Mt. Rainier National Park
National Park Service
U.S. Department of the Interior

Division of Visitor & Resource Protection

Mountaineering Report 2016

A summary of the yearly operations of the Mount Rainier Climbing Rangers

Avalanche Training 2016
(Above) Rangers on the way to a training site for on a day dedicated to avalanche assessment in April 2016.
NPS Photo

Shorthaul Training 2015
(Cover) Two rangers suspended 1500 feet over terrain under shorthaul helicopter with simulated patient litter (bowman bag).
NPS Photo

Mountaineering Report 2016

A summary of the yearly operations of the Mount Rainier Climbing Rangers

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Executive Summary

The Mt. Rainier climbing rangers are a work unit within the Division of Resource and Visitor Protection (Ranger Division) under the Superintendent of the park. Subordinate to the over-arching mission of the National Park Service, the primary mission of the climbing ranger program is to train for and perform emergency services such as search and rescue, EMS, and aviation operations in an alpine mountaineering environment. Our secondary but not unimportant priority is to provide the visitor services and resource protection measures that support and manage the climbing use on Mt. Rainier.

The yearly mountaineering report produced by the climbing rangers is intended to document the climbing use on the mountain, the operational productivity of the climbing ranger work unit, and other trends in wilderness character, research, and projects. A mountaineering report has been produced consistently every year since 2009.

The data in this report is taken and summarized from several systems that the rangers use every day which include the climber's registration system and climbing ranger patrol log. These data are monitored and viewed in aggregate continually during the season to help fine tune operations and provide collaboration on tasks and coordinate daily activities and management actions. In this report, some of these data are presented in graphs and tables that show our performance relative to our mission and goals.

Key Factors in 2016

- The Wilderness Reservation System crashed and was unable to take reservations
- Unusually dry weather provided great opportunities for climbing but did not negatively impact the climbing route by prematurely melting glaciers
- A 15-year low in the number of climbing rangers affected our ability to manage upper mountain operations
- An unusually slow rate of SAR incidents helped minimize system complexities and slow the pace of daily operations

Overall Climbing Statistics and Route Use

Climbing numbers have been somewhat consistent over the last 8 years, hovering roughly between ten and eleven thousand registered climbers. The climbing rangers like to say that there is no other place in the US where so many climbers venture so deeply into technical glaciated terrain. Cumulatively, over ten years, roughly 100,000 people have attempted to climb Mt. Rainier. Nearly ½ million people have tried to climb Mt. Rainier in the last several decades. Climbers from all over the planet have enjoyed climbing on the mountain.

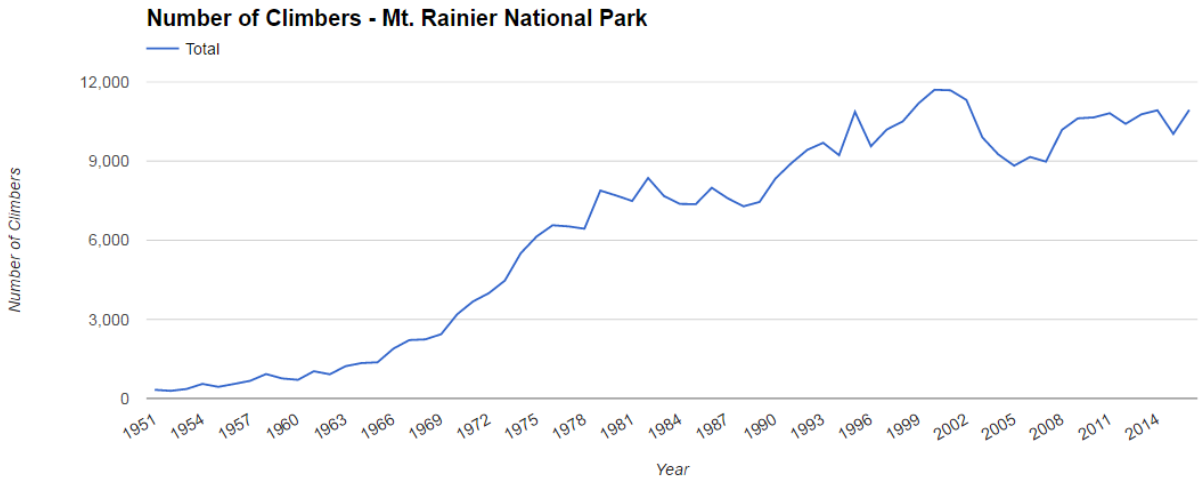

Figure 1. Total number of climbers registering to climb Mt. Rainier by calendar year, January 1 to December 30.

There are two factors that affect the number of climbers who are registering for a climb in any given year. The background factor present on a timescale of months or years is the economy. The average salary of a climber who registers to climb Mt. Rainier is about $98,000. This has been shown in several demographic surveys of climbers over the years. It takes a significant financial commitment to invest in the gear and equipment required to climb the mountain safely. In times when the economy is not doing as well or when unemployment is high, climbing numbers usually decrease.

Table 1. Rate of climbers reaching the actual summit by year

Year	Percent to Summit
2010	0.46
2011	0.50
2012	0.48
2013	0.47

Year	Percent to Summit
2014	0.58
2015	0.49
2016	0.48

The factor that has the greatest effect on climbing numbers and success rates is the weather. If the weather, just by chance, happens to be poor on the weekends for several weeks in a row, overall climbing numbers will decrease and not recover to annual averages for the rest of the season.

There were roughly 10940 climbers in 2016, an increase of close to 1000 over 2015. In 2015, the weather was repeatedly poor on several normally large weekends during the summer. This, as well as an absence of winter snow deposition in 2015, caused the climbing routes to deteriorate early and made climbing technically challenging. These two factors were not present in 2016.

In figure 2, we can observe the weekly intensity of climbing throughout the year (in blue) compared to the 3 year average. The dip in the beginning of July is a period reflective of poor weather, otherwise, climbing numbers would have broken 11,000 for the first time in over 15 years. There is a common spike over Memorial Day and a subsequent lull for a week until it picks back up and increases again after late June.

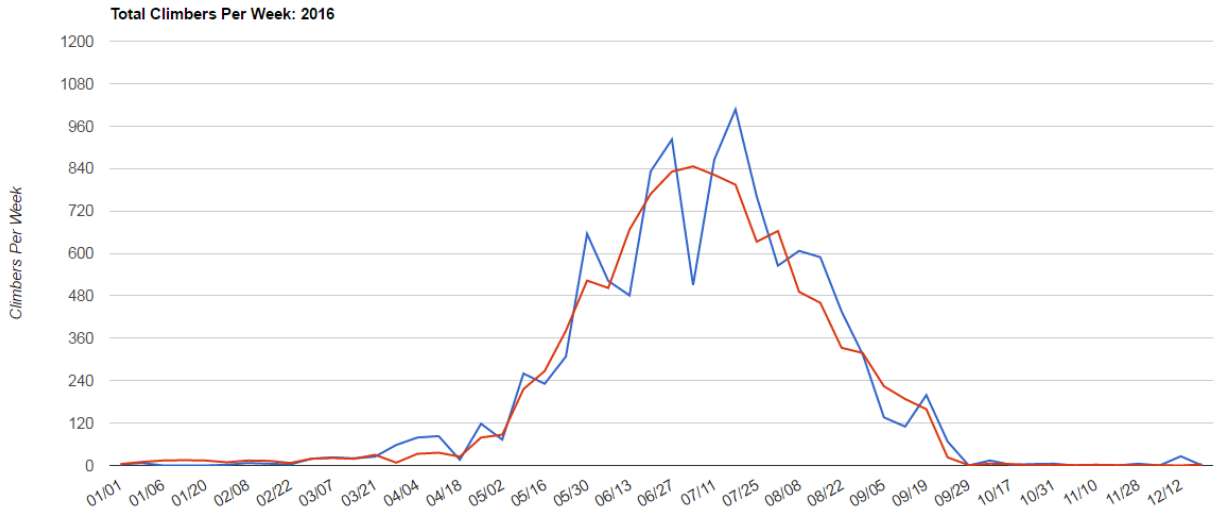

Figure 2. Graph of weekly total of registered climbers attempting all routes on Mt. Rainier from January 1 to December 31 in 2016 (in blue) compared to three-year average (in red).

Table 1 shows route use in 2016 which indicated a fairly average spread between all the routes.

One of the notable trends over the last 10-15 years is fewer ascents of the Ingraham Direct route. Historically, the early season Disappointment Cleaver route would actually ascend the Ingraham Glacier until mid-June. These days, the Ingraham Direct has become too crevasse-riddled to safely ascend by mid-May. This is evidence of a thinning glacier more capable of feeling the effects of the uneven bedrock terrain below. The thinning of the glaciers has been scientifically observed now in several surveys and datasets. (T.W. Sisson, J.E. Robinson, and D.D. Swinney, 2011)

Table 2. Table of route use by route and by year over a six-year period with a six-year running total and as a percent of the six-year total per route.

