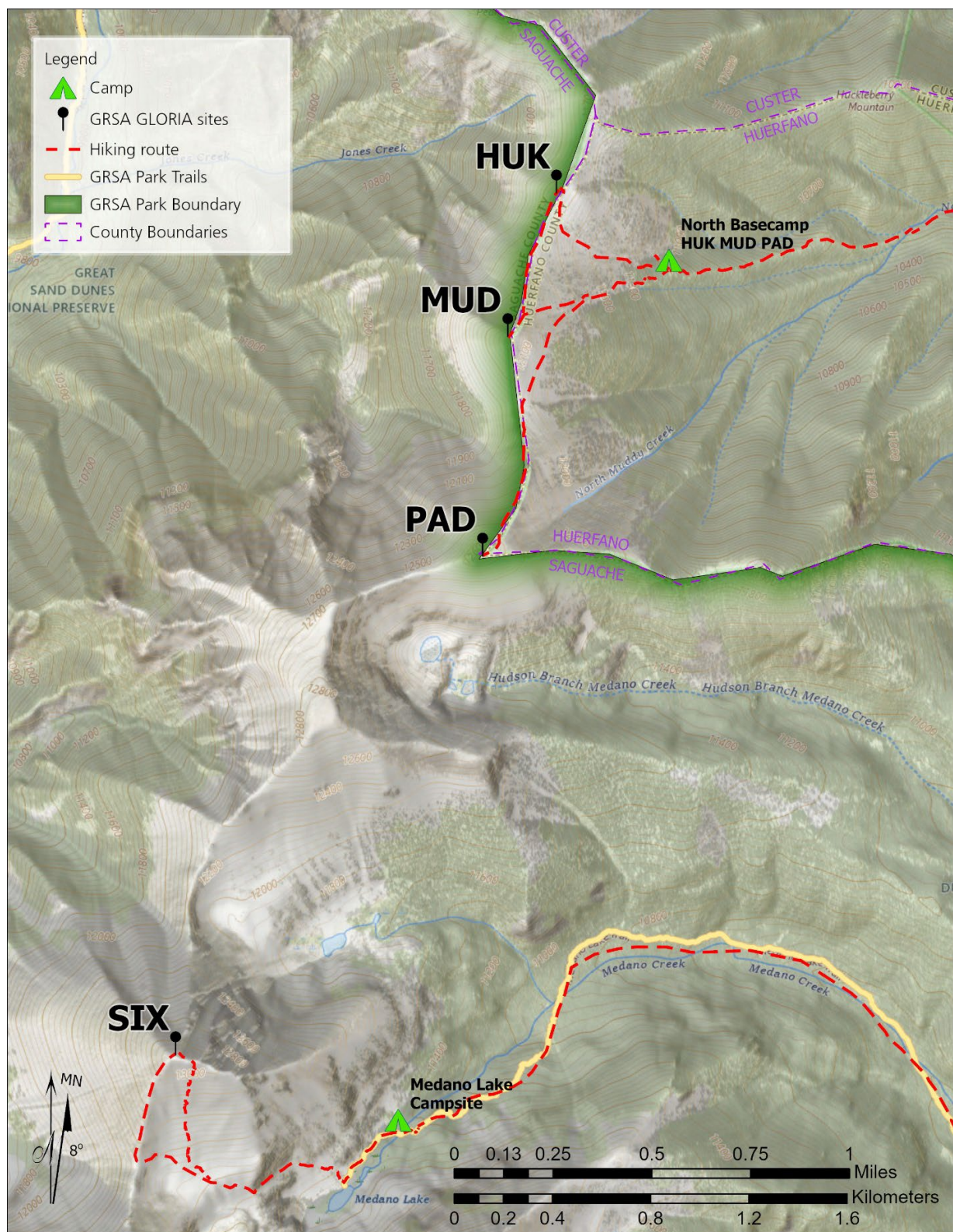


Figure 3. Locations of the four GLORIA peaks in Great Sand Dunes National Park and Preserve.
NPS / KATI ZYBKO

Table 1: Name, location, elevation, and vegetation zone of the four alpine sites within the target region of GRSA.

GLORIA Summit code	Summit name	Latitude (decimal degrees, WGS84 datum)	Longitude (decimal degrees, WGS84 datum)	Elevation (m)	Vegetation Zone
SIX	Medano Peak	37.8615	-105.4923	4,000	Alpine/nival ecotone
PAD	Unnamed	37.8800	-105.4782	3,870	Upper alpine
MUD	Unnamed	37.8878	-105.4771	3,700	Lower alpine
HUK	Unnamed	37.8933	-105.4749	3,550	Lower alpine/subalpine ecotone

Field Sampling

In the 2020 GLORIA sampling, the area was impacted by extreme drought. In 2025, most forbs were past flower, and many of the species were already very dried out at the time of sampling; the area was categorized as experiencing an abnormally dry season to a moderate drought (Figure 2). In general, the dry conditions did not appear to hinder the detection of key species but occasionally made identification more challenging and may have skewed detected species and cover values. For species with limited flowering parts, field botanists used a preponderance of evidence (form, nearby mature plants, ligule characteristics, etc.) and familiarity with certain plants at different life stages where applicable. The crew had varying degrees of alpine plant knowledge, from absolute beginners to those more experienced with alpine botany and GLORIA. Species with lower confidence at the genus or species level were flagged on each data form using the appropriate codes. For *Draba* species specifically, unknown codes were regularly used. *Draba* require assessing the roots for clear determination of certain species, and uprooting every *Draba* to determine its species would negatively impact the local, limited populations.

In past sampling efforts, there were several instances across summits where visual estimates for top cover exceeded the cover sum for the 1 m² quadrats (Pauli et al. 2015, Form 2). In the 2025 sampling effort, crews were instructed to compare visual estimates with the top-cover sum and to reassess if the visual estimate for top cover exceeded it.

