Outdoor recreation use and indicators of the ecological, physical, and social characteristics of recreation settings in the Central Wasatch: Phase 2 trail use report

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Executive Summary

This report provides the first comprehensive assessment of trail use across the entirety of the Central Wasatch. Through the use of both data from infrared trail counters as well as mobile devices we have been able to characterize trail use across the full geographic extent of the Central Wasatch from January 2019 to April 2022. The data compiled and reported on here show several notable trends:

1. **There is an exceptional amount of variation in summer trail use across the Central Wasatch.** While there are certain trails within the Central Wasatch that are heavily used in the summer, the data presented here show that there are also a substantial amount of trails that receive relatively little use. Those individuals seeking "solitude," an "escape from crowds," or the opportunity to "be alone" can still find these experiences in the Central Wasatch, primarily in the central reaches of the region's three Wilderness areas.
2. **Trails that terminate at a high-elevation lake tend to receive the highest levels of use.** It is not surprising to see the highest trail use numbers for the approach trails used to access the region's iconic high-elevation lakes. The question for managers, as well as other stakeholders, is whether these numbers are approaching levels that are too high to maintain a desired quality of visitor experience and limit potential impacts to vegetation, water quality, and wildlife. The data presented in this report suggest current levels of use on trails terminating at high-elevation lakes are not altering the *diversity* of outdoor recreation opportunities provided within the canyons (given the large proportion of trails receiving much less use and offering less social recreation experiences). The data also suggest that more focused research is needed to determine if use on these trails is degrading environmental quality beyond any acceptable thresholds set by resource managers.
3. **Existing trail use patterns within the Central Wasatch offer opportunities to spatially concentrate and temporally disperse use to accommodate more use without degrading recreation experiences.** The data show trail use is spatially concentrated to several trails, most notably those terminating at high-elevation lakes. Managers can spatially concentrate use to those areas where it is already high, so that a smaller proportion of the entire resource area is impacted than if use were deliberately dispersed. This strategy must be accompanied by efforts to ensure there is adequate and appropriate infrastructure at those recreation settings where use is being concentrated. Aside from strategically trying to concentrate use to trails that are currently experiencing high levels of use, resource stewards and managers can take less extensive, and more near-term, actions to continue to provide the diversity and quality of outdoor recreation experiences that are offered by trails within the Central Wasatch. These efforts would primarily involve developing and delivering strategic communication materials focused on temporally distributing use away from weekends and mid-day. The data presented in this report show that weekend trail use more than doubles that of weekday trail use throughout the Central Wasatch. Additionally, the data show that nearly half (49%) of trail use within the canyon happens between 10am and 3pm.

The future of trail use in the region is not clear, but this report can help steer discussions towards potential solutions that minimize the burden on visitors, limit the potential for unacceptable levels of environmental impacts, and preserve the diverse array of recreation opportunities defining the Central Wasatch today.

Introduction

The Central Wasatch provides unparalleled outdoor recreation opportunities for the residents of Salt Lake Valley and the state of Utah, as well as millions of visitors who travel to the state to spend time to hike, mountain bike, and ski. The trails of the Central Wasatch can be conceptualized as the arteries delivering recreationists to the scenic vistas and iconic high elevation lakes that define the region. As such, quantifying and analyzing the amount of trail use within the Central Wasatch can provide a 'pulse' on how much use the area is receiving, as well as how that use varies across space and time. In this report, we provide the first comprehensive assessment of trail use across the full geographic extent of the Central Wasatch. We also characterize temporal variations in trail use by meaningful classifications (season, month, day of the week, and time of day). In doing so, we shed light on recent patterns of trail use and identify potential solutions to concerns over "congestion," "crowding," and "over use." Specifically, the objectives of this report are to:

1. Quantify the number of pedestrian trips taken on the trails of the Central Wasatch.
2. Characterize the variation in use across individual trails within the region.
3. Identify spatial and temporal patterns of trail use.
4. Identify solutions for resource stewards and managers to make both near- and long-term strategic decisions that the diverse array of trail-based recreation opportunities defining the Central Wasatch today.

Methods

Data Collection

Based upon our interviews with key stakeholders, we identified trails and other recreation areas where the volume of outdoor recreation activity might be causing impacts to environmental conditions or visitor experiences (see Smith et al., 2021). We prioritized these trails and areas in determining where to collect trail use data. Our decisions were also informed by discussions with the USDA Forest Service and Wasatch Backcountry Alliance regarding where they had been collecting their own trail use data via trail counters since 2017. Collectively, these discussions allowed us to identify 37 individual trails (and 47 specific trail segments) for which to collect use data. These trails and trail segments are listed in Table 1.

Table 1. Trails and trail segments for which use was estimated, by canyon.

Canyon	Trail *(from west to east)*	Trail Segment *(zone name)*	National Forest System Trail	Trail Counter Present
Little Cottonwood Canyon	Bells Canyon	Bells Canyon – *reservoir*	No	No
	Little Cottonwood Creek	Little Cottonwood Creek (1) – *lower*	Yes	Yes
		Little Cottonwood Creek (2) – *upper*	Yes	Yes
	White Pine	White Pine (1) – *trailhead*	Yes	Yes
	Red Pine	Red Pine	Yes	Yes
	Alta-Brighton Loop	Alta-Brighton Loop Trail – *Alta trailhead*	Yes	No
	Albion Basin [ROAD]	Albion Basin Road	No	Yes
	Albion Meadows	Albion Meadows – *lower*	Yes	No
		Albion Meadows – *upper*	Yes	No
	Cecret Lake	Cecret Lake - *upper*	Yes	Yes
Big Cottonwood Canyon	Ferguson Canyon	Ferguson Canyon	Yes	Yes
	Mt. Olympus	Mt. Olympus	Yes	No
	Broads Fork	Broads Fork	Yes	Yes
	Lake Blanche	Lake Blanche	Yes	Yes
	Mill B North	Mill B North	Yes	No
	Mineral Fork	Mineral Fork	Yes	Yes
	Butler Fork	Butler Fork	Yes	Yes
	Donut Falls	Cardiff Fork	Yes	Yes
		Donut Falls	Yes	Yes
	Mill D North	Mill D North (1) – *trailhead*	Yes	No
	Days Fork	Days Fork	Yes	Yes
	Desolation	Dog Lake – *west side*	Yes	No
		Desolation Lake – *west side*	Yes	No
	Bear Trap	Bear Trap	Yes	Yes
	Wasatch Crest	Wasatch Crest	Yes	Yes
	Silver Fork	Silver Fork	Yes	Yes
	Guardsman's Pass [ROAD]	Guardsman's Pass	No	Yes
	Lake Mary	Brighton Lakes	Yes	No
		Lake Mary – Twin Lakes Reservoir	Yes	No
		Catherine Pass (3) – *Lake Mary*	Yes	Yes
Millcreek Canyon	Neffs Canyon	Neff's Canyon	Yes	No
		Neff's Spring	Yes	No
	Millcreek Canyon [ROAD]	Millcreek Canyon Fee Station	No	Yes
		Millcreek Canyon Winter Gate	No	No
	Rattlesnake	Rattlesnake	Yes	Yes
	Grandeur Peak	Grandeur Peak (face)	No	Yes
		Grandeur Peak (from Millcreek Canyon)	Yes	No
	Thayne's Canyon / Desolation	Thayne's Canyon / Desolation	Yes	Yes
	Pipeline	Pipeline (middle)	Yes	No
		Pipeline (upper)	No	Yes
	Porter Fork	Porter Fork	Yes	Yes
	Bowman Fork	Bowman Fork	Yes	No
	Mount Aire	Mount Aire	Yes	Yes
	Lambs Canyon	Lambs Canyon (1) – *Parley's Canyon trailhead*	Yes	No
		Lambs Canyon (2) – *Millcreek Canyon side*	Yes	Yes
	Alexander Basin	Gobbler's Knob / Alexander Basin	Yes	No

We collected data using both infrared trail counters and mobile location data. Infrared trail counters provide accurate data, by can only be utilized to quantify use on a few number of trail segments. Conversely, mobile location data can provide use data for trail networks spread across extensive geographic regions, but must be calibrated with data collected via another method to yield accurate use estimates. Consequently, our approach utilized a set of infrared trail counters to calibrate estimates of use derived from mobile location data. The research approach is illustrated in Figure 1 and below, we briefly describe each data collection method.

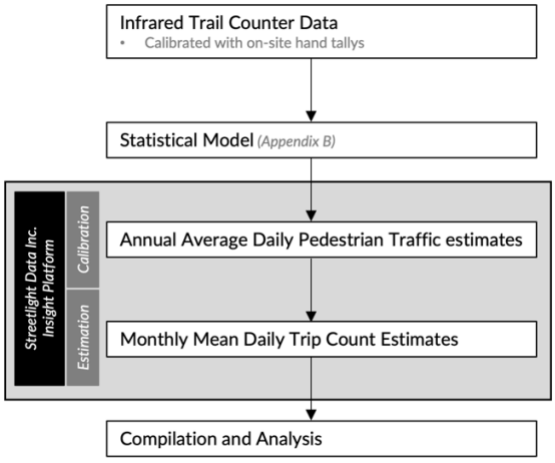

Figure 1. Process for collecting trail use data.