Route	2016	2015	2014	2013	2012	2011	6-yr tot	6-yr % of tot
Disappointment Cleaver	8167	7386	8138	7831	7253	7150	45925	71.89%
Emmons – Winthrop	1610	1465	1466	1670	1469	1826	9506	14.88%
Kautz Glacier	445	520	414	432	388	553	2752	4.31%
Ingraham Direct	103	99	126	98	330	398	1154	1.81%
Fuhrer's Finger	174	76	189	202	167	160	968	1.52%
Little Tahoma	186	148	152	167	130	152	935	1.46%
Liberty Ridge	60	74	94	129	161	137	655	1.03%
Gibraltar Ledges	63	77	123	102	90	169	624	0.98%
Glacier Only	62	68	119	70	214	61	594	0.93%
Ptarmigan Ridge	25	19	38	10	9	50	151	0.24%
Kautz Cleaver	12	17	34	14	14	45	136	0.21%
Tahoma Glacier	10	12	22	14	21	48	127	0.20%
Success Cleaver	24	7	9	5	14	24	83	0.13%
Nisqually Glacier	0	13	4	4	11	13	45	0.07%
Gibralter Chute	0	3	10	2	11	13	39	0.06%
Mowich Face	5	6	2	7	16	2	38	0.06%
Wilson Headwall	0	5	0	3	13	4	25	0.04%
Sunset Ridge	3	2	4	3	4	2	18	0.03%
Kautz Headwall	0	2	3	6	0	5	16	0.03%
Nisqually Ice Cliff	0	3	0	2	8	2	15	0.02%
Sunset Amphitheater	0	3	2	4	2	3	14	0.02%
Nisqually Cleaver	0	2	0	4	3	3	12	0.02%
Tahoma Cleaver	4	3	0	0	0	2	9	0.01%
Curtis Ridge	4	4	0	0	0	0	8	0.01%
Edmonds HW	0	2	4	0	0	2	8	0.01%
Willis Wall	0	0	0	0	0	6	6	0.01%
Liberty Wall	0	0	0	0	0	0	0	0.00%
Total	10975	10016	10953	10779	10328	10830	63881	100.00%

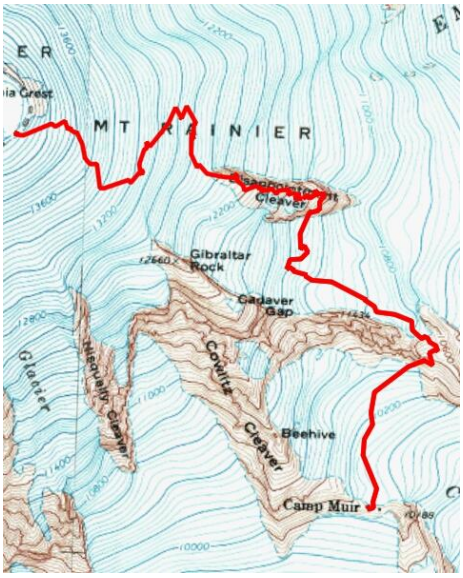

Figure 3. The Disappointment Cleaver route for most of the 2016 season

In figure 3, the Disappointment Cleaver route is seen to be the way it was for most of the year. Although many rangers and guides expected key snow bridges over crevasses to collapse and render a much more circuitous route, only minor route changes were needed over the summer. This is contrasted by many years where the route traverses to the north from the top of the Disappointment Cleaver then turns south and contours at 13,400 to the top of the Nisqually Cleaver.

Climbing Program Operations

Figure 4. The Mt. Rainier Climbing Ranger work unit at the beginning of the 2016 season in May pose for a photo in full uniform. Left to right: Brian Hasebe, Cameron Reade, Forrest Madsen, Scotty Barrier, Peter Ellis, Julian Hanna, Stefan Lofgren, Sam Siemens-Luthy, Thomas Payne. Not pictured: Kurt Hicks, Ryan Lazzeri, John Papineau, Seth Swallen, and Joe Phelan.

Program Configuration

The climbing program is normally organized into 'teams' that work together as a unit all summer in an eight-day-on / six-day-off schedule throughout the summer. In 2016, it was necessary to abandon this convenient system of organization and 'cascade' our schedule. This meant that there were no longer 'teams'. Each ranger came on duty and went off duty sequentially over a period of days that prioritized Saturday through Monday periods with the most rangers on duty at one time. This also meant that on Tuesday and Wednesday, there were often only two climbing rangers on duty in the whole park. Typically, one would be at Muir and one at the Climbing Information Center (CIC). Often the ranger who was working at the CIC was the climbing program manager, not usually involved in field operations at all!

The climbing program had 12 full-time members on its team in 2016. This was a decrease of five field rangers from 2015 and was the smallest number of climbing rangers in 15 years. There were 4 permanent members on its staff, consisting of the Climbing Program Manager and 3 supervisory/lead rangers. There were 5 seasonal climbing rangers, two high camp laborers, and one CIC ranger. We hired two rangers who worked just about 2 months; one in a 60-day critical need appointment and the second in a competitive appointment with only enough funding to cover 2 months. We also filled our fourth GS-9 permanent climbing ranger position in September, which had been vacant for about one year.

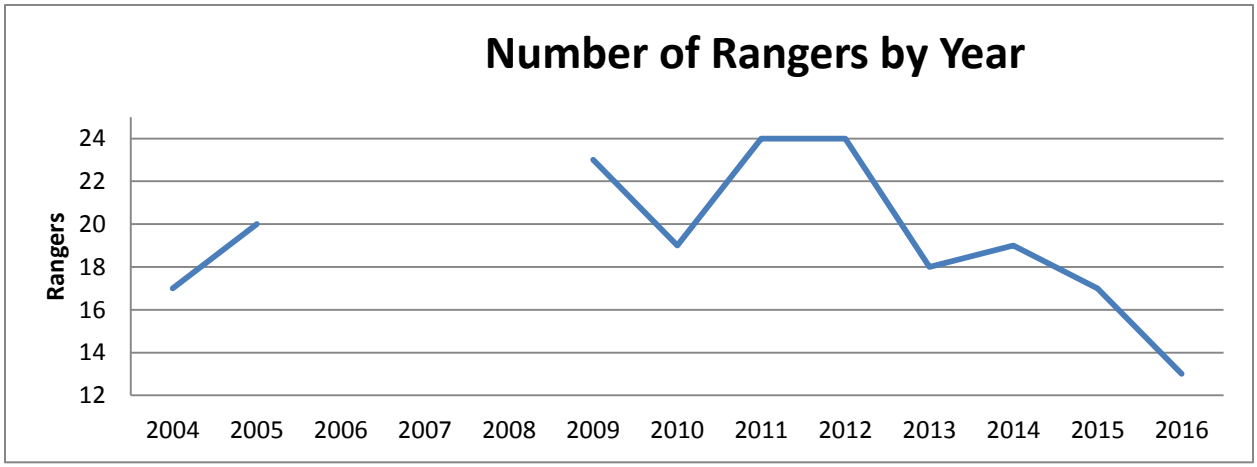

Figure 5. Graph showing the number of rangers per year integral to the climbing program. There was no mountaineering reports published in 2006 – 2008.

There are a few reasons for this season's decrease in the number of climbing rangers. Since the fee was increased in 2011, the climbing program has gradually hired more permanent rangers. This was part of the objective of the fee increase. A permanent ranger costs about the same as three seasonal rangers. The gradual decline in the total number of rangers was part of the plan. Also, in 2015, total climbing numbers dipped by about 1000 climbers compared to the recent previous years. Climbing

fee revenue went from $412K to $365K approximately. In 2016, we had no choice to lower our estimation of what revenue we may see in climbing fees. And then on top of that, in 2016, some larger budget challenges were present and the overall (non-climbing fee) sources of funding decreased more than what the addition of the permanent staff cost. These budget issues are not expected to be as large of a factor in the 2017 season.