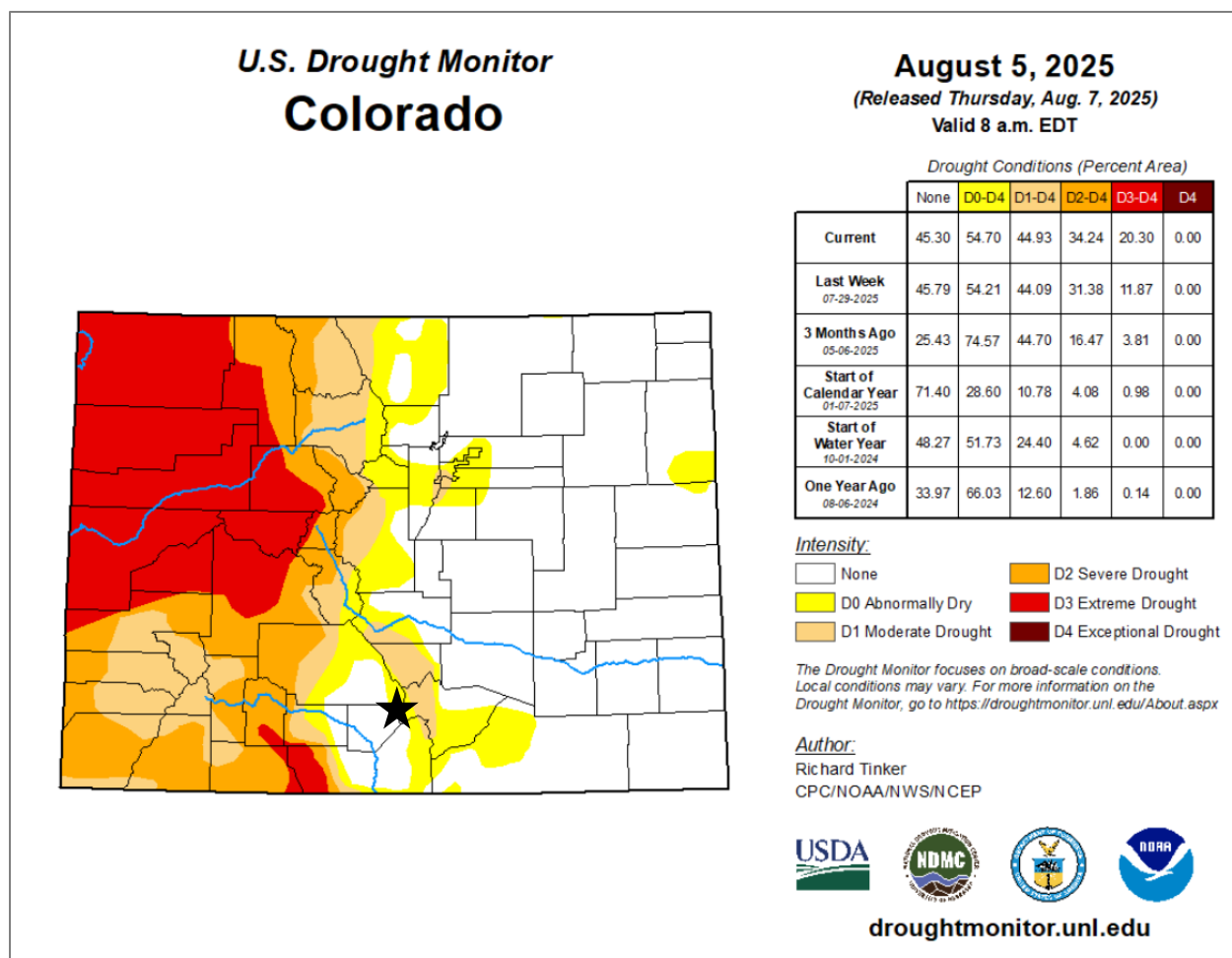


Figure 4. U.S. Drought Monitor Map for Colorado at the time of GLORIA Great Sand Dunes sampling in 2025. Star shows the location of the GLORIA site.

NDMC

The 2025 crew sampled all four summits comprising the GRSA GLORIA site over the course of eight days across two hitches, including travel days. A summary of site access and setup is provided by summit, along with notes on observations and potential sampling errors. During revisit sampling, the crew followed GLORIA protocol and the ROMN Revisit SOP (Appendix C). The general timeline of sampling activities is provided below, which allowed flexibility as we had more or fewer crew members available throughout the sampling effort.

1. Locate the high summit point; cache gear.
2. Establish cardinal directions; find corners of quadrat clusters and flag “no-walk” areas in these locations.
3. One team would begin taking overview photos and replacing/photographing temperature loggers, then move on to completing the land-use and disturbance forms. A second team (sometimes just one person) would immediately begin summit-area section species lists. A

third team would begin with the vegetation quadrats and would be joined by the first team when their tasks were complete.

Descriptions of how each peak was sampled—including the number of sampling days, crew members, site access, notes on field measurements, general observations, and potential sampling errors—are provided below in the order that peaks were sampled in 2025. HUK was sampled first, as it is the easiest peak to access from the north basecamp. MUD, the second-easiest peak to access, was sampled next, followed by PAD. SIX was accessed via the Medano Lake backcountry campsite. SIX was sampled last, after the crew was well acclimated to working at altitude and well practiced with the GLORIA protocol.

HUK

The crew took a total of 1.5 days to sample HUK. The first day included calibration to ensure that new crew members were familiar with the GLORIA protocol and common plant species in the area. The time needed to sample plots gradually decreased as all crew members became more familiar with the plants and the sampling protocol.

Site Access and Set-up

HUK is located approximately 1 km overland from the north basecamp. It took around 45 minutes to hike up to the summit of HUK carrying field gear. In 2025, the crew did not need to leave quickly due to a storm, but if needed by future crews, treeline is approximately 0.5 km from HUK, heading straight down the mountain toward camp.

The crew used HUK as a calibration peak, including site set-up, to ensure consistency in plant identification (ID) and plot sampling across researchers (Figure 3). The crew did not encounter any difficulties (missing plot markers, etc.) in setting up HUK.

Observations and Sampling Errors

The crew was able to easily locate all monuments. The logger crew in 2024 reported no issues locating and replacing all the temperature loggers.