Infrared Trail Counters

Infrared trail counters count the number of individuals passing by an infrared scope, detecting the radiation emitted by each individual (TRAFx, 2019). Data collected via trail counters provides accurate estimates of use at a fine temporal resolution (Lindsey et al., 2007). We installed 31 trail counters on the trail segments listed in Table 1 in early spring 2022; trail counter locations are also shown in Appendix A. We selected locations in consultation with the USDA Forest Service and the Wasatch Backcountry Alliance, avoiding trail segments for which they had, or were planning to have, counters placed that season. Technicians conducted hand tallys of the number of individuals passing by select trail counters throughout the summer of 2022. Hand tally counts are used to calibrate data from the counters and offset any systematic bias that may be inherent in the counter data (e.g., from individuals who are very close together when passing the counter). Technicians also periodically collected the counter data throughout the summer and fall of 2022 to ensure the counters were working and tracking use correctly. Both the USDA Forest Service and the Wasatch Backcountry Alliance have similar protocols in place for how they monitor their counters; consultation with representatives from these organizations allowed us to ensure consistency with their established methods.

While trail counters can provide accurate estimates of use at a fine temporal resolution, they are costly to deploy at scale. An individual infrared counter costs approximately $500 and, more importantly, requires calibration using data collected by hand-tally (ideally for approximately 2 to 4 hours per counter per year). Trail counters are also prone to malfunctions, weather damage, vandalism, and theft. Consequently, many researchers have started to use mobile location data as a method of quantifying trail use more efficiently at scale.

Mobile Location Data

Mobile location data are often colloquially described as 'digital footprints' that trace the exact geographic coordinates of mobile location devices, such as cell phones. Mobile location data, the digital tracks if you will, are derived from location-based services embedded in a variety of 3rd party applications installed on mobile phones. These applications collect users' geographic position and subsequently sell these data to developers who then manipulate the data to make them useful for specific use cases, like transportation planning. For this study, we acquired mobile location data via Streetlight Data, Inc.

In the case of Streetlight Data, Inc., their manipulation process involves creating trips out of discrete users' mobile location data and 'snapping' those trips to the closest trail (the platform uses the OpenStreetMap (OSM) Pedestrian layer). A distinct trip begins/ends when the mobile device has been stationary for 5-minutes (Gische, 2022). Consequently, trip counts are the total number of trips passing through each trail segment in which a user did not stop for longer than 5-minutes. The platform provides a *Pedestrian Tool* which allows analysts and researchers to estimate average daily trips passing through user-defined zones (i.e., polygons) which intersect the OSM Pedestrian layer. These user-defined zones are also referred to as 'geofences.'

We identified 53 distinct zones throughout the Central Wasatch (Figure 2). Each zone was placed on one of the aforementioned trail segments where the volume of outdoor recreation activity might be causing impacts to environmental conditions or visitor experiences. For each zone, we obtained monthly trail use data from January 2019 to April 2022, the most recent month for which data were available as of the writing of this report. The Central Wasatch Commission has contracted with Utah State University to collect data for subsequent months, as they become available, for integration into the Commission's Environmental Dashboard (https://cwc.utah.gov/environmental-dashboard/).

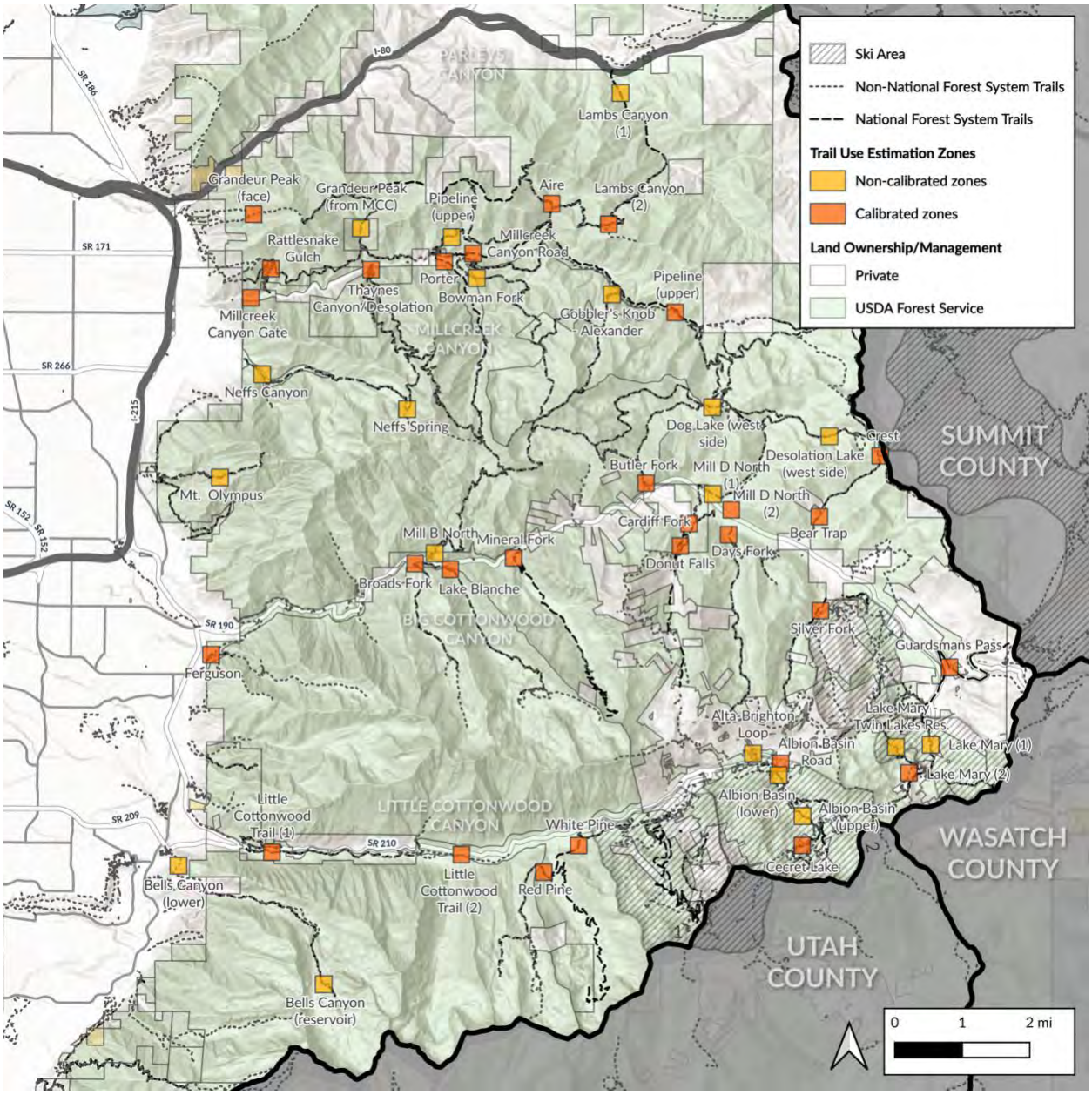

Figure 2. Zones for which trail use data were collected within the Central Wasatch. Calibrated zones are those that coincide with a infrared trail counter, while non-calibrated zones are those where no physical trail counter is or was present.

Data Analysis

Data analysis involved three phases. First, we generated average annual daily traffic estimates from the trail counter data. Second, we use these estimates as calibration data to derive monthly trail use estimates via mobile location data. Third, we visualize and summarizing these monthly data across meaningful characteristics (e.g., canyon, type of day, part of day). The process for estimating average annual daily traffic estimates from the trail counter data is described in Appendix B. We focus the results below on the final monthly trail use estimates derived via mobile location data.

Results

General Trends in Trail Use Across the Central Wasatch

Variation in Use Across Trails

Estimated pedestrian trail use *by season* is shown in Table 2 and Figure 3. We focus first on the general distribution of trail use in the Central Wasatch during the summer months, when use is highest.

Approach trails to many of the high elevation lakes in the Central Wasatch experience very high use levels in the summer months. The Brighton Lakes trail (Big Cottonwood Canyon) sees approximately 3,700 trips per day in the summer months. White Pine, Cecret Lake, and the lower sections of the Albion Meadows trail in Little Cottonwood Canyon receive an average of between 1,500 and 3,000 trips per day in the summer. Lake Blanche and Donut Falls in Big Cottonwood Canyon receive slightly fewer trips, but are still among the most heavily trafficked trails in the summer months. High levels on the trails leading to the lakes of the Central Wasatch in the summer will not surprise anyone familiar with the area. The lakes provide an outstandingly beautiful end to a hike, and air temperatures are often considerably cooler in the lakes' high alpine pockets than the are at the trailhead and in the Salt Lake Valley below.