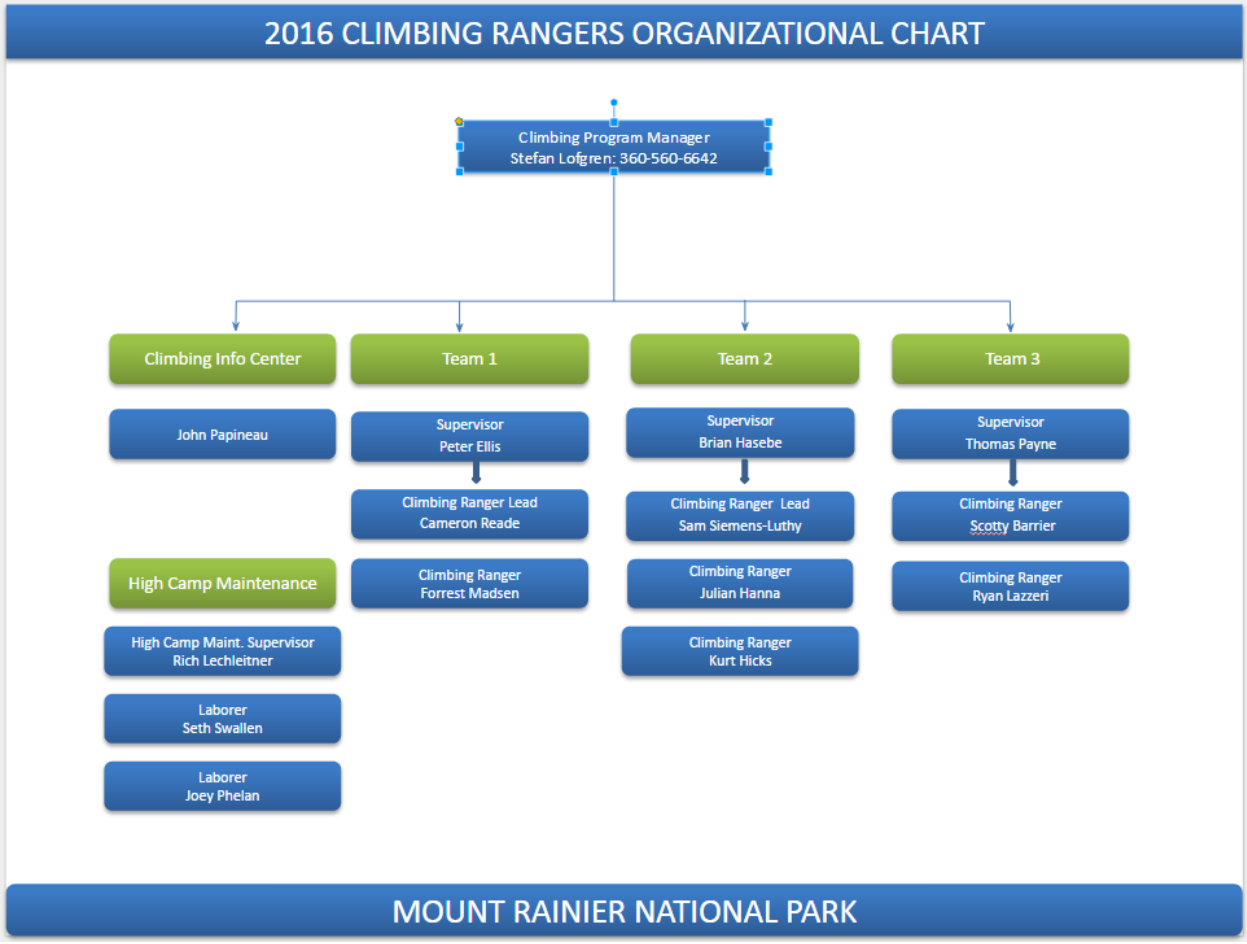

Figure 6. This graph shows the organization of the climbing ranger work unit.

Core Skills and Training

The climbing rangers positions have five core skills; 1) Mountaineering, 2) Aviation, 3) Emergency Medical Services, 4) Technical Rope Rescue, and 5) Avalanche Assessment. In each of these skills, we have a set of training and certification requirements. Rangers are not expected to have all these certifications before they enter on duty.

Mountaineering

In mountaineering, we are supporting seasonal rangers with training up until the AMGA Alpine Guide Course level. This involves two courses, either the Rock Guide Course or the Alpine Skills course and then the Alpine Guide course. For skiing (included as a mountaineering skill), we are systematically trying to get all our seasonals to at least the AMGA Ski Guide course. For our permanent rangers (currently four in 2017), we are getting all our rangers through the full Alpine

Guide curriculum and full certification as an Alpine Guide, which is also in their position descriptions. We prefer to get them through as many Ski Guide courses as we can with full-certification as the end result. In nearly all of the climbing rangers' near misses and fatalities over the last 30 years, mountaineering practices (climbing and skiing) skills and decision making has been identified as a root cause of the accident.

Table 3. Table showing climbing ranger achieved (x) and planned (p) AMGA training courses as of 2016

	Alpine Curriculum					Rock Curriculum			Ski Curriculum		
	Alpine Skills	Alpine Guide	Ice Instruct	Adv. Alpine	Alpine Exam	Rock Guide	Adv. Rock Guide	Rock Exam	Ski Guide	Adv. Ski Guide	Ski Exam
Rgr1	X	X	X	X	P	X			P		
Rgr2	X	X	P								
Rgr3	X	P							X	P	
Rgr4		P	P			X			X	X	X
Rgr5	X	P							X		
Rgr6	X	P	P			X					
Rgr7	X	P							X	X	X
Rgr8	X	P							P		
Rgr9	X	P							P		
Rgr10	P										
Rgr11		X	X	X	X	X	X	X	X	X	P

Some may argue that the guide curriculum and the work duties the ranger employs are not congruent. This may be partly true, but guide-specific parts of the AMGA training have helped the rangers understand the role and importance of guiding and also help them understand what *good guiding* is. A large part of our work is to monitor the climbing guide services. The benefit to the evaluation and testing in the AMGA courses is that rangers are tested in the application of fine technical skills and in decision making and judgment by detached third parties who are professional subject matter experts.

Table 4. Climbing ranger training sessions and total hours by category

Training Type	Number	Personnel-Hours
Administrative	2	18
Avalanche	3	124
Aviation	7	410
Climbing Ranger	7	576
Emergency Medical	2	264
Search and Rescue (incl. tech rope rescue)	23	831

Training Type	Number	Personnel-Hours
Supervisory	1	12
Wildland Fire	1	85
Total:	46	2321

Aviation

Aviation duties are a complex and professional level set of skills closely scrutinized and regulated by strict policy in the Department of the Interior. One of the first courses new climbing rangers are put through is A-100, basic aviation safety. It is an eight-hour course and is required by the Department of the Interior for anyone who may fly. Next, we send them to a week-long helicopter crewmember course. They are issued a taskbook and spend a subsequent year as a trainee. In this *HECM* training they learn how to perform passenger briefings, crew and cargo manifests, to wear the correct personal protective equipment, prepare cargo and sling loads, manage a remote helispot and assist the helicopter manager and pilot with other duties. Once rangers have obtained this qualification after a year, then we train them as short-haul team members and in STEP procedures (single-skid, toe-in, one-skid, entry and exit procedures). Short-haul is a particular method of helicopter rescue where there is a jettisonable rope affixed to the helicopter of at least 100', but may be up to 400'. There is a ring on the end of the rope. The ranger is trained in a special technique to clip his/her harness into the rope and fly to the rescue location or injured party. The ranger is then trained to use several adjuncts to package and/or extricate the patient using the same method. This is an advanced aviation skill. For instance, only after a season or two of general helicopter experience are rangers accepted on to the short-haul team. This is a common world-wide rescue method and used in places like Chamonix, France by highly respected rescue organizations such as PGHM.

Figure 7. Climbing rangers conduct crevasse rescue training simulating rescuing an injured patient.

Emergency Medical Services

Climbing rangers are all Emergency Medical Technicians when they achieve their full-performance level. Because no one outside our work environment could possibly achieve all the requisite skills before we hire them, we sometimes make allowances for rangers to enter into the position with less than an EMT certification, however they are required to fulfill this skill level within a year of getting a job here. Climbing rangers often respond to medical incidents around the park and in the frontcountry environment.

Technical Rope Rescue

This is the bread and butter skill of the climbing ranger. The National Park Service has in recent years established a system-wide set of Search and Rescue (SAR) qualifications. There is a path of sequentially higher qualifications called Search and Rescue Technician and Technical Rescue Technician (SRT and TRT). New climbing rangers spend a year or two knocking out pre-requisite classes and training and are given a task book for each higher level skill. On the way there, the intermediate level (TRT1) requires the completion of a week-long technical rope rescue seminar such as taught once a year by the NPS, or taught by contractors such as Rigging for Rescue, LLC, and Conterra LLC. Each year, the climbing rangers contract a course taught by training vendors such as these.

Avalanche Assessment

Climbing rangers also must complete a US Level II avalanche class. The avalanche training landscape is set to change over the next couple of years and we anticipate that the standard level of training for a climbing ranger to be at the professional level.

Other Skills and Training

Rangers receive a substantial array of other job-related training such as training in the NPS-wide risk management system entitled "Operational Leadership", backcountry navigation skills, administrative and supervisory training, and resource management training.