Some initial errors in cover estimates on the HUK peak were potentially due to the experiential learning curve of several crew members who had no previous experience with the GLORIA protocol. Whenever possible, a more experienced botanist or plant ecologist was paired with a less experienced data recorder to help them learn plants and cover and better ensure the accuracy of the data. Unknown plants were flagged in plots with bright green flags and marked on data forms as needed, so as not to interrupt the flow of data collection. A more experienced crew member periodically checked in with all teams, visited the flagged plants, and either identified them in the field or collected them to key out back at camp. Within the site and the buffer, fresh elk scat was observed, as well as some small-rodent activity. Some bark beetle disturbance was also observed about 500 m southeast of the plot.



Figure 5. Training the crew on botany and cover estimates on HUK in Great Sand Dunes National Park and Preserve.

NPS / LAUREN LAUGHLIN

MUD

MUD was sampled in one full day, spread over two half days (see Appendix A). On the first day, the crew arrived at the peak around 11 a.m., after finishing HUK, and began setup. The crew descended at around 2:30 p.m. due to incoming weather. The following day, the crew finished sampling mid-day.

Site Access and Set-up

MUD had some significant issues with setup that had not been noticed or documented in the past. These issues stem from the initial site setup: some of the 5 m and 10 m past measurements were not far enough down in elevation. For example, the N10 m location was only about 3.6 m down in elevation from the N05 m monument, instead of the protocol-defined 5 m drop. This made the summit area sections (SAS) sections very small when a crew ran a straight line between monuments. From previous photos, it appears that crews contoured the 5 m and 10 m SAS lines, instead of running a straight line, as the protocol states. For the 2025 sampling, the crew sampled the peak with the monuments in their current places, following the protocol with a straight line connecting the 5 m

monuments. However, the 10 m drop was sampled with a contour following photos from previous visits. Sampling the 10 m SAS with the protocol-defined straight lines would have made the sections significantly smaller, and the crew did not want to skew the data by making this adjustment. A decision should be made whether the monuments should be adjusted to their proper locations or if future crews should continue sampling this peak in that way.



Figure 6. Elizabeth Wu and Kati Zybko sampling quadrats on MUD in Great Sand Dunes National Park and Preserve, with a view of Crestone Peak to the northeast.

NPS / LAUREN LAUGHLIN

Observations and Sampling Errors

Overall plant community composition was similar between MUD and HUK. At this point in sampling, the crew was feeling more confident with the botany and their cover estimates. Please note the previously mentioned problems with the site setup, which may have contributed to errors between sampling years. Elk and small-mammal scat were observed within the buffer, as well as an elk skeleton and some dead trees. The cause of death for those trees is unknown.

All temperature loggers were relatively easy to find and replace during the 2024 visit.

PAD

The PAD peak took 1.5 days to sample. A crew of 5 began site setup at 1:00 p.m. while the rest of the crew finished sampling MUD. The crew of five descended around 2:15 p.m. on the first day due to an approaching storm. The second day, the full crew sampled the rest of the peak, beginning around 6:45 a.m. and descending around 1:30 p.m. once sampling was completed.



Figure 7. A view of the sunrise over the valley from the hike to PAD.

NPS / LAUREN LAUGHLIN

Site Access and Set-up

The crew accessed PAD via overland travel and occasional game trails through scattered patches of krummholz vegetation, followed by attaining and traveling along the ridgeline between MUD and PAD (Appendix B). Total travel time was 1.5–2 hours on the way to the summit and 1–1.5 hours on the way back to camp. In 2025 sampling, the crew did not have to flee the peak due to an incoming storm. In past years, crews reached the treeline more quickly by heading northeast off the summit to get off the ridge, then traversing along game trails toward dense krummholz and eventually taller forest cover.



Figure 8. Looking towards Mount Herard and SIX from PAD in Great Sand Dunes National Park and Preserve.

NPS / LAUREN LAUGHLIN

Observations and Sampling Errors

There is clear elk presence in this area. The crew mostly followed elk trails to the peak, observed some elk from the peak, and observed some scat as well. While the 2025 crew did not observe abundant soil slumping, creating small terraces on the north aspect, crews in the past did, likely a result of the elk presence. Future crews should look for this and note if they see it. Crews also observed some recent rodent burrows on the site, as well as some dead spruce within the buffer.

All temperature loggers were relatively easy to locate and replace during the 2024 visit.

SIX

SIX was the most difficult peak to survey due to its longer and steeper access, topographic complexity, high elevation (above 13,000 ft), exposure to thunderstorms with an approximately 2.5 km distance from summit to treeline, and unpredictable weather patterns. The full crew (eight members) sampled the entire peak in one day on the second hitch, thanks to a perfect weather

window. The crew was able to stay on the peak until nearly 5:00 p.m. to finish sampling, motivated by the good weather and the possibility of not having to return the following morning.

Site Access and Set-up

SIX can be reached by following a climber's trail between Medano Lake and Mount Herard and branching off to the north at the saddle on the ridge between Mount Herard and SIX, then following the ridgeline all the way to the summit. On the approach to the peak, the crew hiked toward the saddle of Medano Peak (SIX) and Mount Herard but turned toward SIX before reaching the saddle as a more direct route. This route, though direct, was steep and slow going. On the way down, the crew followed the saddle and joined up with the climber's trail. The consensus was that the saddle and ridge to the peak is the more advisable way to approach the peak. The more direct route would be appropriate if the crew had to bail due to incoming weather. If future crews have the time, it might be helpful to scope out some of the hike after setting up basecamp, to get an idea of what the approach will look like in daylight.



Figure 9. Surveying plots on the flank of SIX in Great Sand Dunes National Park and Preserve.
NPS / LAUREN LAUGHLIN

Site setup went smoothly. In the past, the crew noted that the pSW-5 intersection line distance recorded on the GLORIA Manual Form 1 from 2015 was longer than expected (likely a 5 m drop in elevation rather than a straight line across) (Pauli et al. 2015). The 2020 crew kept the same distance as the 2015 crew for consistency and recorded corrected intersection-line values on Form 1. The 2025 sampling crew used the same values as the 2020 crew, rather than deviating from what had been done in the past. In future sampling, a decision should be made if this sampling should be adjusted to fit the protocol, or whether sampling should continue as it has been done, so as not to skew the data. The 10 m intersection lines were not flagged due to loose rock and steep drop-offs, consistent with past sampling years. The crew did their best to follow lines of sight for all associated observations.