Trails on the boundary of the forest see some of the highest use levels within the region. For example, Neffs Canyon (Millcreek), received 1,161 trips per day in the summer months. The Mt. Olympus trail (between Big Cottonwood and Millcreek), the Little Cottonwood Creek trail (Little Cottonwood), and the Rattlesnake Gulch Trail (Millcreek Canyon) also see relatively high levels of use in the summer months, averaging 640, 589, and 408 trips per day respectively. The high use levels experienced by these trails is likely attributable to the facts they are adjacent to residential neighborhoods, have established parking areas, and in certain cases facilitate shorter and easier hikes than many of the more well-known trails in the Central Wasatch.

The remaining trails we examined experienced notably less use than either the urban-adjacent trails or the high-alpine approach trails. Those trails seen in Table 2 and Figure 3 that receive an average of between 100 and 750 daily trips are well-traveled but receive substantially less use than the Central Wasatch's most popular trails. Trails receiving this amount of use include those that terminate in at peaks, Mt. Olympus and Grandeur for example, as well as others that do not terminate at a high-elevation lake, Cardiff and Broads Fork for example.

The Central Wasatch's least traveled trails are listed towards the bottom of Table 2 and right-hand side of Figure 3. What is notable here is that there are a substantial amount of trails and trail segments that receive very little use. The trails to the west of Desolation and Dog Lakes, for example, receive less than 100 trips per day in the summer months. Mount Aire, in Millcreek Canyon, is another good example of a lightly used trail; it receives an average of 82 trail users per day in the summer months.

In summary, the distribution of summer trail use across the Central Wasatch reveals several key trends that we highlight here and then return to in the discussion.

1. There is an exceptional amount of variation in summer trail use, with many trails seeing *relatively* little use.
2. Trails that terminate at a high-elevation lake tend to receive the highest levels of use.
3. Trails that are adjacent to residential areas in the Salt Lake Valley also see heavy use.
4. There are many trails that receive a substantial amount of use but are not among the Central Wasatch's most-popular trails; these trails tend to be those that terminate at peaks as well as those that are not used to access a high-elevation lake.

Table 2. Estimated mean daily pedestrian trip counts by season.

	Summer			Fall			Winter			Spring		
Trail Name	Mean	Std. Dev.	Rank *(by season)*	Mean	Std. Dev.	Rank *(by season)*	Mean	Std. Dev.	Rank *(by season)*	Mean	Std. Dev.	Rank *(by season)*
Brighton Lakes	3,735	1,548	2	1,867	1,700	2	-	-	43	111	206	19
White Pine (1) – *trailhead*	2,858	1,131	3	1,832	1,079	3	736	288	3	526	500	4
Cecret Lake - *upper*	2,557	1,871	4	1,012	1,054	5	455	308	5	207	288	13
Catherine Pass	1,533	744	5	787	705	6	18	22	35	16	30	41
Albion Meadows – *lower*	1,444	1,065	7	707	408	7	-	-	43	56	105	28
Lake Blanche	1,286	775	8	608	337	11	236	112	13	369	484	10
Ferguson Canyon	1,177	803	9	630	137	10	308	99	8	915	1,037	3
Neff's Canyon	1,161	703	10	1,088	267	4	1,313	550	1	1,121	1,109	2
Donut Falls	1,101	801	11	379	233	16	276	145	10	372	464	9
Red Pine	991	347	12	678	442	8	281	134	9	149	149	15
Albion Meadows – *upper*	867	649	13	275	204	20	-	-	43	21	37	37
Mill D North (1) – *trailhead*	812	525	14	478	199	13	349	110	6	299	331	11
Alta-Brighton Loop Trail – *Alta trailhead*	806	440	15	224	176	21	-	-	43	70	134	26
Cardiff Fork	640	332	16	277	102	18	467	159	4	491	545	6
Mt. Olympus	640	601	17	471	120	14	215	69	15	408	528	8
Little Cottonwood Creek (1) – *lower*	589	444	19	407	204	15	175	39	16	463	609	7
Albion Basin Road	487	254	20	127	119	25	-	-	43	71	149	25
Butler Fork	419	294	21	285	110	17	150	119	18	138	155	16
Rattlesnake	408	264	22	538	256	12	331	127	7	518	578	5
Lake Mary – *Twin Lakes Reservoir*	235	119	24	157	157	23	-	-	43	3	9	47
Thayne's Canyon / Desolation	197	257	25	135	76	24	95	70	24	129	217	18
Grandeur Peak (from Millcreek Canyon)	195	272	26	125	136	26	258	291	11	156	265	14
Broads Fork	170	128	27	90	86	31	38	37	33	73	73	23
Mill B North	168	103	28	98	46	30	40	33	32	86	113	20
Grandeur Peak (face)	137	132	30	174	130	22	226	132	14	214	239	12
Pipeline (upper)	129	182	31	116	100	27	76	58	26	132	168	17
Little Cottonwood Creek (2) – *upper*	129	84	32	84	65	33	43	33	31	71	127	24
Silver Fork	126	45	33	111	72	29	63	56	29	31	34	34
Lambs Canyon (1) – *Parley's Canyon TH*	122	64	34	63	33	35	15	26	36	5	13	44
Bowman Fork	118	96	35	78	81	34	97	96	23	26	41	35
Wasatch Crest	109	54	36	113	113	28	69	67	27	20	44	38
Desolation Lake – *west side*	84	71	37	46	39	38	12	18	38	9	24	43
Mount Aire	82	53	38	40	24	41	5	13	40	17	37	40
Days Fork	57	36	39	20	17	46	103	81	21	49	73	31
Mineral Fork	53	46	40	52	31	37	33	33	34	20	21	38
Millcreek Canyon Fee Station	41	31	41	61	41	36	45	42	30	50	57	30
Bells Canyon – *reservoir*	38	25	42	14	12	50	-	-	43	3	11	46
Porter Fork	36	45	43	23	20	45	116	164	20	38	55	33
Millcreek Canyon Winter Gate	35	53	44	26	30	43	97	77	22	55	64	29
Guardsman's Pass	33	29	45	41	33	40	166	72	17	77	116	22
Dog Lake – *west side*	32	43	46	18	16	47	10	12	39	3	9	47
Gobbler's Knob / Alexander Basin	30	33	47	18	19	48	3	9	42	-	-	49
Neff's Spring	23	22	48	16	22	49	4	9	41	4	10	45
Bear Trap	20	15	49	24	18	44	88	66	25	26	45	35
Pipeline (middle)	14	13	50	12	10	51	14	14	37	11	14	42
Lambs Canyon (2) – Millcreek Canyon side	5	6	52	38	42	42	67	29	28	44	52	32

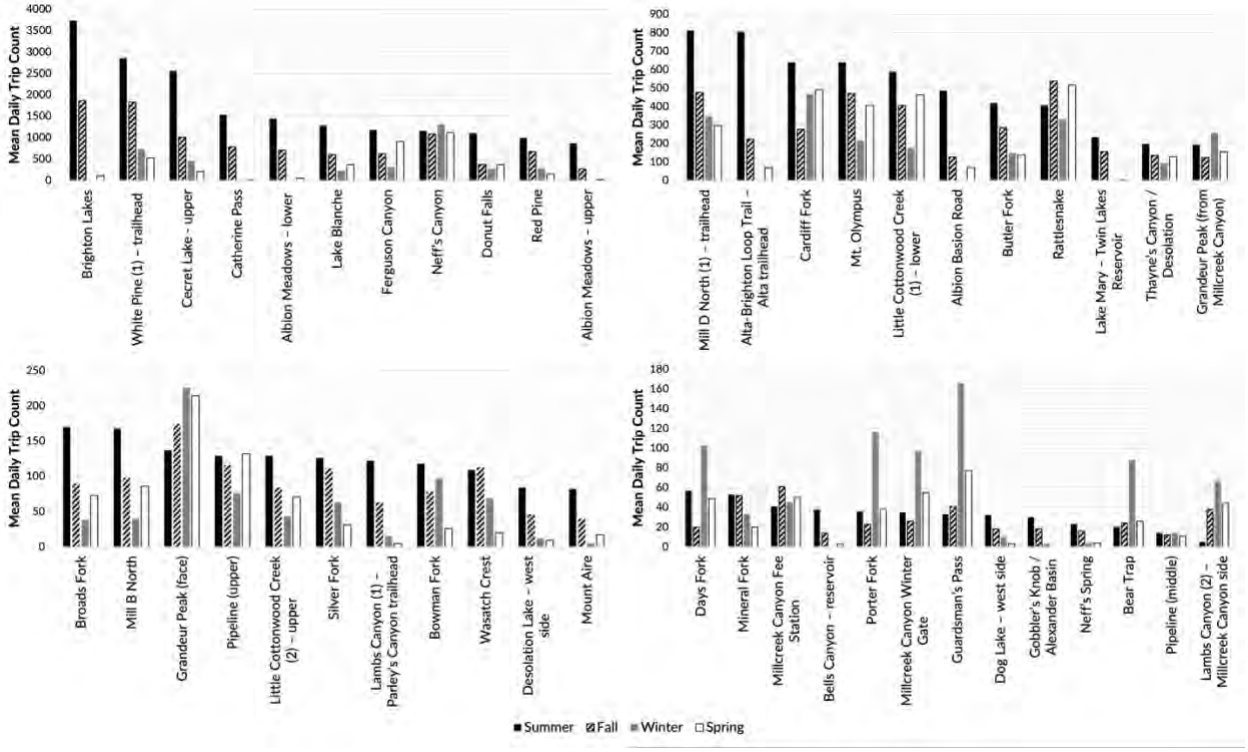

Figure 3. Estimated mean daily pedestrian trip counts by season.