Mountaineering Patrols

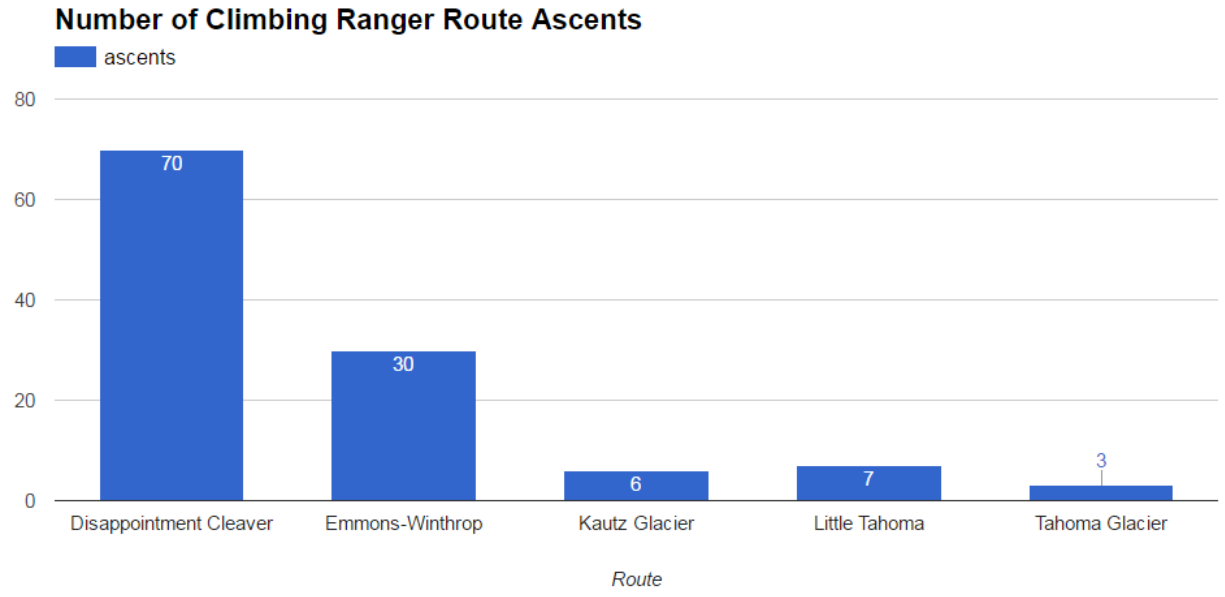

Figure 8. Number of climbing ranger ascents on various routes on the mountain

Climbing rangers, as you can see from figure 14, spend the majority of their time climbing, monitoring, and patrolling the standard routes on Mt. Rainier. Patrols provide the opportunity to be present as visitors are climbing the route, observe trends, pick up litter, stray wands, and human waste, provide training opportunities, and keep rangers fit and acclimatized so that during rescues, rangers are not maxing their physical capabilities.

Climbing rangers do patrols to less traveled routes to maintain their mountaineering skills and conduct wilderness character monitoring, as well as gain familiarity with the mountain. Due to low staffing numbers, and poor weather at times, climbing rangers did not patrol as many routes in 2016 as in years past.

An Analysis of Climbing Ranger Staffing in 2016

There were on 9 field climbing rangers plus two short-term, two-month appointed ranger in 2016. Though it was challenging during the summer operation, in retrospect, it has made a good case study on how many climbing ranger staff it takes to manage visitors and climbers on Mt. Rainier while still providing professional standards of staffing and team resources for SAR responses. Although our performance measures shown below don't show a *dramatic* decline, there was a very perceptible difference between 2016 and years before in the level of intensity of daily work activities,

training opportunities, and our ability to manage the number of climbers in the CIC and at the high camps. Considering the rescue load was small in 2016 and would normally contribute to decreasing the intensity of our workload, this is something we are paying very close attention to in planning for the 2017 season.

Climbing rangers log data about their daily work duties at the end of every 8-day shift. These data reflect summaries based on the rangers' patrol logs.

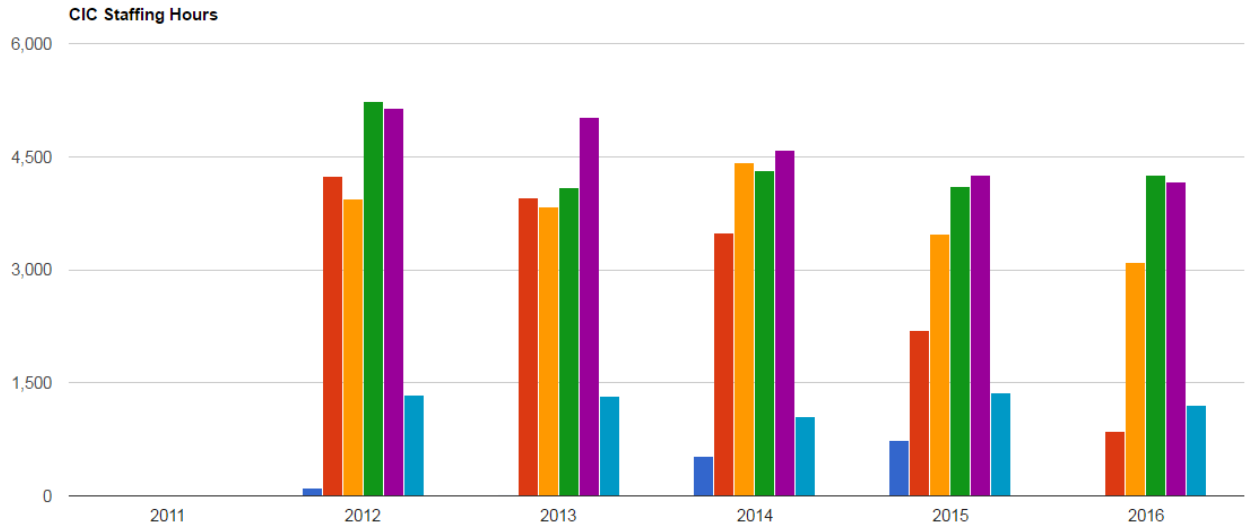

Figure 9. Climbing Information Center ranger-hours 2012 to 2016. Blue: April, Red: May, Orange: June, Green: July, Purple: August, Light Blue: September.

In figure 9, you can see a yearly comparison of hours the climbing rangers staffed the CIC from 2012-2016. Each column is a month in that year from April to September. The trend is quite obviously down. We felt the heavy impact of the absence of a *reservation* system in the CIC. Everyone who might have otherwise sought and obtained a reservation (pre-purchasing the climbing fee and prefilling out a permit) now showed up the day of their climb and these administrative processes were handled then, instead of in April during the reservation process. This added to the workload of registering climbers. We are taking steps in 2017 to address this and ensure we have a working reservation system and also by providing extra rangers to help register climbers during peak periods.

Figure 10 shows the number of hours climbing rangers were staffing the high camps. The differences between 2016 and other years is obvious. On some days during the summer, there are over 1000 people who go to Camp Muir. There are often more than 150 people at Camp Muir spending the night. When there are not enough rangers to give climbing briefings to all these people, it results in crowding in crux areas on the route, more litter trash and human waste on the climbing route, a messier high camp, overflowing and unsanitary toilets, as well as worn-out rangers. We are also taking steps in 2017 to provide better coverage at both Camps Muir and Schurman.

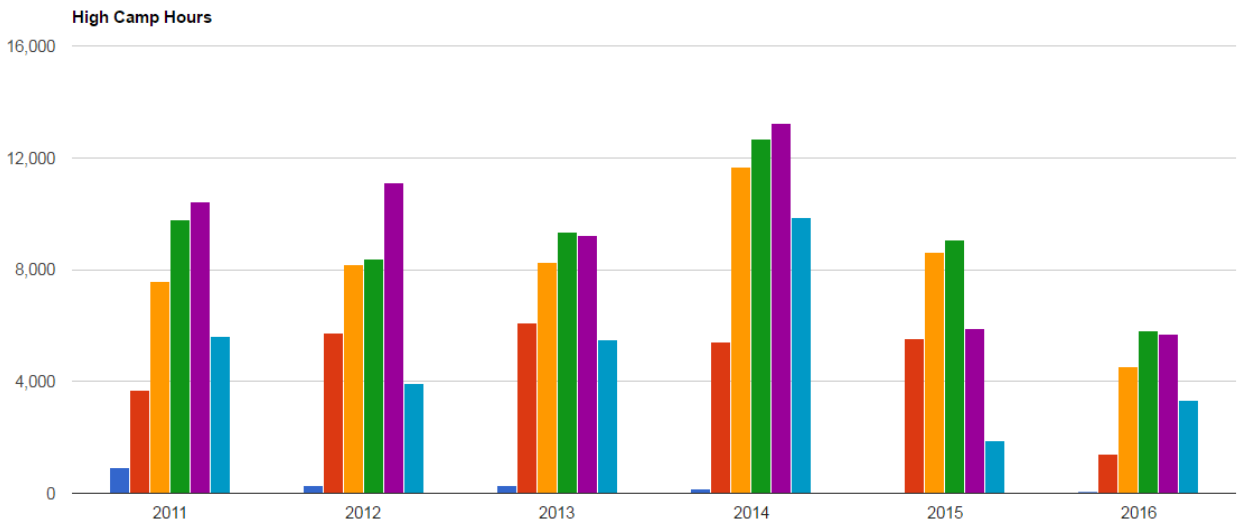

Figure 10. Ranger-hours staffing high camps from 2011 to 2016. Blue: April, Red: May, Orange: June, Green: July, Purple: August, Light Blue: September.