Observations and Sampling Errors

By the time the crew sampled SIX, they had multiple field days of experience with the GLORIA protocol and the plant species in the area. Crew members had also settled into a rhythm of task division and of maximizing each member's respective strengths and skill sets. Plant species were very similar to those on HUK, MUD, and PAD, which helped greatly reduce the time required for sampling. Some elk scat was observed within 1 km of the site, along with a pika and some burrows. This site also sees the most human activity of the four peaks, since it is adjacent to Mount Herard and has a well-worn trail for most of the approach.

Portions of the eastern summit-area section were difficult to safely sample due to loose scree and generally rocky, steep, and exposed areas (especially in some of the rock crevices in the southern portion of the section).

When a ROMN crew visited SIX in 2024 to swap the 2020 loggers, the crew was unable to find the north logger. The reason is the north plot is a flipped plot (the 3x3 plot monument is at N31 instead of N11), of which the logger crew was unaware. During the 2025 sampling, this logger was successfully retrieved. The current logger on the north aspect is in the area where it would be if the plot was not a flipped plot. The logger on the east aspect is located slightly outside the E22 plot (it is in the lower left-hand corner of E32), but it is close enough to the correct location that the crew found it in 2024.



Figure 10. Photo showing the SIX N 3x3 plot grid and the logger location flagged near the whiteboard, outside the plot. Logger is installed to the right of the plot when looking towards the summit.

NPS / MAYA MCCAIN

Upon reviewing the datasheets in the office, it appeared that the metadata from the 2025 field forms was not correct. While there should have only been four forms for the north aspect, there were several more than four, each with N, NW, or NE as their given aspects. Crews were likely confused by shooting bearings from the quadrats and were tired from a long day spent at 13,000+ ft. To determine which forms were truly on the north aspect and which were elsewhere, a crew member compared each form to every quadrat photo. Vegetation and solid rock top cover were extremely helpful indications of which form was truly associated with which aspect and quadrat. All forms lined up, and their corrections have been recorded on the forms themselves. In future years, crews should be diligent about this and ask questions if they are ever unsure. Crew lead should also thoroughly review all datasheets before leaving the peak and consider whether sampling a full peak in only one day is enough time to be thorough.

Notes for Future Sampling

General Tasks Prior to 2030 GLORIA Sampling Event

1. Consider making one more 1x1 m cover plot with PVC to retire the old wooden one, which is warped and more challenging to set up.
2. Consider making a new photo pole that is compatible with the GLORIA manual. We improvised with an adjustable backcountry ski pole.
3. Update master plot layout sheets for each site in advance of the field visit. This sheet will include key plot location information (which is often hard to read on old, scanned field forms) and highlights any anomalies in site setup. While this was done manually this year, GLORIA International will apparently provide these in the future; follow up with them.

Logistical Notes for Future Sampling Events

1. In the past, crews have suggested training on CSU campus for crew members who are not familiar with GLORIA protocol, as well as spending a day up on Trail Ridge Road in Rocky Mountain National Park to learn some of the basic alpine plants as well as practice top cover estimates. In 2025, it was not feasible to align schedules in the midst of a busy field season, so the crew learned the protocol and alpine botany at basecamp the first night and on HUK the first morning. This worked alright, but we recommend a full training day before field sampling at the beginning of the hitch.
2. Campsites at Medano Lake (the trailhead for SIX) are first-come, first-served basis. It is advisable that crews access the lake on a weekday, since weekends are the busiest. In 2025, the trailhead was empty on Tuesday, and the crew was able to park four vehicles there. However, the parking lot is small and may be full if accessed on a weekend. Other potential parking is available further away from the trailhead.
3. The 2020 crew suggested sampling the closest, lowest-elevation, easiest-access peak first (HUK) to get the crew calibrated, followed by peaks with increasing elevation gain and/or hiking time. The 2025 crew followed this sequence, which worked very well.
4. Ensure that the crew is clear on visual estimation of top cover vs. total cover and calibrated in their cover estimation up front. Consider recalibrating the crew at the beginning of each day, since crew members may forget due to being at elevation for extended periods of time, early mornings, and long, busy days in the field.
5. Stress the importance of clear, legible writing on field forms. For this protocol, with a large group of people and an extended period of time in the backcountry, it likely does not make sense to rely on digital data collection.
6. GLORIA database plant names can be different from the latest nomenclature in the Flora of Colorado (Ackerfield 2022). While state nomenclature can change quickly, the GLORIA database taxonomy had not been updated previously. A species crosswalk is beneficial for

anyone entering data and who is not familiar with both the old and new names. In Winter of 2026, the GLORIA database is standardizing everything against GBIF (the Global Biodiversity Information Facility), and significant efforts have been made to clean up the vegetation dataset for all sampling visits at Great Sand Dunes National Park and Preserve including this 2025 visit.

7. Check the status of the access trails prior to visiting these sites, as the number of unstable standing dead trees and downed trees is likely to increase in the future. Given the status of forests on the approach to all of the GLORIA summits, it would be worth making contingency plans in the event of a wildfire as part of the larger backcountry safety plan for the crew—especially for less-traveled areas leading to HUK, MUD, and PAD.
8. The crew had cell phone reception for almost the entire duration of the field sampling period, including both campsites (with better reception at the first campsite), which allowed crew members to occasionally check the latest NOAA weather forecast (including forecasted and approaching electrical storms) and check-in with emergency contacts. All major cell service providers had at least some service in the backcountry for personal check-ins. The crew also had two two-way Spot-X satellite messenger devices for morning and evening check-ins with emergency contacts. In the limited cases where the crew split up, each smaller group carried a radio to communicate with the other.

Conclusion

The 2025 GLORIA field crew was able to successfully sample all four summits over the course of five days on the peaks. Including travel, the effort totaled eight days of work. Efficiencies were gained by dividing the crew into two smaller teams on several occasions. This allowed the first team to complete a small list of remaining plots on a summit started by the entire crew on the previous day, while the other team started setting up the next summit. Since there is a clear line of sight between most peaks, crews were able to communicate with radios and cell phones.

The 2025 growing season was likely influenced by the drought the state endured throughout the year, though it was not as extreme as the drought during the 2020 sampling. Many species were past their prime of flowering at the time of sampling, particularly the forbs, so much of the ID relied on vegetative characteristics. In general, this did not appear to hinder detection of key species but occasionally made identification more challenging and may have affected observed vegetation cover.