Variation in Use Across Seasons

Aside from the large variation in use across individual trails, our data also show an exceptionally high amount of variation in use on individual trails throughout the year. Across all trails that we examined, summer use (June – August) was 1.8 times higher than fall use (September – November), 2.8 times higher than spring use (March – May), and 3.7 times higher than winter use (December – February). For most trails, this is simply because they become inaccessible in the winter. Only those trails along the foothills of the Wasatch Front (e.g., Neffs & Ferguson Canyon) see relatively stable use levels throughout the year. Table 3 illustrates the difference between trail use for each season and the annual average. Table 4 shows the difference between trail use for each month and the annual average.

Table 3. Difference between seasonal mean daily trip county and annual mean daily trip count.

Trail	% difference between seasonal mean daily trip count and annual mean daily trip count			
	Summer	Fall	Winter	Spring
Albion Meadows – *upper*	230.0%	5%	-100%	-92%
Alta-Brighton Loop Trail – *Alta trailhead*	221.3%	-11%	-100%	-72%
Albion Basin Road	209.2%	-20%	-100%	-55%
Catherine Pass – *trailhead*	205.9%	39%	-100%	-100%
Bells Canyon – *reservoir*	205.1%	8%	-100%	-75%
Brighton Lakes	189.3%	45%	-100%	-91%
Albion Meadows – *lower*	189.1%	42%	-100%	-89%
Catherine Pass	188.5%	48%	-97%	-97%
Lake Mary – Twin Lakes Reservoir	164.0%	77%	-100%	-97%
Cecret Lake - *upper*	159.6%	3%	-54%	-79%
Lambs Canyon (1) – *Parley's Canyon trailhead*	157.6%	34%	-68%	-89%
Gobbler's Knob / Alexander Basin	155.6%	53%	-71%	-100%
Mount Aire	144.2%	19%	-84%	-50%
Desolation Lake – *west side*	139.0%	32%	-65%	-74%
Dog Lake – *west side*	118.1%	23%	-34%	-82%
Lake Blanche	117.0%	3%	-60%	-38%
Donut Falls	115.4%	-26%	-46%	-27%
Neff's Spring	109.3%	45%	-64%	-62%
White Pine (1) – *trailhead*	103.8%	31%	-48%	-62%
Red Pine	100.7%	37%	-43%	-70%
Broads Fork	90.7%	1%	-57%	-18%
Mill B North	77.8%	4%	-58%	-9%
Butler Fork	76.3%	20%	-37%	-42%
Mill D North (1) – *trailhead*	73.3%	2%	-25%	-36%
Little Cottonwood Creek (2) – *upper*	62.6%	6%	-46%	-11%
Silver Fork	59.3%	40%	-20%	-61%
Ferguson Canyon	58.4%	-15%	-58%	23%
Bowman Fork	52.0%	0%	24%	-67%
Mt. Olympus	51.9%	12%	-49%	-3%
Little Cottonwood Creek (1) – *lower*	47.4%	2%	-56%	16%
Wasatch Crest	47.1%	51%	-8%	-73%
Thayne's Canyon / Desolation	44.5%	-1%	-30%	-6%
Mineral Fork	38.6%	34%	-13%	-47%
Cardiff Fork	36.3%	-41%	-1%	4%
Pipeline (upper)	15.0%	3%	-33%	18%
Pipeline (middle)	12.2%	-5%	8%	-15%
Grandeur Peak (from Millcreek Canyon)	4.9%	-33%	39%	-16%
Neff's Canyon	-1.2%	-7%	12%	-5%
Days Fork	-4.0%	-67%	74%	-16%
Rattlesnake	-8.5%	21%	-26%	16%
Millcreek Canyon Fee Station	-16.4%	24%	-8%	2%
Grandeur Peak (face)	-28.4%	-9%	19%	12%
Porter Fork	-35.0%	-59%	109%	-32%
Millcreek Canyon Winter Gate	-37.6%	-53%	75%	-1%
Bear Trap	-51.4%	-42%	113%	-37%
Guardsman's Pass	-60.3%	-51%	99%	-8%
Lambs Canyon (2) – *Millcreek Canyon side*	-88.7%	-5%	68%	9%

Table 4. Difference between monthly mean daily trip county and annual mean daily trip count.

	% difference between seasonal mean daily trip county and annual mean daily trip count											
Trail	January	February	March	April	May	June	July	August	September	October	November	December
Albion Meadows – *upper*	-100%	-100%	-100%	-100%	-71%	-16%	459%	248%	86%	-30%	-41%	-100%
Albion Meadows – *lower*	-100%	-100%	-100%	-100%	-59%	-17%	388%	196%	37%	-5%	92%	-100%
Alta-Brighton Loop Trail – *Alta trailhead*	-100%	-100%	-100%	-100%	2%	81%	377%	205%	37%	31%	-100%	-100%
Albion Bason Road	-100%	-100%	-100%	-100%	64%	222%	312%	94%	-8%	49%	-100%	-100%
Cecret Lake - *upper*	-66%	-35%	-45%	-84%	-97%	-60%	308%	218%	111%	-16%	-91%	-65%
Brighton Lakes	-100%	-100%	-100%	-100%	-69%	74%	290%	205%	164%	70%	-100%	-100%
Catherine Pass	-98%	-93%	-97%	-100%	-93%	58%	277%	231%	183%	47%	-85%	-100%
Lake Mary – *Twin Lakes Reservoir*	-100%	-100%	-100%	-100%	-89%	52%	265%	176%	237%	93%	-100%	-100%
Gobbler's Knob / Alexander Basin	-81%	-100%	-100%	-100%	-100%	-7%	250%	224%	142%	66%	-49%	-18%
Bells Canyon – *reservoir*	-100%	-100%	-100%	-100%	-7%	210%	231%	175%	32%	14%	-21%	-100%
Dog Lake – *west side*	-23%	-69%	-100%	-80%	-34%	183%	175%	-17%	-32%	122%	-28%	-8%
Neff's Spring	-100%	-100%	-100%	-100%	40%	215%	135%	-23%	67%	123%	-55%	31%
White Pine (1) – *trailhead*	-48%	-49%	-49%	-64%	-36%	108%	126%	56%	86%	30%	-38%	-52%
Red Pine	-58%	-40%	-56%	-53%	-53%	89%	121%	64%	111%	30%	-48%	-37%
Lambs Canyon (1) – *Parley's Canyon trailhead*	-93%	-72%	-100%	-88%	-60%	225%	117%	122%	65%	53%	-22%	-30%
Mount Aire	-87%	-100%	-100%	-21%	69%	150%	116%	109%	13%	73%	-56%	-63%
Wasatch Crest	0%	16%	-29%	-100%	-93%	-21%	115%	48%	203%	25%	-74%	-51%
Lake Blanche	-61%	-60%	-63%	-47%	67%	182%	95%	39%	21%	24%	-53%	-67%
Donut Falls	-46%	-50%	-52%	-49%	89%	171%	90%	53%	4%	-23%	-70%	-51%
Desolation Lake – *west side*	-75%	-49%	-85%	-100%	-26%	268%	77%	72%	60%	67%	-31%	-74%
Mill D North (1) – *trailhead*	-22%	-23%	-34%	-61%	37%	146%	60%	-7%	-5%	-8%	7%	-43%
Pipeline (middle)	-13%	-30%	5%	-100%	72%	-44%	59%	22%	19%	27%	-60%	88%
Bowman Fork	8%	31%	-59%	-93%	-34%	127%	55%	-29%	-49%	-9%	54%	34%
Little Cottonwood Creek (2) – *upper*	-72%	-23%	-79%	-59%	185%	126%	51%	-9%	-4%	-18%	28%	-50%
Butler Fork	-47%	-25%	-55%	-57%	44%	169%	50%	-13%	21%	40%	-16%	-49%
Silver Fork	-43%	-35%	-19%	-61%	-71%	65%	46%	48%	105%	3%	-4%	17%
Days Fork	24%	147%	89%	-53%	-59%	-33%	39%	-32%	-62%	-83%	-60%	15%
Broads Fork	-46%	-60%	-11%	-53%	67%	172%	31%	43%	48%	-14%	-44%	-75%
Mill B North	-70%	-59%	-51%	-4%	136%	149%	30%	3%	-7%	18%	-29%	-55%
Cardiff Fork	-12%	-3%	-22%	-8%	144%	68%	21%	-19%	-53%	-49%	-37%	-15%
Ferguson Canyon	-63%	-64%	-22%	85%	164%	107%	6%	-25%	-33%	-24%	-36%	-73%
Little Cottonwood Creek (1) – *lower*	-61%	-66%	-49%	82%	180%	97%	0%	-35%	7%	-10%	-48%	-66%
Mineral Fork	-32%	33%	-33%	-56%	-2%	132%	-4%	-30%	60%	40%	-15%	-63%
Thayne's Canyon / Desolation	-45%	-22%	-45%	-14%	143%	148%	-14%	-38%	-30%	-26%	27%	-43%
Mt. Olympus	-59%	-54%	-46%	-3%	149%	159%	-20%	-27%	15%	-8%	-5%	-46%
Neff's Canyon	-17%	13%	-15%	52%	83%	28%	-31%	-45%	-24%	-19%	-21%	-15%
Rattlesnake	-43%	-35%	-6%	114%	110%	6%	-36%	-54%	-24%	-1%	10%	-49%
Millcreek Canyon Fee Station	-27%	2%	-26%	54%	119%	6%	-45%	-48%	20%	-5%	-2%	-50%
Grandeur Peak (from Millcreek Canyon)	7%	96%	-36%	-21%	98%	99%	-47%	-62%	-66%	-58%	10%	-35%
Bear Trap	134%	102%	61%	-87%	-86%	-48%	-50%	-58%	-30%	-59%	-38%	90%
Porter Fork	45%	250%	2%	-69%	7%	5%	-54%	-62%	-61%	-64%	-55%	-19%
Pipeline (upper)	-44%	-36%	-27%	43%	172%	141%	-68%	-77%	-49%	-18%	33%	-49%
Grandeur Peak (face)	2%	6%	-5%	79%	110%	21%	-71%	-74%	-69%	-34%	27%	-21%
Guardsman's Pass	71%	103%	125%	-22%	-88%	-48%	-72%	-69%	-64%	-83%	-18%	75%
Millcreek Canyon Winter Gate	57%	91%	63%	-31%	21%	56%	-82%	-100%	-84%	-65%	-19%	34%
Lambs Canyon (2) – *Millcreek Canyon side*	-13%	78%	3%	47%	104%	-88%	-93%	-90%	-63%	-44%	49%	72%