In figure 11, we can see the most recent data from 2014-2016 and the average number of rangers at both high camps and the number of days that the camps were unstaffed from May 1 to September 30. Blue-Green columns are the number of days at camps Muir and Schurman from May 1 to Sept 30 where there were 0 rangers. Red-purple columns are the average number of rangers at high camps May 1 - Sept 30.

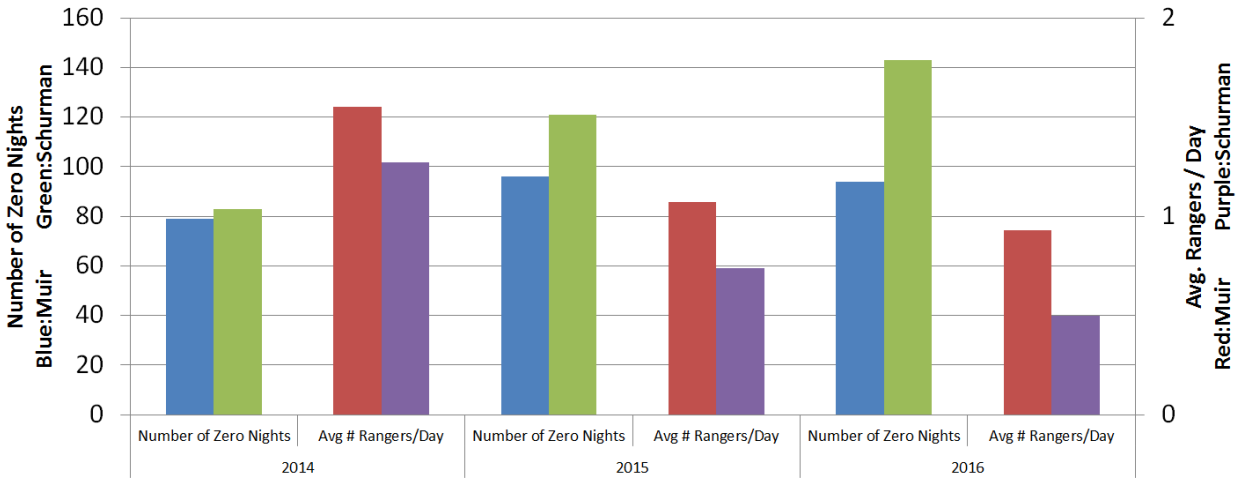

Figure 11. Graph showing high camp staffing data from May 1 to September 30. Blue and green represent the number of nights at Muir and Schurman (respectively) where there were no rangers read on the scale on the left. Red and purple represent the average number

There were also many other factors that were negatively impacted. Some of these factors were training time per ranger, commercial services (guide) monitoring sessions, resource management efforts, litter and impact patrols, climbing registration, and several others factors. We are making progress in 2017 to stem these challenges.

Ranger Stations

The Climbing Information Center (CIC) at Paradise is the main climbing permit issuing station in the park. In 2016 the CIC was staffed by climbing rangers on a rotating schedule, with one main CIC employee, whose job it was to maintain continuity in daily CIC operations. This was a departure from how the CIC had been run for the past several years, with its own dedicated staff.

It may be impossible to ever know for sure which is the best way to staff the Climbing Information Center. By placing climbing rangers in the CIC, it ensures that the information passed to climbers is current, as these same climbing rangers have likely been up to Muir or the summit recently. However, climbing rangers typically have much longer seasons and require much more training, which are both more expensive. Only up to a certain point is it a good use of resources to staff the CIC with rangers who are skilled and trained to do much different work.

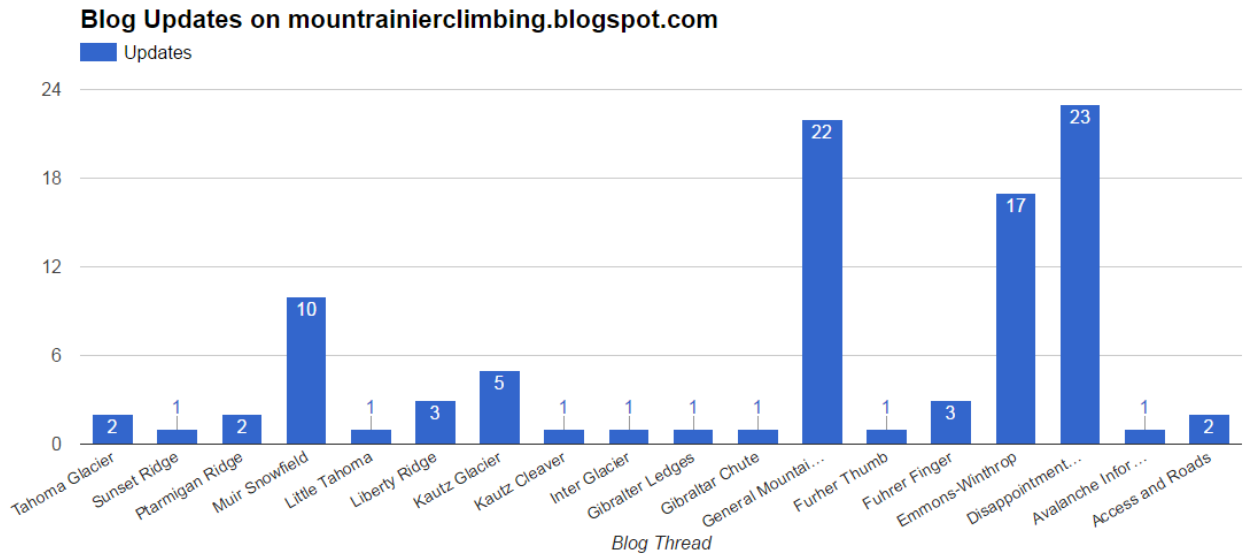

Figure 12. Climbing ranger blog updates by thread in 2016

In 2016, we could not afford to dedicate a staff to work solely at the CIC, so what climbing rangers we had, also had scheduled shifts in the CIC. This impacted the staffing high camps.

The White River Wilderness Information Center (WIC) was no longer staffed by the Camp Schurman rangers on Friday afternoons and Saturday mornings in 2016 as it had been for almost 20 years. Climbing rangers did stop into the ranger station on their way to and from Camp Schurman to pass along updated route conditions. The addition of a functioning network bridge at Camp Schurman provided a reliable phone line for the first time, making relaying route conditions on a daily basis much easier. A big thanks to the east district staff for their help in 2016!

Mountrainierclimbing.blogspot.com

The climbing blog has been the best way the climbing rangers have been able to get updated route conditions out to the public in a timely way. The blog is immensely popular and takes hits from all

over the world. In the past several years, there have been many hundreds of thousands of hits, with the overall views surpassing 1,000,000. We actually receive requests to advertise on it from large corporations.

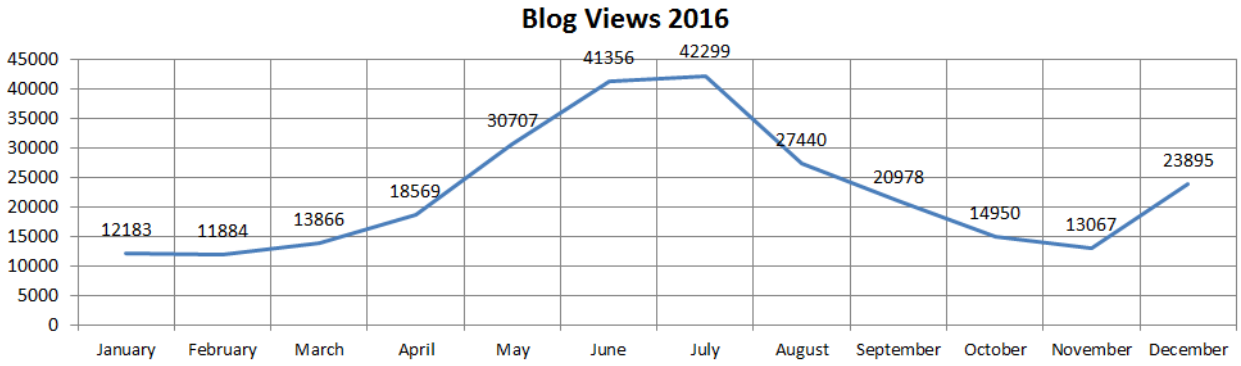

Figure 13. Graph showing the number of combined blog hits on all mountrainierclimbing.blogspot.com pages.

Communications

The climbing program is a complex system of integral operations that historically function in relative isolation from each other. Communication is nearly always identified as "how we can do better next time" after each incident. Communicating the plan, the organizational structure, conditions, and other important information is not just crucial on an emergency operation, but also during regular daily and routine operations. Therefore it is worth continually documenting the efforts we are taking to use new technologies and philosophies to increase communication up, down, and sideways through our program.

The biggest gain in 2016 was the implementation of a long-sought-after microwave communication infrastructure linking Camp Schurman to the rest of the park. This system was shown to be feasible during a proof-of-concept demonstration in 2006. In 2010, a simple microwave system was installed at Camp Muir enabling a common VOIP phone to work. Also, as a practical upshot, internet and an internal network connection was enabled to Camp Muir. This was a game changer. It increased the reliability of communication as well as the density of information communicated because finally you could sit down and talk on the phone in the warm environment of the ranger station rather than searching for a cell phone signal outside in the cold and/or wind.