Literature Cited

- Ackerfield, J. 2022. Flora of Colorado, second edition. Botanical Miscellany No. 60. BRIT Press, Fort Worth Botanic Garden | Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.
- Ashton I., Schweiger E.W., Burke J., Shorrock D., Pillmore D., and Britten M. 2010. Alpine vegetation composition structure and soils monitoring protocol: 2010 version. Natural Resource Report. Natural Resource Report NPS/ROMN/NRR—2010/277. National Park Service, Natural Resource Program Center. Fort Collins, Colorado.
<https://irma.nps.gov/DataStore/Reference/Profile/2166893>
- Pauli, H., Gottfried, M., Lamprecht, A. Niessner, S.; Rumpf, S., Winkler, M., Steinbauer, K., and Grabherr, G., coordinating authors and editors (2015). The GLORIA field manual – standard Multi-Summit approach, supplementary methods and extra approaches. 5th edition. GLORIA-Coordination, Austrian Academy of Sciences & University of Natural Resources and Life Sciences, Vienna.
- National Drought Mitigation Center (NDMC). 2021. U.S. Drought Monitor Map Archive.
<https://droughtmonitor.unl.edu/Maps/MapArchive.aspx>
- Wingate, J. L. 2017. Sedges of Colorado. Parker, Colo: Wingate Consulting.

Appendix A: US-GRSA 2025 Field Log

This appendix provides a day-by-day summary of crew activities, travel, and fieldwork completed during the 2025 GLORIA sampling effort (Table 2).

Table 2. Summary of field activities and crew logistics for the 2025 GLORIA vegetation survey.

Date	Peak	Crew	Activities	Notes
7/29/2025	N/A	Lauren Laughlin, Sonja Long, Rebecca Fries, Liam Bauer, Elizebeth Wu, Clark Hollenberg, Kati Zybko, Grant Pottash, Ed Brett, Mila Garelle-Essam	Travel to the Muddy Creek Trailhead of the Rainbow Trail from Fort Collins and Denver, stopping to meet and disperse gear in Westcliffe; hike to backcountry campsite (~2 miles off trail with about 1,300 ft of gain) and set up camp.	5 hr. drive from Fort Collins with the goal of meeting in Westcliffe between 12 and 1pm. At camp, crew went over general site setup and some cover estimates as a primer for actual field work.
7/30/2025	HUK	Lauren Laughlin, Sonja Long, Rebecca Fries, Liam Bauer, Elizebeth Wu, Clark Hollenberg, Kati Zybko, Grant Pottash, Ed Brett, Mila Garelle-Essam	Site set-up, protocol review and training, 6 1x1 m cover plots, 5 SAS's, disturbance forms, and most photos completed	Left camp at 5:30 am and got to peak at 6:15. While three crew members who had done GLORIA before started setup, all other crew members calibrated on the botany and general protocol training
7/31/2025	HUK & MUD	Lauren Laughlin, Sonja Long, Rebecca Fries, Liam Bauer, Elizebeth Wu, Clark Hollenberg, Kati Zybko, Grant Pottash, Ed Brett, Mila Garelle-Essam	HUK: 10 1x1 m cover plots, 3 SAS's, remaining photos; MUD: site set-up started, 3 1x1 m cover plots, disturbance forms, and photos started	Left camp at 5:30 and got to HUK at 6:15. Descended around 2:30 pm due to an incoming storm
8/1/2025	MUD& PAD	Lauren Laughlin, Sonja Long, Rebecca Fries, Liam Bauer, Elizebeth Wu, Clark Hollenberg, Kati Zybko, Grant Pottash, Ed Brett, Mila Garelle-Essam	MUD: 13 1x1 m cover plots, 8 SAS's, and rest of photos completed. Measurements for site setup retaken. PAD: site setup, 1 1x1 m cover plot, and disturbance forms	Left camp at 5:30 am and got to MUD at 6:30. At 1:00 pm, 5 members of the crew went on to work on site setup on PAD, and the other half remained at MUD to finish retaking measurements from site setup. Both crews descended around 2:15 pm due to an incoming storm.
8/2/2025	PAD	Lauren Laughlin, Sonja Long, Rebecca Fries, Liam Bauer, Elizebeth Wu, Clark Hollenberg, Kati Zybko, Grant Pottash, Ed Brett, Mila Garelle-Essam	Completed 15 1x1 m cover plots, 8 SAS's, and all photos.	Left camp at 5:30 am and got to peak at 6:45 am. Descended when finished with the peak at 1:30 pm. With a fairly early finish, the crew packed up camp, hiked out, and drove back home

Table 2 (continued). Summary of field activities and crew logistics for the 2025 GLORIA vegetation survey.

8/12/2025	N/A	Lauren Laughlin, Sonja Long, Rebecca Fries, Liam Bauer, Elizebeth Wu, Bodie Spinner, Phil Krenning, Maya McCain	Travel to trailhead from Fort Collins, Lakewood, and Denver, stopping to meet and disperse gear in Westcliffe; hike to backcountry campsite (~3 miles on trail with about 1,850 ft of gain) and set up camp.	The road to Medano Lake Trailhead is rough but certainly not impossible. A high clearance 4wd vehicle is required to navigate the road (2025 crew had 1 Ram 1500, 2 Jeep Wranglers, and 1 Chevy Tahoe and accessed the trailhead with ease). 5 hr. drive from Fort Collins with the goal of meeting in Westcliffe between 12 and 1pm.
8/13/2025	SIX	Lauren Laughlin, Sonja Long, Rebecca Fries, Liam Bauer, Elizebeth Wu, Bodie Spinner, Phil Krenning, Maya McCain	Site setup, 16 1x1 m cover plots, 8 SAS's, all photos, and disturbance forms	Crew took advantage of weather window and sampled entire peak. Left camp at 5:30 am and arrived at peak to sample around 7:00 am. Weather stayed clear all day, crew descended after finishing sampling at 5:00 pm.
8/14/2025	N/A	Lauren Laughlin, Sonja Long, Rebecca Fries, Liam Bauer, Elizebeth Wu, Bodie Spinner, Phil Krenning, Maya McCain	Packed up camp, hiked back to cars, sorted out gear at trailhead, and drove back home	N/A

Appendix B: US-GSD 2025 Route Maps

This appendix presents topographic route maps used during the 2025 field season in Great Sand Dunes National Park and Preserve, showing access to trailheads, camps, and monitoring sites (Figures 11–13).