Immediately noticeable in Table 4 is the high levels of use to the trails in and around Alta and Brighton during the months of July and August. The summer wildflower season and cooler temperatures likely play a significant role in the spatial concentration of trail use in the summer months at the Central Wasatch's highest elevations. Also noticeable is that use peaks at other lower elevation trails slightly earlier in the season, around May and June. The only exception to this trend is the Guardsman's Pass road, which sees little pedestrian use in the summer relative to the higher levels seen from December through March.

Variation in Use Across the Week

Continuing to break use down to finer temporal resolutions, we examined trail use by the type of day, comparing weekdays (Monday – Friday) to weekends (Saturday & Sunday). The differences between weekend and weekday use, by trail segment, is shown in Table 5. On average across all of the trails we analyzed, mean daily trip counts were 2.2 times higher on weekends relative to weekdays. The peak in weekend use is similar when we examine just summer use. Specifically, use was 2.1 times higher in on the weekends relative to weekdays in the summer. Differences between trail use on weekdays and weekends, by trail, are visualized in Appendix C.

Table 5. Differences between weekend daily trip counts and weekday mean daily trip counts, by trail.

	Mean daily trip counts (Annual)				Mean daily trip counts (Summer only)			
Trail	All days	Weekdays	Weekends	% difference	All days	Weekdays	Weekends	% difference
Bells Canyon – reservoir	13	6	29	378.1%	38	17	92	431%
Bear Trap	42	27	80	198.4%	20	16	31	102%
Lambs Canyon (2) – Millcreek Canyon side	47	31	89	189.2%	5	5	4	-5%
Wasatch Crest	74	49	140	187.6%	109	68	215	216%
Guardsman's Pass	91	62	163	163.8%	33	31	41	34%
Red Pine	518	355	926	160.8%	991	716	1,674	134%
Desolation Lake – west side	35	24	61	154.9%	84	65	128	98%
White Pine (1) – trailhead	1,454	1,008	2,566	154.4%	2,858	2,180	4,550	109%
Mt. Olympus	466	323	817	152.7%	640	428	1,132	165%
Catherine Pass	531	372	939	152.3%	1,533	1,103	2,628	138%
Lake Blanche	626	438	1,096	150.1%	1,286	932	2,161	132%
Mill D North (1) – trailhead	488	344	845	145.5%	812	635	1,241	96%
Silver Fork	83	59	144	142.5%	126	99	195	96%
Alta-Brighton Loop Trail – Alta trailhead	251	179	433	141.6%	806	573	1,402	145%
Cardiff Fork	518	369	883	139.3%	640	455	1,080	138%
Albion Meadows – lower	500	361	848	135.1%	1,444	1,044	2,447	134%
Lambs Canyon (1) – Parley's Canyon trailhead	48	35	81	133.1%	122	103	166	60%
Albion Meadows – upper	263	191	444	131.7%	867	635	1,447	128%
Albion Basion Road	157	115	266	131.2%	487	352	831	136%
Gobbler's Knob / Alexander Basin	12	9	20	130.2%	30	19	59	217%
Brighton Lakes	1,291	945	2,173	129.8%	3,735	2,797	6,126	119%
Mineral Fork	40	30	68	123.5%	53	44	78	80%
Neff's Spring	11	8	18	119.2%	23	23	24	6%
Broads Fork	93	71	150	112.3%	170	137	250	82%
Porter Fork	58	44	91	109.3%	36	25	60	142%
Grandeur Peak (from Millcreek Canyon)	202	154	321	108.4%	195	160	273	71%
Thayne's Canyon / Desolation	149	115	236	105.0%	197	168	263	56%
Millcreek Canyon Winter Gate	60	46	94	104.7%	35	22	63	187%
Butler Fork	248	191	389	104.0%	419	339	615	82%
Cecret Lake - upper	1,002	775	1,567	102.2%	2,557	2,003	3,910	95%
Lake Mary – Twin Lakes Reservoir	89	69	139	102.1%	235	175	382	118%
Ferguson Canyon	912	709	1,421	100.5%	1,177	1,000	1,596	60%
Grandeur Peak (face)	232	183	356	94.9%	137	124	167	35%
Donut Falls	539	423	823	94.6%	1,101	875	1,652	89%
Mill B North	105	82	158	92.1%	168	151	215	42%
Dog Lake – west side	15	12	22	83.8%	32	34	28	-16%
Neff's Canyon	1,386	1,125	2,035	80.9%	1,161	942	1,681	79%
Pipeline (middle)	13	10	19	80.6%	14	10	25	146%
Rattlesnake	567	462	832	79.9%	408	373	488	31%
Little Cottonwood Creek (2) – upper	83	68	119	75.1%	129	103	197	91%
Mount Aire	37	30	52	72.7%	82	67	117	74%
Millcreek Canyon Fee Station	58	49	82	69.9%	41	30	69	128%
Little Cottonwood Creek (1) – lower	489	412	679	64.9%	589	546	676	24%
Days Fork	62	52	85	62.1%	57	48	79	65%
Pipeline (upper)	131	118	168	42.7%	129	131	131	1%
Bowman Fork	79	84	64	-24.0%	118	117	120	3%

Believing that the Covid-19 pandemic, and the subsequent shift to remote work, might have spread some of the peak weekend use out more broadly across the week, we examined the fluctuation in weekend trail use by year (Table 6). The data suggest the pandemic year (2020) likely did have some effect on the proportion of trail use happening on the weekends. Weekend trail use was *only* twice that of weekday trail use in 2020. The proportion rose back to its pre-pandemic level (2.2 times weekday use) in 2021.

Table 6. Comparison of weekday and weekend mean daily trip counts, by year.

Year	All days	Weekdays	Weekends	% difference between weekends and weekdays
2019	355	264	586	122%
2020	448	350	691	97%
2021	297	220	488	122%

Variation in Use Across the Week

At the finest temporal scale, we analyzed trail use by time of day. The proportion of mean daily trip counts by time of day for each trail are reported in Table 7. Figure 4 also summarizes these proportions by season. The data show use peaking towards the middle of the day, with nearly half (49%) of all trail use in the Central Wasatch occurring between the hours of 10am and 3pm. The data also show slightly more trail use in the peak afternoon hours (3pm-7pm) relative to the peak morning hours (6am-10am). There is only a small proportion (8%) of all trail use that occurs between 7pm and 6am. Use is slightly more distributed when we look specifically at the summer months (June – August), but the general trend of peak use during the middle of the day is still present (Table 8).