The next step was to provide the same upgrade at Camp Schurman. There was no line of sight between Camp Schurman and a point where there was access to the NPS network and internet. Plus, NPS encryption requirements had increased the cost of the microwave radios involved. The cost of the system was out of reach for us.

In 2013, a group of local climbers were attempting the summit from Camp Schurman when they were stranded by a rapidly worsening storm. They spent a few days in a very small snowcave until rangers were able to arrive on scene during another storm. Several of the individuals in that party

contacted the Washington National Parks Fund and several years later enough money was collected through donations and fundraisers to purchase and install this system. The primary fundraiser for this has become Recreational Equipment, Inc's annual non-profit climb.

This system was installed and began to work in July 2016. Now climbing rangers can call from Camp Muir to Camp Schurman and have discrete conversations about weather, conditions, rescue plans, coordinate daily operations and even get online and check the weather forecast and update the blog after their climbs. They can call and be called internally to or from any other extension in the park.

In 2016, all climbing rangers on duty called into a virtual meeting no matter where they were (on patrol via satellite phone, at Camp Muir, at Camp Schurman, at the CIC, at home, etc…) every day at 4:00 pm. This helped tremendously to bring the climbing rangers together and bring a higher level of coordination to our operation.

A special thanks for enabling this is given to Kelly Jackson at REI's main office in Kent, Wa.

Resource Protection

Although the primary work responsibilies climbing rangers prepare for are emergency services, they are also wilderness rangers who must have skill in climbing to access the area of land in our district, monitor its use, document impacts, and clean up areas of impact. Rangers take several different approaches to managing wilderness for integrity of character. Part of rangers' spiel when they are registering or talking to climbers on the mountain includes resource protection measures usually quantified by "leave no trace" principles. Climbing rangers also are the chief implementers of the blue bag system, a system of collecting human waste off the mountain and transporting it to collection facilities. Rangers also record impacts to wilderness character in a geo-database and conduct surveys on the cleavers in alpine areas for the development of campsites and other manmade features, impacts, trash, and damage.

Wilderness Impact Monitoring

As a part of each individual's weekly climbing ranger patrol log, rangers are required to enter each impact they observe. There are roughly 62 impact categories under 8 general categories. The more impacts the rangers record, the better decisions managers can make and intervene to control or mitigate these impacts.

Climbing rangers recorded 1157 individual impacts in 2016. It is important to consider that this doesn't represent an increase or decrease in total impacts on Mt. Rainier. The number of impacts recorded every year are only a reflection of the number of rangers, their field time, and the importance that supervisors place on their employees to record impacts.

Table 3. Total number of each type of wilderness impact observed by major category in 2016.

Impact Category	Number of Observations
Administrative	6
Air Quality	2
Aquatic Resources	4
Campfires	1
Installation	7
Landscape Conditions	1056
Non-Compliance	30
Sanitation	51
Total	1157

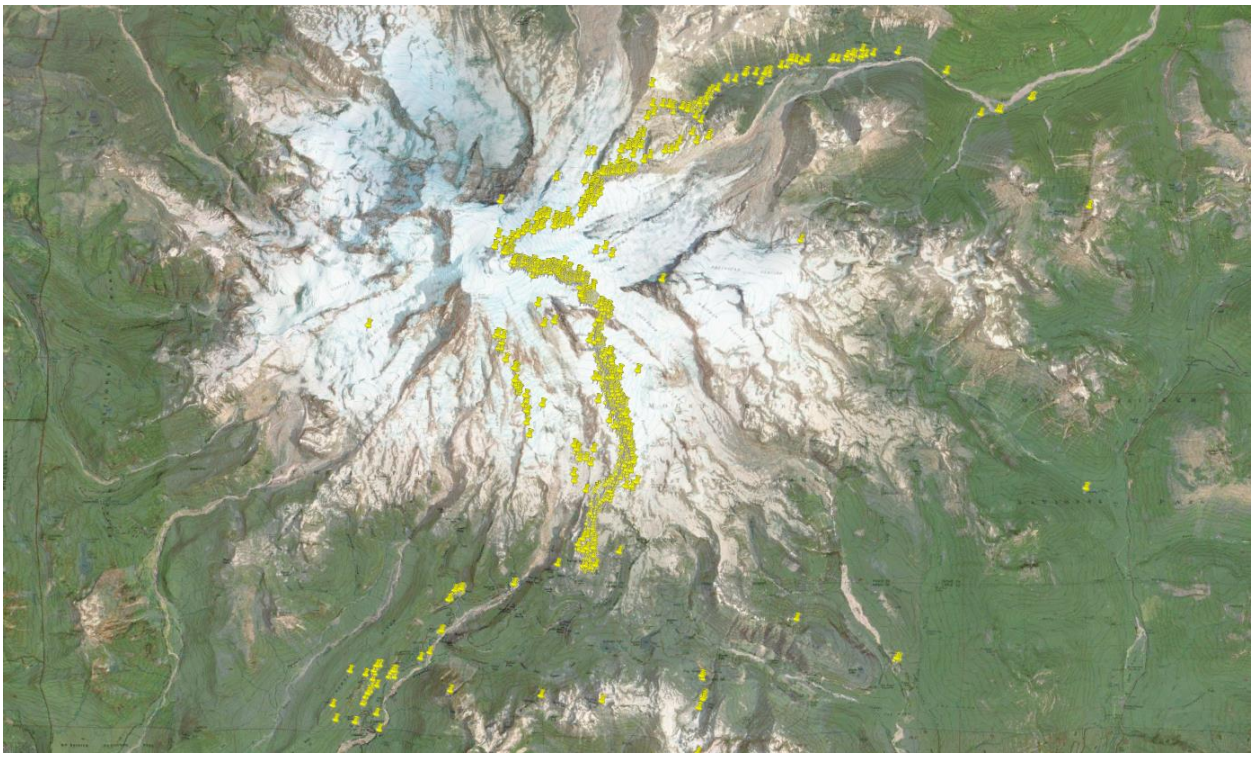

Figure 14. A map showing a portion of the 1157 impacts recorded by rangers in 2016

You can see in figure 13 that we only observe impacts in the places that we actually go. There is really nothing scientific to find by observing these impacts on the main routes. However, our impact monitoring system is configured to automatically produce weekly aggregate summaries. Sometimes

trends can be identified that an individual ranger observing an impact may not realize. A great example of this is during the 2013 season when many individual rangers observed a fox that was getting into climbers' food. A pattern wasn't identified until an impact summary was performed. We bought some temporary food storage containers (5-gallon buckets) and had climbers store their food in them. The problem (and observations) decreased substantially.

Although landscape conditions such as litter or denuded vegetation are the most intuitive types of impacts to record, wilderness character is far more complex and subtle than that. The four qualities of wilderness are, 1) Natural, 2) Untrammeled, 3) Undeveloped, and 4) Solitude, or Primitive and Unconfined. Our impact categories we observe are set up to indicate all these qualities.

Table 4. Impact Category "Landscape Conditions" broken down into its sub-categories.

Landscape Condition - Subcategory	Number
Abandoned Manmade Item	22
Alpine Campsite Rock Ring	18
Expanding Campsite	11
Injured Vegetation or Tree	2
Litter	623
Meadow Stomping	4
Social Trail	25
Trampled Vegetation	111
Wand	240
Total	1056

The most common impact shown in table 3 and 4 represent primarily litter and stray wands, which by the end of the summer, melt out of the snow and are just lying on bare ground. This doesn't necessarily show that more or fewer people are littering in August, but this is when we see most of the melted out litter on the ground. This figure also represents a large volume of meadow stomping, denuded vegetation, and campsite rings that develop or become exposed later in the season after the snow has melted.

The data also suggests several areas where we could develop strategies to lessen the impacts on the mountain and preserve the wilderness character. These include removing wands from the Muir snowfield and the climbing routes, which accounts for the second most overall documented impacts behind litter. Another common wilderness impact that preserves the character and cleanliness of the mountain is removal of blue bags and human waste. The data we are currently collecting on commercial, single engine, and military over-flights is being used in management plans to regulate flights over the park.

Human Waste

Nothing much has changed from last year in our management of human waste. We have two systems, the toilets at the high camps and the blue bag system.

The toilets at high camps are not "composting" toilets, but they are somewhat effective at separating the solids and liquids. The liquids are dispersed directly back into the rock debris below Camps Schurman and Muir. The solids are somewhat dehydrated and then transferred (by hand!) to 40-gallon barrels, which in turn are flown off the mountain by helicopters. The barrels are then transported to a waste processing facility outside the park.

The blue bag system is used in areas where there are no toilets. Human waste is deposited on the ground or snow. The solids are picked up like you pick up your dog's poop in the park. The waste is transported by the visitor/climber to a high camp or ranger station where they are put in a barrel. The barrel is either flown from Camp Schurman/Muir or picked up by vehicle at ranger stations. These barrels are then transported to an incinerating facility outside the park.