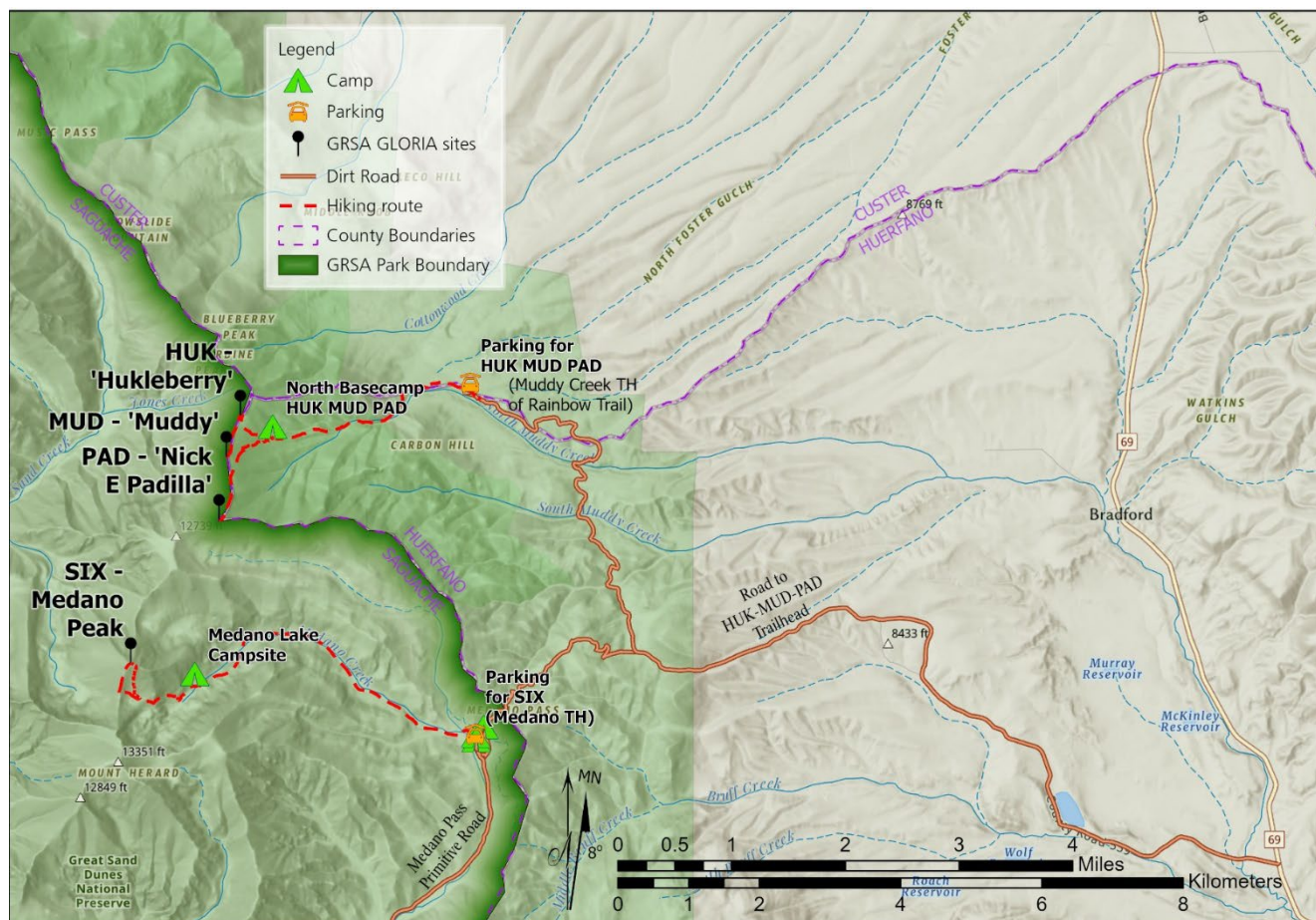


Figure 11. Overview of 2025 access routes to reach trailheads in Great Sand Dunes National Park and Preserve.
NPS / KATI ZYBKO