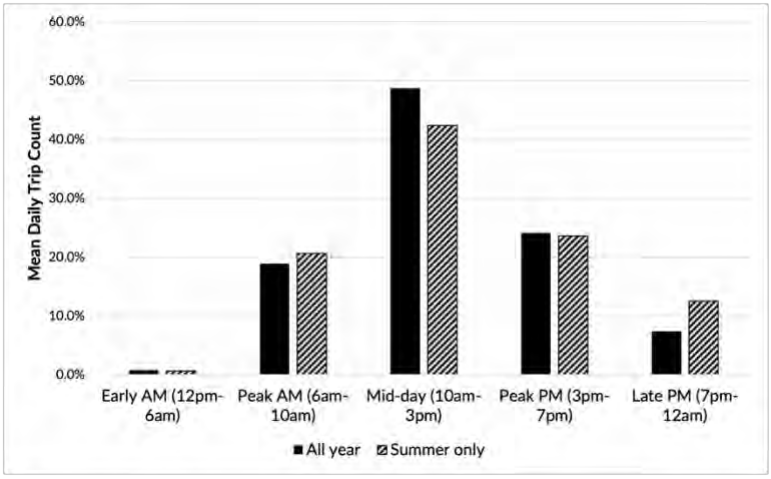

Figure 4. Proportion of daily trip counts by time of day (Annual).

Table 7. Proportion of daily trip counts by time of day (Annual)

Trail	Early AM (12pm-6am)	Peak AM (6am-10am)	Mid-day (10am-3pm)	Peak PM (3pm-7pm)	Late PM (7pm-12am)
Pipeline (middle)	2%	13%	63%	18%	5%
Wasatch Crest	2%	19%	63%	14%	2%
Dog Lake – *west side*	0%	8%	57%	24%	10%
Lambs Canyon (2) – *Millcreek Canyon side*	0%	20%	57%	21%	2%
Cardiff Fork	0%	7%	57%	31%	5%
Neff's Spring	0%	29%	56%	8%	5%
Gobbler's Knob / Alexander Basin	0%	18%	56%	18%	8%
Desolation Lake – *west side*	0%	18%	56%	22%	3%
Catherine Pass	0%	16%	56%	21%	7%
Bells Canyon – *reservoir*	0%	12%	56%	28%	5%
Cecret Lake - *upper*	0%	11%	55%	24%	10%
Days Fork	1%	25%	54%	16%	4%
Donut Falls	0%	9%	53%	30%	7%
Brighton Lakes	0%	14%	52%	25%	8%
Guardsman's Pass	0%	18%	52%	26%	4%
Lambs Canyon (1) – *Parley's Canyon trailhead*	0%	19%	52%	24%	6%
Albion Meadows – *upper*	0%	14%	51%	24%	10%
Lake Mary – Twin Lakes Reservoir	0%	19%	51%	20%	10%
Albion Meadows – *lower*	0%	15%	50%	25%	10%
Mill D North (1) – *trailhead*	0%	16%	49%	29%	6%
Thayne's Canyon / Desolation	1%	21%	49%	24%	6%
Silver Fork	0%	20%	48%	25%	7%
Mt. Olympus	2%	29%	48%	16%	5%
Millcreek Canyon Winter Gate	0%	17%	48%	29%	6%
Alta-Brighton Loop Trail – *Alta trailhead*	1%	15%	48%	25%	11%
Lake Blanche	1%	18%	48%	27%	6%
Albion Basion Road	0%	17%	48%	25%	10%
Mount Aire	1%	25%	47%	17%	9%
Mill B North	1%	8%	47%	34%	10%
Porter Fork	0%	21%	47%	27%	5%
White Pine (1) – *trailhead*	1%	21%	47%	25%	7%
Bowman Fork	0%	11%	47%	37%	4%
Little Cottonwood Creek (2) – *upper*	2%	14%	47%	27%	11%
Red Pine	1%	25%	47%	21%	6%
Butler Fork	1%	23%	47%	23%	6%
Little Cottonwood Creek (1) – *lower*	0%	16%	46%	28%	9%
Neff's Canyon	0%	13%	46%	32%	9%
Grandeur Peak (face)	2%	24%	46%	22%	7%
Bear Trap	0%	31%	46%	21%	2%
Mineral Fork	0%	23%	45%	25%	7%
Pipeline (upper)	2%	27%	43%	23%	5%
Rattlesnake	1%	21%	41%	27%	10%
Grandeur Peak (from Millcreek Canyon)	9%	26%	40%	19%	6%
Ferguson Canyon	1%	10%	40%	35%	14%
Millcreek Canyon Fee Station	1%	20%	39%	25%	15%
Broads Fork	2%	21%	33%	32%	12%

Table 8. Proportion of daily trip counts by time of day – Summer only (June - August)

Trail	Early AM (12pm-6am)	Peak AM (6am-10am)	Mid-day (10am-3pm)	Peak PM (3pm-7pm)	Late PM (7pm-12am)
Desolation Lake – west side	0%	22%	56%	17%	5%
Catherine Pass	0%	18%	56%	19%	7%
Gobbler's Knob / Alexander Basin	0%	21%	55%	13%	10%
Cardiff Fork	0%	8%	55%	28%	9%
Bells Canyon – reservoir	0%	13%	53%	32%	2%
Lambs Canyon (2) – Millcreek Canyon side	0%	15%	51%	0%	34%
Brighton Lakes	0%	16%	51%	24%	9%
Albion Meadows – upper	0%	15%	49%	23%	12%
Donut Falls	0%	11%	48%	30%	11%
Albion Basion Road	0%	14%	47%	26%	13%
Pipeline (middle)	0%	18%	47%	34%	0%
Alta-Brighton Loop Trail – Alta trailhead	0%	16%	47%	24%	13%
Millcreek Canyon Winter Gate	0%	14%	47%	30%	9%
Lake Mary – Twin Lakes Reservoir	0%	24%	47%	18%	11%
Little Cottonwood Creek (2) – upper	2%	14%	46%	20%	18%
Lambs Canyon (1) – Parley's Canyon trailhead	0%	21%	45%	27%	7%
Albion Meadows – lower	0%	15%	45%	25%	14%
Mill D North (1) – trailhead	1%	19%	45%	26%	9%
Neff's Spring	0%	42%	45%	9%	3%
Lake Blanche	1%	23%	45%	23%	9%
Cecret Lake - upper	0%	14%	44%	27%	15%
Butler Fork	1%	25%	43%	21%	10%
White Pine (1) – trailhead	1%	21%	43%	24%	11%
Mt. Olympus	2%	36%	43%	11%	7%
Silver Fork	1%	17%	43%	24%	16%
Bowman Fork	0%	18%	41%	31%	10%
Bear Trap	0%	30%	41%	19%	10%
Red Pine	2%	26%	41%	21%	10%
Grandeur Peak (from Millcreek Canyon)	1%	27%	40%	24%	8%
Mineral Fork	0%	16%	40%	30%	14%
Guardsman's Pass	0%	15%	40%	37%	8%
Thayne's Canyon / Desolation	1%	22%	40%	26%	12%
Millcreek Canyon Fee Station	3%	28%	39%	13%	17%
Neff's Canyon	0%	18%	39%	25%	18%
Wasatch Crest	0%	37%	39%	20%	5%
Porter Fork	1%	22%	37%	30%	11%
Mill B North	3%	12%	36%	29%	19%
Pipeline (upper)	1%	29%	36%	21%	13%
Mount Aire	0%	30%	36%	18%	16%
Dog Lake – west side	0%	8%	35%	35%	22%
Days Fork	3%	19%	34%	30%	14%
Ferguson Canyon	1%	13%	34%	31%	20%
Little Cottonwood Creek (1) – lower	1%	22%	33%	29%	15%
Grandeur Peak (face)	3%	35%	33%	19%	10%
Rattlesnake	0%	23%	32%	23%	22%
Broads Fork	1%	20%	27%	39%	14%

Discussion

This report provides the first comprehensive assessment of trail use across the entirety of the Central Wasatch. Through the use of both data from infrared trail counters as well as mobile devices we have been able to characterize trail use across the full geographic extent of the Central Wasatch. Just as importantly, we have been able to characterize trail use for every month from January 2019 to April 2022 (with more recent data consistently being compiled as they

become available for the purposes of integrating them into the Central Wasatch Commission's Environmental Dashboard). Generally, the patterns in trail use are not that surprising to those who live, work, or recreate in one of the area's three canyons. However, the data on trail use do provide reliable evidence that can help guide the stewardship and management of the region for years to come. The data compiled and reported on here show several notable trends. We highlight these here and discuss their implications for future stewardship and management efforts.