The combined overhead in maintaining these two systems costs between 80,000 and 100,000 dollars, if you include all the people, materials, supplies, and transportation costs. Several 10's of thousands of those dollars are paid for by money not associated with the climbing program or the cost recovery fee (climbing fee). The exact cost of operating the system is not easy to figure because you have to account for a percentage of several people's time who are neither working in the ranger work unit nor paid out of its funding sources.

In 2016, of the total equipment cost of operating the human waste system in the alpine areas of Mt. Rainier that was paid for out of climbing fees was about $10,600. It does not account for two seasonal positions that are devoted to dealing much of their time with keeping the toilets working. This figure does not change much from year to year.

Below is the number of each type of human waste collected in the areas impacted by climbing.

Table 5. Total Human Waste Removed from Mt. Rainier in 2016

Location	Number of Barrels	Pounds of Waste
Camp Muir		
Raw Human Waste	14	6000

Blue Bags	8	1500
Camp Schurman		
Raw Human Waste	3	1550
Blue Bags	3	600
White River		
Blue Bags	1	150
Paradise		
Blue Bags	3	600
West Side Rd		
Blue Bags		10
Totals	32	10,410

Campsite Surveys

Later in the summer in September or October, rangers conduct campsite surveys on the cleavers such as Wapowety, Success, Puyallup, Ptarmigan Ridge, and Curtis Ridge. We keep a database of known rock rings and monitoring each cleaver every few years for change and make selections on which rock rings to dismantle and rehabilitate.

Figure 15. Map showing a 2016 survey of Curtis Ridge and campsite recorded in geodatabase with pictures

These surveys are a part of our wilderness management efforts and can only be conducted within a few weeks in September when the weather is still favorable and snow has not obscured the ground yet.

Glacier Research

The North Cascades and Columbia Network Inventory and Monitoring Program gives the climbing rangers a small amount of money for assisting them with research on the Nisqually and Emmons Glaciers. Our role is limited to assisting with the schlepping of gear and some technical assistance with the mountaineering end of things. The primary goal is to determine the mass-balance of the two glaciers. Up to eight stakes are driven into each glacier with a 'steam-drill', which consists of a backpack mounted propane boiler and pressure tank with a nine meter rubber hose with a one meter steel tip and nozzle.

Stakes are placed at Ingraham Flats (an analog to 11,000 feet on the Nisqually), 9,800' on the Muir Snowfield (also analog to the Nisqually), one at 7,800 feet, two stakes at 6,200 feet (on in the debris covered area, one in the bare ice), and finally one in the debris covered area at the terminus. On the Emmons Glacier, one stake is placed at about 10,200 feet, 8,900 feet, 7,600 feet, two stakes at 6,200 feet (debris and bare ice), and finally one at the terminus. Some years more stakes are placed as needed. The stakes are drilled down to firn ice, often more than nine meters deep.

The stakes are installed during maximum winter/spring accumulation when the snowpack is greatest at those altitudes. Other measurements such as snow density and intermediate layers are taken using a screw-driven snow core and a long snow probe. Ultimately, in the fall at minimum snowpack (or maximum melt) in September or October, the stakes are read again.

The final conclusion each year is called the 'net-balance'. Is there a positive balance, meaning was there more accumulation of snow than melting, or was there a negative balance, meaning more melting of snow and ice than accumulation?

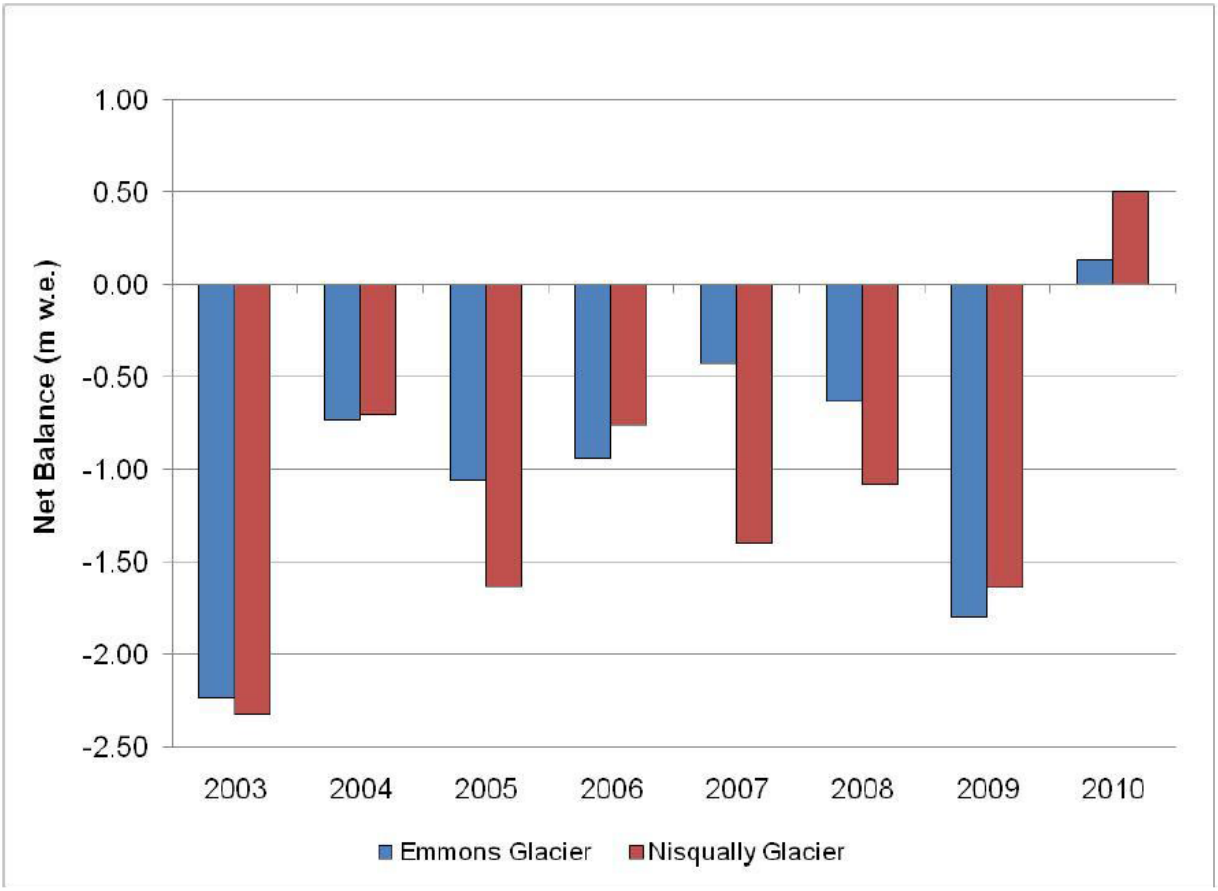

Figure 16. Rainier National Park Glacier Mass Balance Monitoring Annual Report, Water Year 2010 (Riedel and Larrabee, 2010.).

In the graph above you can see the data collected between 2003 and 2010. In every year since 2003 except one there has been a net loss of mass on the Nisqually and Emmons Glaciers. (Larrabee & Riedel, 2010). Recent provisional data up to water year 2016 shows similar data. These data help explain some of the phenomena and trends we see as climbers.

Up until the 1990's, the Disappointment Cleaver route would occasionally dip down below the Disappointment Cleaver from Ingraham Flats to the "football field" and ascend the Emmons Glacier just north of the DC. In recent times, this route variation is not possible due to this portion of the glacier being exceptionally broken up with crevasses. Also, up until the 1990's, it was common to transition from a direct ascent to the top of the DC on the Ingraham Glacier in mid-June.

Volunteer, SCA's, and other partners

The climbing program has historically relied on volunteers to conduct some of its operations, but in recent years we have been trying to find more appropriate ways to use volunteers. In the past, as many as 6-8 volunteers have committed to full-time schedules, a tight training regime, and have

earned no more than $20/day in per diem for their efforts. The type of individual who is willing and available to commit to a period of 4-5 months for that kind of pay is limited to younger men and women who have fewer responsibilities in life.

These individuals also come with less experience, certifications, training, and time in the mountains. In 2016, we did not employ any full-time volunteers.

In 2017, we have planned a shorter term volunteer system. The full-time paid staff will recruit friends or professionals from similar industries for single trip patrols. This model is similar to Denali National Park's volunteer model, except that our patrols will be on the order of a few days or up to a week rather than several weeks or up to a month. The guide services Rainier Mountaineering, International Mountain Guides, and Alpine Ascents International will also provided volunteer hours per their contract to the park as they have for many years doing trail maintenance and other resources protection work.

Table 6. Summary of volunteer hours by various volunteer program.