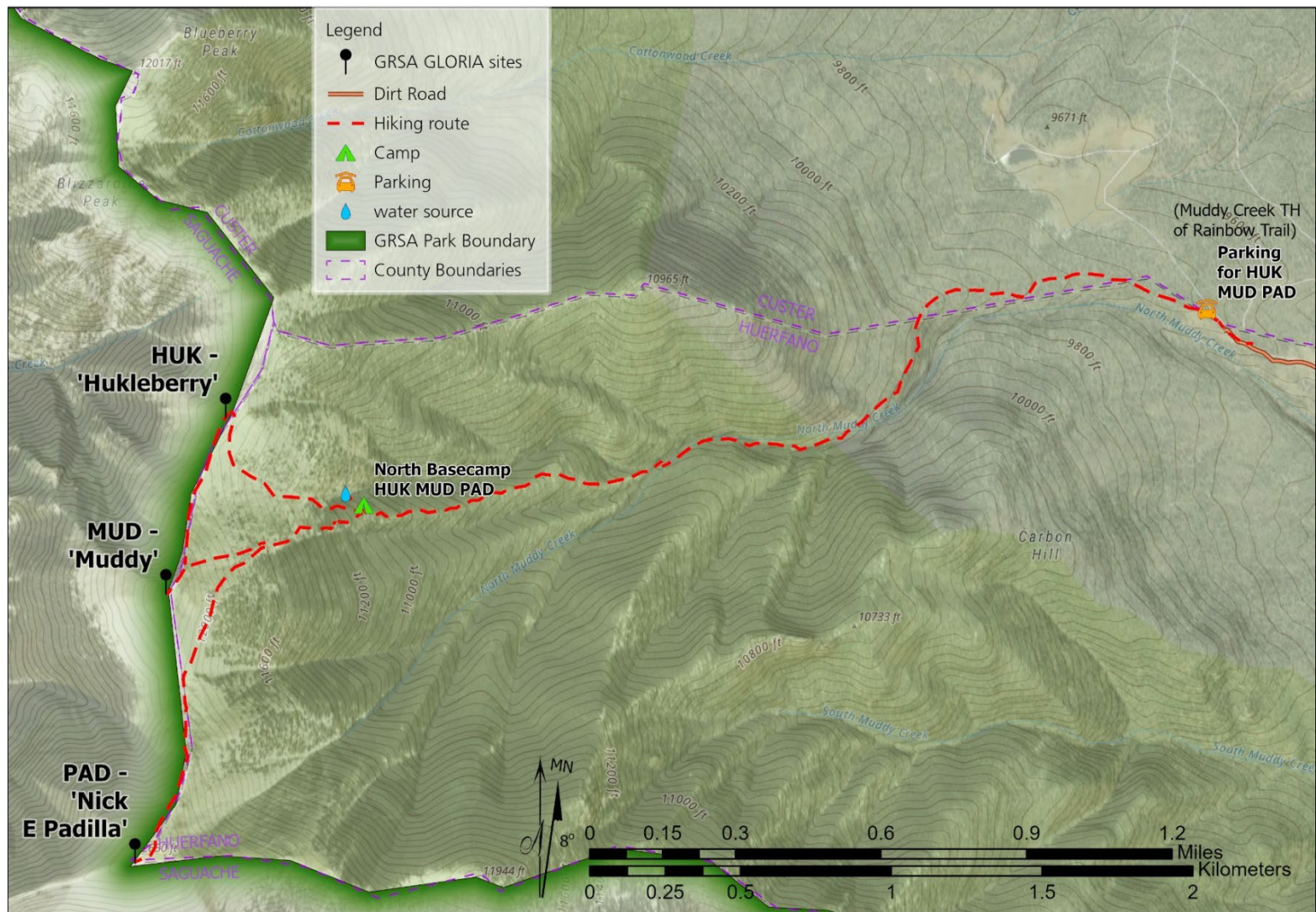


Figure 12: Routes from the parking area to camp, HUK, MUD, and PAD in Great Sand Dunes National Park and Preserve.
NPS / KATI ZYBKO

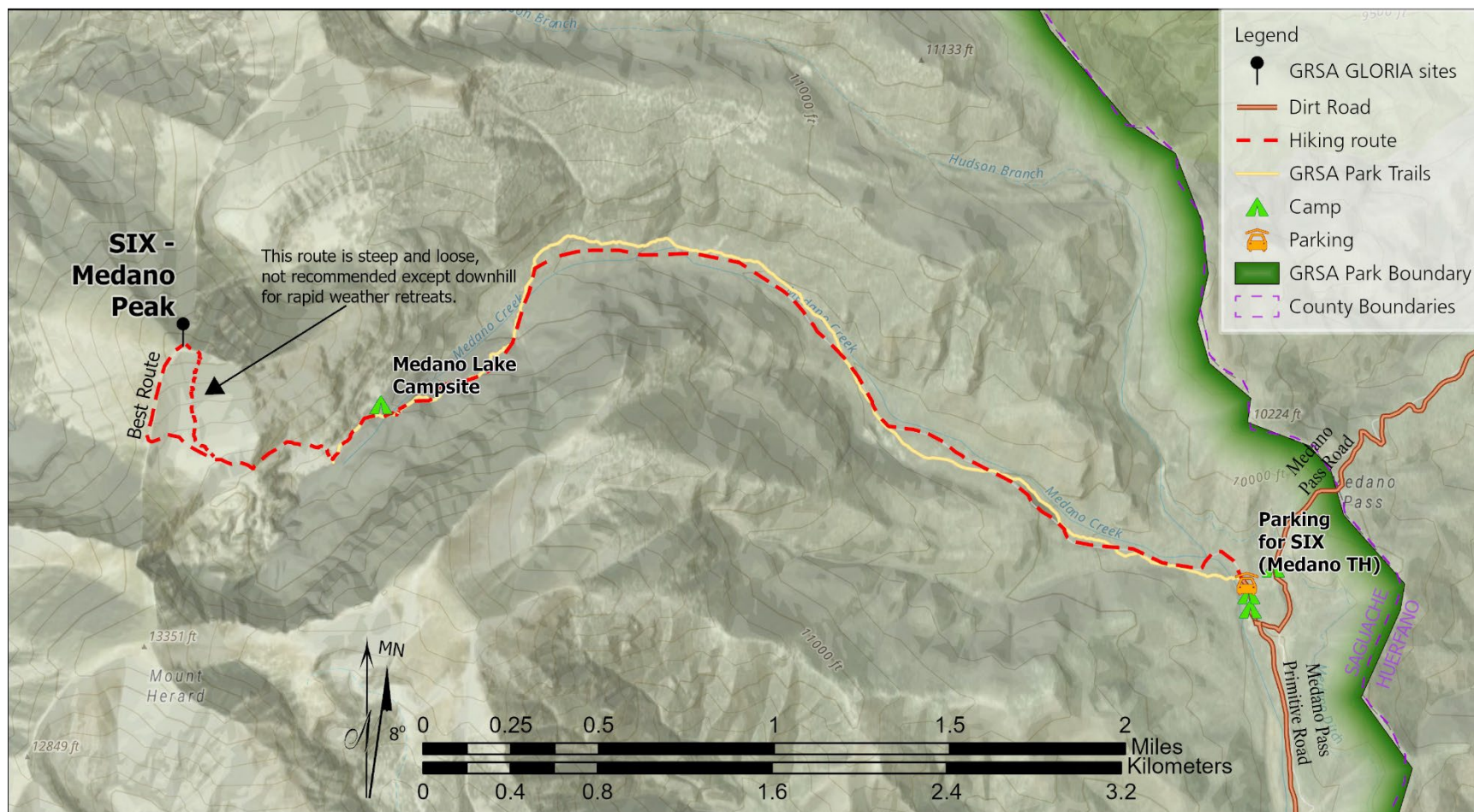


Figure 13. Route from Medano Lake trailhead to camp and SIX in Great Sand Dunes National Park and Preserve.
NPS / KATI ZYBKO

Appendix C: ROMN Revisit SOP

This appendix provides the Rocky Mountain Network (ROMN) standard operating procedures for revisiting and resampling GLORIA summit monitoring sites, including site setup, measurements, and vegetation sampling protocols.