1. **There is an exceptional amount of variation in summer trail use.**

   A blanket characterization of the recreational opportunities offered during the summer in the Central Wasatch as "crowded," "overrun with visitors," or "exceptionally busy" would be incorrect. While there are certain trails within the Central Wasatch that are heavily used in the summer, the data presented here show that there are also a substantial amount of trails that receive relatively little use. 22 of the trails for which we collected data receive fewer that 150 trips per day in the summer months. These trails tend to be those that (we would argue) are less well known amongst the general recreating public of the Salt Lake Valley. For example, the upper section of the Little Cottonwood Creek trail (Little Cottonwood Canyon), the Silver Fork trail (Big Cottonwood Canyon), and the Bowman Fork trail (Millcreek Canyon) only receive 129, 126, and 118 trips per day on average during the summer.

   The Recreation Opportunity Spectrum (ROS) is the management framework that is intended to inform the decisions of the USDA Forest Service. The ROS is grounded in the belief that recreationists can choose to recreate in settings which offer different recreation opportunities (Clark & Stankey, 1979). These opportunities are believed to be primarily informed by the biological (i.e., the presence or abundance of non-human species), physical (i.e., infrastructure), and social (i.e., the number of other recreationists present) characteristics of each setting. The framework guides the agency to provide a diverse array of settings so that the greatest number of the recreating public can find the settings that meet their personal preferences and tastes.

   The trail use numbers documented in this report show that with regards to the social characteristics of trails in the Central Wasatch, there are is a wide variety of recreation experiences to be had. Those individuals seeking "solitude," an "escape from crowds," or the opportunity to "be alone" can still find these experiences in the Central Wasatch, primarily in the central reaches of the region's three Wilderness areas.

2. **Trails that terminate at a high-elevation lake tend to receive the highest levels of use.**

   It is not surprising to see the highest trail use numbers for the approach trails used to access the region's iconic high-elevation lakes. The Brighton Lakes trail complex sees an average of over 3,500 trips per day in the summer months. The White Pine trail (used to access both White and Red Pine Lakes) as well as the Cecret Lake trail (both in Little Cottonwood Canyon), experience nearly as many trips in the summer, 2,858 and 2,557

per day. These are exceptionally high use numbers for wildland recreation settings. The question for managers, as well as other stakeholders, is whether these numbers are approaching levels that are too high to maintain a desired quality of visitor experience and limit potential impacts to vegetation, water quality, and wildlife. With regards to negative impacts on the visitor experience, our previous work in the region (Lamborn, Burr, & Kessler, 2015a, 2015b; Lamborn, Burr, & Lofthouse, 2015a, 2015b; Lamborn et al., 2014a, 2014a, 2014b) and recent research elsewhere (Kyle & Landon, 2021) suggests that recreationists' normative evaluations of the number of people at a setting does change over time. More simply put, recreationists tend to get used to how busy it is at any given setting, adjusting their expectations as use increases while maintaining a consistent level of satisfaction. Given this, managers might be inclined to continue to let use rise believing that visitors will adjust their expectations. Alternatively, managers might be inclined to take action to taper or limit the number of visitors to these high elevation lakes if current or projected levels of use are having a negative and significant impact on environmental quality. Our previous work for the Central Wasatch Commission has found the amount of use on the *informal* trails surrounding high elevation lakes in the region does impact the width of those trails (Spernbauer et al., 2023). That work highlights several specific actions that managers can take to limit the proliferation and degradation of informal trails around high elevation lakes. Future work can more directly assess whether current use levels on the formal trails of the Central Wasatch are having a significant impact on environmental quality.

The data presented in this report suggest current levels of use on trails terminating at high-elevation lakes are not altering the *diversity* of outdoor recreation opportunities provided within the canyons (given the large proportion of trails receiving much less use and offering less social recreation experiences). The data also suggest that more focused research is needed to determine if use on these trails is degrading environmental quality beyond any acceptable thresholds set by resource managers. If use is not degrading biological indicators beyond any established thresholds, the next logical question for managers as well as stakeholders throughout the region is what strategies can be implemented to accommodate any future increases in trail use.

3. **Existing trail use patterns within the Central Wasatch offer opportunities to spatially concentrate and temporally disperse use to accommodate more use without degrading recreation experiences.**

The spatial and temporal patterns of trail use across the Central Wasatch described in this report can guide the near-term actions of the municipalities of the Salt Lake Valley, Salt Lake County, the USDA Forest Service and other allied stakeholders who shape where and when outdoor recreation happens across the region. First, the data show trail use is spatially concentrated to several trails, most notably those terminating at high-elevation lakes. While this may not be immediately perceived as an opportunity or as a "good" thing, it is. A principle of sustainably managing outdoor recreation in a way that limits resource impacts is to take actions that reduce the amount of impact each individual recreationist has (Hammitt et al., 2015). Managers can do this by spatially concentrating use to those areas where it is already high, so that a smaller proportion of the entire

resource area is impacted than if use were deliberately dispersed (through use restrictions at high-demand locations, outreach efforts, etc.). This strategy must be accompanied by efforts to ensure there is adequate and appropriate infrastructure at those recreation settings where use is being concentrated. "Adequate and appropriate" infrastructure includes sufficient parking to minimize the impacts of on-road parking (Monz et al., 2016), restroom facilities, and site hardening where allowed; it may even include the establishment of a visitor center[1]. It is unclear whether the allied interests who steward and manage the Central Wasatch would like to see use concentrated to those areas and trails that are currently experiencing high levels of use, in an effort to limit resource impacts where use is currently low. It is a strategy that would require a substantial amount of deliberate planning, collaboration, and resources to effectuate successfully.

Aside from strategically trying to concentrate use to trails that are currently experiencing high levels of use, resource stewards and managers can take less extensive, and more near-term, actions to continue to provide the diversity and quality of outdoor recreation experiences that are offered by trails within the Central Wasatch. These efforts would primarily involve developing and delivering strategic communication materials focused on temporally distributing use away from weekends and mid-day. The data presented in this report show that weekend trail use more than doubles that of weekday trail use throughout the Central Wasatch. Additionally, the data show that nearly half (49%) of trail use within the canyon happens between 10am and 3pm. Combined, these two statistics highlight how trail use can seem exceptionally high on certain days and at certain times. Efforts on this front can be very informal, such as briefing agency staff, county destination marketing organizations, and municipal leaders on the benefits of recreating in the canyons during the week and earlier/later in the day. Efforts can also be more strategic, coordinated, and formal such as a memorandum of understanding between the USDA Forest Service, Salt Lake County, and the municipalities of the Salt Lake Valley in how they will share information about the recreation opportunities within the Central Wasatch. While coordinated and formal educational campaigns focused on responsible and safe outdoor recreation behavior have yet to receive much focus from state agencies (Smith & Trout, 2023), they can be implemented in an effort to temporally disperse recreation activity away from peak days (weekends) and times of day (mid-day).

The data presented in this report, and primarily the three broad patterns/trends discussed above, can help the numerous municipalities, counties, non-profit organizations, and agencies who collectively share an interest in the future of trail use within the Central Wasatch. The data and discussion points here are meant to catalyze future discussions and collaborations between and amongst these groups. The future of trail use in the region is not clear, but this report can help steer discussions towards potential solutions that minimize the burden on visitors, limit the potential for unacceptable levels of environmental impacts, and preserve the diverse array of recreation opportunities defining the Central Wasatch today.

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[1] Recent research has documented the spatial concentration of recreationists' around both parking areas and visitor's centers (Wilkins et al., 2021).

References

Clark, R. N., & Stankey, G. H. (1979). *The recreation opportunity spectrum: A framework for planning, management, and research* (Gen. Tech. Rep. PNW-98). U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

Gische, K. (2022, October 17). *How does a trip start and end?* https://support.streetlightdata.com/hc/en-us/articles/360018550852-How-does-a-trip-start-and-end-

Hammitt, W. E., Cole, D. N., & Monz, C. A. (2015). Chapter 10: Strategies and concepts of management. In *Wildland recreation: Ecology and management* (3rd ed., pp. 181–195). John Wiley & Sons, Ltd.

Kyle, G., & Landon, A. (2021). Shifting setting densities and normative evaluations of recreation experiences over time. *Landscape and Urban Planning*, *208*, 104034. https://doi.org/10.1016/j.landurbplan.2020.104034

Lamborn, C. C., Burr, S. W., & Kessler, B. A. (2014a). *Central Wasatch visitor use study: Summer quarterly report* (IORT-PR-2014-1). Utah State University.

Lamborn, C. C., Burr, S. W., & Kessler, B. A. (2014b). *Central Wasatch visitor use study: Fall quarterly report* (IORT-PR-2014-2). Utah State University.

Lamborn, C. C., Burr, S. W., & Kessler, B. A. (2015a). *Central Wasatch visitor use study: Follow-up survey report* (IORT-PR-2015-3). Utah State University.

Lamborn, C. C., Burr, S. W., & Kessler, B. A. (2015b). *Central Wasatch visitor use study: Spring quarterly report* (IORT-PR-2015-2). Utah State University.