Volunteer Program	Number of Hours
VIP	60
SCA (Student Conservational Assoc)	0
MRA (Mountain Rescue Assoc)	990
Total	1050
Estimation of Equivalent Dollar Value	$19,800

Toilet Construction at Camp Muir

The Camp Muir development concept plan calls for building two two-holer outhouses to replace the single units between the helipad and the public shelter. Once completed and the two toilets units are operational, the old ones will be torn down. The next stage of construction will be to tear down the client shelter that RMI, AAI, and IMG use and replace that with a rock-faced building similar to the public shelter and the ranger station. However, this is likely several years away.

Currently, the NPS is mostly done with the first toilet located *behind* the public shelter. This site was chosen to keep the odors from drifting downwind to the public shelter and to help keep the ridge clear for more day use.

Building in this kind of environment is challenging enough. Living in it is even more of a challenge. Construction crews have tried living in a few different shelters, the only one that has met their needs, and provided rest and sleep protection is the actual toilet itself. It is mouse-proof, sound-proof, wind-proof, and warm and doesn't need to be dug out or reset every few days. So the construction crews

have been allowed to live in the 1st toilet while they are building the second one that will replace the 'guide' toilet on the other side of camp.

Construction will begin on the new 'guide' toilet in 2017. Meanwhile with the main body of the public toilet built, only interior work will mainly need to be done. It is realistically going to take another two years or so before they are both put in service as toilets.

Guiding

Mount Rainier National Park allows three types of guiding, 1) Concession Contracts, 2) Commercial Use Authorizations, and 3) Commercial Non-Profit climbs. There are three concessions contracts, a) Alpine Ascents International, b) International Mountain Guides, and c) Rainier Mountaineering, Inc. The three concessions contracts ended their 10-year term in 2016. An new prospectus was advertized and new applicants were reviewed. In the fall of 2016, the contracts were awarded to the three existing contract holders for another 10-year term. The competitive process has improved the guiding experience on Mt. Rainier.

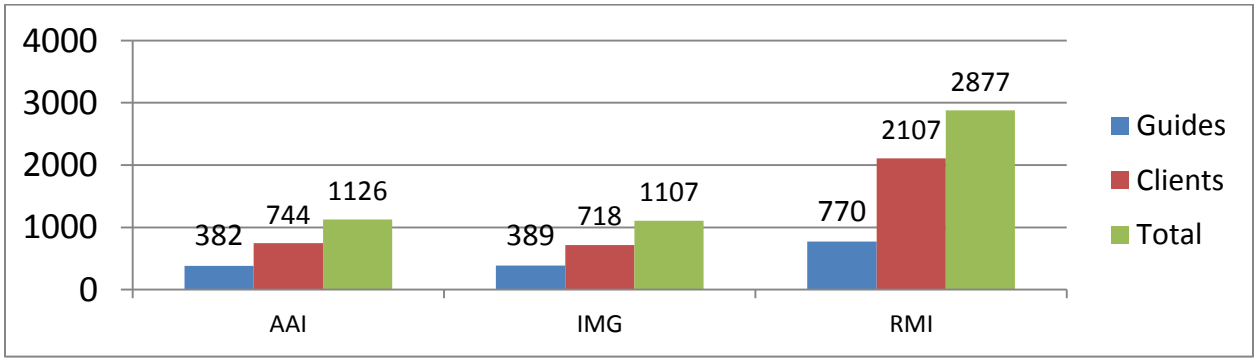

Figure 17. Graph showing guides, clients, and combined totals per each concessions contract on summit oriented trips requiring a climbing pass

Mt. Rainier also allows 15 guide companies one trip per company. These commercial use authorizations (CUA's) also are competitive. More than 15 companies apply, but the park selects the companies who meet internally selected criteria the best. The CUA term lasts two years, then another round of selections begin.

Mt. Rainier also allows commercial non-profits to conduct fundraising climbs for charities. This is not allowed without a specific Commercial Non-Profit permit.

RMI's contract allows for groups of 24 per day at Camp Muir. IMG and AAI's contracts allow for 12 at Muir per day and 12 at Ingraham Flats per day. This split was especially desired as it gives users a choice on what kind of experience they want to have.

Table 7. Number of commercial services monitoring sessions performed by climbing rangers in 2016

Concessioner or CUA Holder	Number of Monitoring Instances
Alpine Ascents International	8
Alpine Endeavors	1
International Mountain Guides	11
KAF Adventures	1
Kling Mountain Guides	1
Madison Mountaineering	1
Mountain Madness	2
Mt. Baker Mt. Guides	1
North Cascades Mountain Guides	1
Northeast Mountaineering	1
Northwest Mountain School	1
Peak Mountain Guides	1
Pro Guiding	1
Rainier Mountaineering, Inc	14
Timberline Mountain Guides	1

All guide services are monitored by climbing rangers for compliance with their contracts. The climbing program obtains money from franchise fees from the guide services to monitor the guiding activity in the park. This program helps to maintain a high level of service and accountability to the public and a high standard of resource protection. The guide services generally do an outstanding job and service to their clients.

Search and Rescue

Climbing Ranger SAR Response and Preparedness

Climbing rangers primary work responsibility is emergency services which SAR is certainly part of. This is a unique primary job duty as rangers are typically focused more generally on visitor and resource protection and management.

In fiscal year 2016, (Oct 1, 2015 – Sept 30, 2016) there were 33 search and rescue operations. There was one upper mountain fatality and there were numerous upper mountain aviation and short haul

based rescues. When aviation operations are included in a SAR response, the cost dramatically increases. Fortunately, this cost is not born by the park and doesn't take away from its operational budget. A regional search and rescue contingency account kicks in when unprogrammed (unplanned) rescue costs exceed $500.

Table 8. Total SAR expenditures 2005 - 2016

Year	Total SAR Expenses
2016	$196,351
2015	$145,821
2014	$149,023
2013	$149,229
2012	$359,342
2011	$130,398
2010	$160,689
2009	$54,078
2008	$68,740
2007	$142,200
2006	$62,303
2005	$276,157

These costs represent "un-programmed" costs, which are defined as overtime, gear, supplies, and aviation resources that are not a part of normal scheduled operations. This cost does not account for normal scheduled time rangers are on duty. In general, the larger years' sums represent years where there were multiple major search operations or multiple fatalities or aviation based rescues.

No climbing fee money is dedicated to paying for any of these un-programmed costs. However, a small percentage of the climbing fee money does go to search and rescue.

There were a total of 3020 SAR personnel-hours in fiscal year (October 1 2015 – September 30, 2016). Of those, 885 hours were climbing ranger hours, or roughly 30%. Another 30%, or roughly 862 hours were put in by local mountain rescue teams. The remaining 40% of SAR hours accounts for all the other park work units, primarily, but not limited to rangers in other work units.

Figure 18. A ranger brings in the short-haul line from the helicopter

Mountain Rescue

The Mountain Rescue Association (MRA) provides a very valuable service. Mt. Rainier National Park currently has a patrol program with its Washington chapters where we invite them to come and practice their skills here; in turn they are given free admittance to the park. They can perform a climbing patrol on the mountain while training. This allows them to be "proximal" to incidents when they are occurring. Mountain Rescue's participation in our search and rescue incidents is invaluable because each MRA volunteer working on a SAR may keep a ranger in a ranger station or allow another ranger to get some needed rest.

For the first time in the winter of 2015/2016, the park offered a house for MRA members to come and stay in order to do patrols, and act as potential supplemental resources should a search and rescue incident take place.

The MRA members often comprise the bulk of the field resources during winter rescues, so providing a place for them to stay, even while no incidents are going on, is a valuable resource both to the park service as well as the MRA.

The units that participated in our program in 2016 were the following: Tacoma, Olympic, Seattle, Everett, Bellingham, and Central Mountain Rescue. And the total hours that these units volunteered for the park in 2016 was just over 990.

Funding, Expenditures, and Budget

Expenses

Table 9. Table of Expenditures in the Climbing program by category in 2016

Category	Expense
Personnel	$531,854.26
Travel	$15,816.55
IT	$14,796.26
Supplies	$13,986.65
Vehicles	$12,524.68
Training	$11,112.50
Human Waste	$10,651.46
Misc	$2,948.16
Total	$613,690.52

The climbing program's budget is complex to manage. The budget cycle is by fiscal year (Oct-Sept). The planning, hiring, training, and equipping of the climbing program needs to be taken care of before the climbing season has begun, and thus before the fees have been collected!

This means that we commit to spending money before we know exactly what our budget is. However much this seems like a poor business practice, we have been able to make this work since the fee's inception in 1995.

The entire climbing program's budget in 2016 was $613,690.52.

Funding Sources

Table 10. Funding accounts by program and funding appropriation

Funding Account/Program	Revenue
Climbing Cost Recovery	$377,436.00

Funding Account/Program	Revenue
NPS Base Funds	$162,154.00
Concession Franchise Fees	$72,000.00
Glacier I&M Research	$2,100.00
Total	$613,690.52

This graph represents all income categories. Roughly $377,436 were collected from the sale of climbing passes at roughly a 10% / 90% split between youth passes and adult passes respectively ($32 / $46).

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Division of Visitor and Resource Protection

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