Created July 23, 2024, by Erin Borgman, Katherine Zybko, and Dana Witwicks

Last updated July 24, 2025

General revisit tips

- Verify correct declination for region and declinate all crew member's compasses (NCEI Geomagnetic Calculators).
- Make sure crew has previous visits site establishment measurements (Pauli et al. 2015, Form 1) and 'position of start line' for the supplemental 10x10 grids (Form 6-S, only done at ROMO currently).
- For a **gear list** see the GLORIA Manual, 5th edition section 3.2, page 30.
- When approaching the site, cache gear well away from where you think the site edge should be. Lay out gear on a tarp so the team can find what they need.
- Use a system of multi-colored pin flags to keep track of where you are within the site. For example:
 - Use both pink and blue pin flags for the 5-m monument in the quadrat clusters and for defining the 10 m SAS corners in each cardinal direction.
 - Use blue for the SAS intermediate points between cardinal directions (e.g. NE, SE, SW, NW)
 - Use red for the marker nails in each quadrat cluster and in between blue flags to delineate the 5-m and 10-m SAS line boundaries.
 - Use green flags for unknowns.
- Assign 2 people to take photos and verify site measurements, using the last visit photos as a guide.
- When using the tape measure, don't pull tight for the measurement, but rather let it lay naturally on the ground (this is a deviation from the GLORIA Manual that says to pull the tape tight).
- All azimuths and distances are measured from the highest summit point (HSP; see GLORIA Manual 5th ed. p.30 and box 3.3 on p.34).

Workflow for setting up a summit site

1. Using a GPS and site photos, locate the HSP and place a flag.
2. Establish cardinal directions; find monuments of quadrat clusters and flag "no-trample" areas in these locations.
3. Use previous visits measurements and a tape from HSP down to 5-m to find the monument at the N11 corner of the quadrat cluster and place two flags. Using the 3x3 plot tape and photos, find the 3

nails with washers in the other corners and place flags. As you do this, double check the azimuths and distances. Repeat for each cardinal direction.

4. Have a botany crew start working on N11.
5. Have photo crew get started on photos (make sure they have the previous visit photos to reference so they are the same).
6. Continue to run the tape past the 5-m monument, all the way down to the 10-m SAS corner (there is no monument here, use previous visits measurements to locate) and place two flags. Do this for each cardinal direction.
7. Measure out intermediate points (e.g. NE) for the 5-m and 10-m SAS line boundaries using last visit's measurements and place blue flags, fill in the rest of the boundary line with another colored flag so it is easy to visualize.
8. Crews should verify that all previous visit measurements are accurate, if not, correct distances and azimuths should be remeasured. Form 1 of the GLORIA Manual should always be completely filled out.
9. Once photo crew is finished, they can work on the disturbance form and soil collection.

3x3 quadrat cluster set up

(See GLORIA Manual 5th ed. p.31)

- Set up flags at each corner and spread out the flexible tape.
- Stake each eyehole loop to hold it down.
- Set up the 1x1-m quadrat, using photos as a guide to place it precisely in the same location before.
- Have the photo team take photos before botanists start, when possible. See GLORIA Manual 5th ed. Pg. 46 for photo instructions.
 - Avoid high contrast, don't have pointing frame obscuring the quadrats, make sure all 4 sides of plot are visible.

Summit Area Section sampling tips

(See GLORIA Manual 5th ed. pgs.41-43)

- The botanist completing the summit area sections should methodically walk the 5-m section ("pie slice") for that cardinal direction.
- Create a species list first, making sure to check in with the quadrat cluster botanist first, so that species are not missed.
- Spend extra time in unique microclimates.
- When the species list is complete, compare this with the species list from the last visit to make sure you didn't miss anything that was found previously.
- Fill in the abundance classes for each species.

Quadrat cluster sampling tips

(See GLORIA Manual 5th ed. pgs.38-41)

- Record the average aspect (N, NE, E, SE, S, SW, W, or NW) and slope angle (use clinometer, this is in degrees, 360° scale).
- Start with Top cover surface estimates. One good technique is to start with the smaller cover types. For example, if vascular species has the largest cover, do that one last by subtracting the other lesser covers from 100 for an estimate. Check that it makes sense and, if not, adjust where necessary. Walk around the plot and try to get directly over it (view it as perpendicular to the slope angle).
 - Refer to the printed cover visual aids, you may use your hand as an approximate 1%
 - Litter: Count any dead plant material as litter, unless it is the growth habit of the plant to have some die-back (e.g., some grasses or *Carex* sp. may keep dead leaves attached). If there is a fully dead plant that is still standing that is counted as litter, no matter the angle it is leaning at.
 - Lichens: vagrant/floating lichens are counted in the 'Lichens on soil not covered by vascular plants' type, not litter.
 - Scat: Animal scat is counted in the bare ground type, not litter.
- Next, estimate the Subtype percentages for top cover.
 - Note that these subtypes are recorded as the percentage of the respective Top cover type, not of the whole quadrat.
- Create the species list of all vascular species in the plot next.
- Once this is completed, compare this with the species list from the last visit to make sure you didn't miss something that was found previously.
- Crew can add a confidence rating if they are unsure of an ID (e.g. put a 's' for if you are unsure of the species). Explain in comments if this is done.
- Next estimate visual cover for each species on the list. Look down on the quadrat from different sides. Start with rarer species and those with the smaller cover. Get down low and check under plants to avoid missing things.
- Add up the cover of all individual vascular plant species and compare this with the vascular plant top cover. It should be **at least as high as the top cover and can exceed it** (due to overlapping layers). If it is lower than the top cover, go back and adjust your cover estimates.
- Complete the pointing in the grid frame using a pin flag. Note that when you hit a plant species, you don't record the ground cover below it. Only record ground cover when there's no vegetation at a point.
- If a pin point hits multiple species, record them all.
- Check if everything seems reasonable. Did you hit something a bunch of times but estimated its cover very low? If so, you may need to reevaluate the visual species cover estimates.

**National Park Service
U.S. Department of the Interior**



Natural Resource Stewardship and Science

[Natural Resource Stewardship and Science](#)

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525