Lamborn, C. C., Burr, S. W., & Lofthouse, J. (2015a). *Central Wasatch visitor use study: Winter quarterly report* (IORT-PR-2015-1). Utah State University.

Lamborn, C. C., Burr, S. W., & Lofthouse, J. (2015b). *Central Wasatch visitor use study: Ski area report* (IORT-PR-2015-6). Utah State University.

Lindsey, G., Wilson, J., Rubchinskaya, E., Yang, J., & Han, Y. (2007). Estimating urban trail traffic: Methods for existing and proposed trails. *Landscape and Urban Planning*, *81*(4), 299–315. https://doi.org/10.1016/j.landurbplan.2007.01.004

Monz, C. A., D'Antonio, A., Lawson, S., Barber, J., & Newman, P. (2016). The ecological implications of visitor transportation in parks and protected areas: Examples from research in US National Parks. *Journal of Transport Geography*, *51*, 27–35.

Smith, J. W., Miller, A. B., Lamborn, C. C., Monz, C., & Rumore, D. (2021). *Outdoor recreation use and indicators of the ecological, physical, and social characteristics of recreation settings in the Central Wasatch: Phase 1 interim report*. Institute of Outdoor Recreation and Tourism, Utah State University. https://digitalcommons.usu.edu/extension_curall/2206/

Smith, J. W., & Trout, C. (2023). *An overview of state funding for outdoor recreation and tourism in Utah*. Institute of Outdoor Recreation and Tourism.

Spernbauer, B. S., Monz, C., D'Antonio, A., & Smith, J. W. (2023). Factors influencing informal trail conditions: Implications for management and research in Urban-Proximate parks and protected areas. *Landscape and Urban Planning*, *231*, 104661. https://doi.org/10.1016/j.landurbplan.2022.104661

TRAFx. (2019). *Infrared trail counter*. TRAFx Research Ltd. https://www.trafx.net/brochures/TRAFx_Infrared_Trail_Counter.pdf?v=190724

Wilkins, E. J., Howe, P. D., & Smith, J. W. (2021). Social media reveal ecoregional variation in how weather influences visitor behavior in U.S. National Park Service units. *Scientific Reports*, *11*(1), Article 1. https://doi.org/10.1038/s41598-021-82145-z

Appendix A: Trail Counter Locations

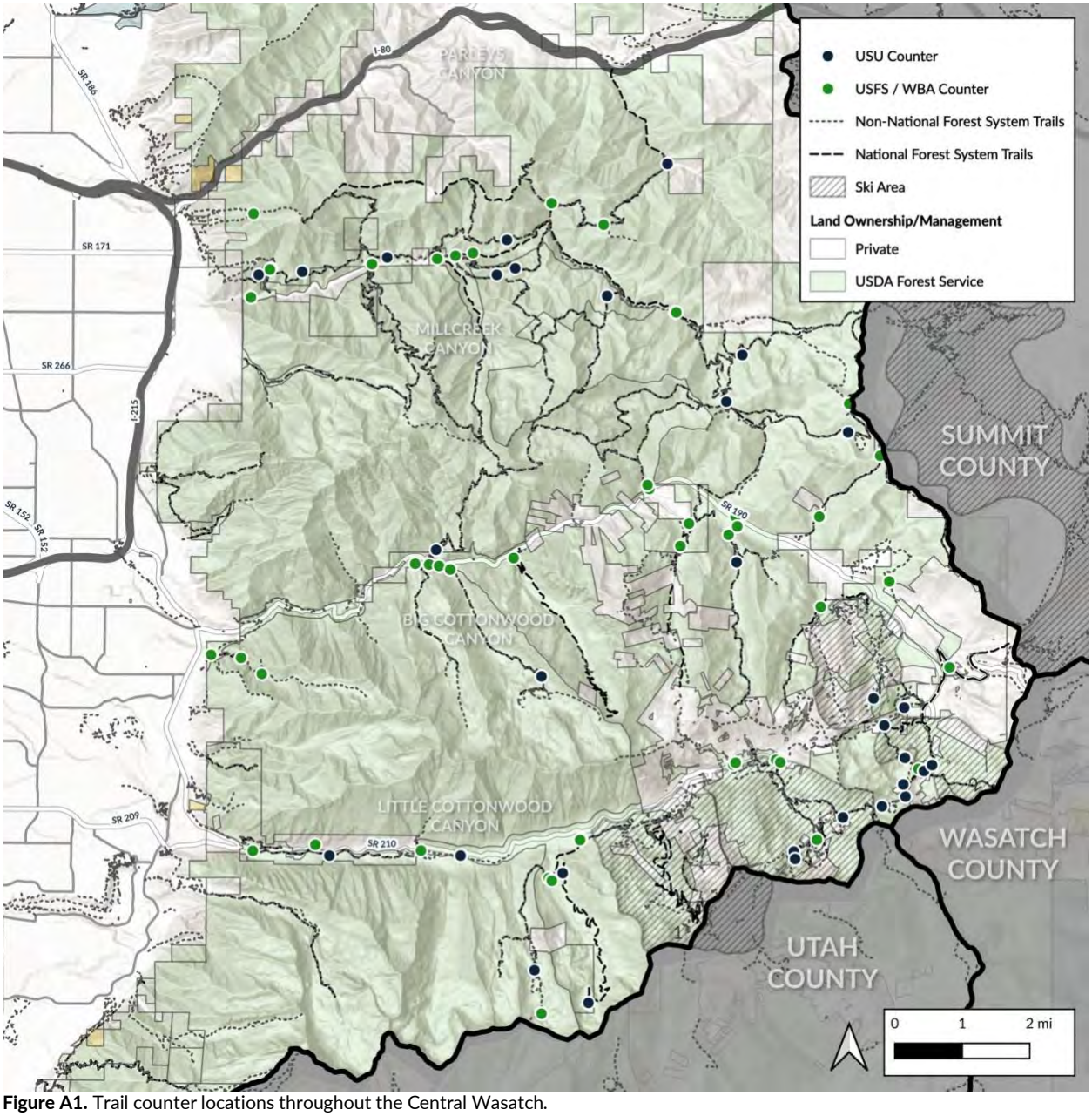

Figure A1. Trail counter locations throughout the Central Wasatch.

Appendix B: Estimating Average Daily Traffic Estimates From Trail Counter Data

Estimating Average Daily Traffic Estimates From Trail Counter Data

Trail counter data is not continuous throughout the year, given individual trail counters are moved from location to location as the seasons change. This prohibits the direct estimation of Average Annual Pedestrian Traffic, the required measure to calibrate use estimates from mobile location data. Consequently, we constructed a statistical model using data from all counter locations to generate estimates of Annual Average Daily Pedestrian Traffic. By pooling data all counter locations, we are able to apply our understanding of the inferential relationships between specific factors believed to affect trail use from a counter location where data were collected for a particular period of time, to other counter locations where data were not collected for that time period.

The summary statistics describing the trail use data from the counter locations is shown in Table B1. Given the data are overdispersed (as is common with trail use data), and that they are in a panel time-series format (locations as panels and days as time-periods), we fit them with a population-averaged negative binomial panel time-series model.

Table B1. Summary statistics for observed and estimated daily trail use counts

	Mean	Std. Dev.	Lower Bound	Upper Bound
Observed (*n* = 12,353)	205.4	352.7	0.0	6704.0
Estimated (*n* = 60,920)	246.5	519.6	3.6	8118.9

The covariates we included in the model to predict trail use included *canyon*, *year*, *month*, *weekend_FrSu* (a dummy variable for if the day was between Friday and Sunday), and *weekend_SaSu* (a dummy variable for if the day was either Saturday or Sunday). These covariates are described in Table C-2. The model was fit in Stata 16.1 with the *xtnbreg* command and the *pa* (population-averaged) option.

Table B2. Covariates used to fit the model predicting trail use

Covariate	Levels
Canyon	1 = Millcreek Canyon
	2 = Big Cottonwood Canyon
	3 = Little Cottonwood Canyon
Month	1 = January
	2 = February
	3 = March
	4 = April
	5 = May
	6 = June
	7 = July
	8 = August
	9 = September
	10 = October
	11 = November
	12 = December
Year	2017
	2018
	2019
	2020
	2021
	2022
Weekend *(Saturday & Sunday)*	0 = Monday – Friday
	1 = Saturday – Sunday

The final model results are shown in Table B3. The model suggests:

- *Canyon* has a significant effect on trail use, with the rate of trail use in both Big and Little Cottonwood Canyons being 9.013 and 6.303 times that of trail use in Millcreek Canyon. This finding was expected.
- *Month* has a significant effect on trail use, with trail use peaking in July. This was also to be expected given the seasonal nature of trail use in the three canyons.
- *Weekend_SaSu* has a significant effect on trail use, with the rate of trail use on Saturdays and Sundays being 2.0 times that of trail use during other days of the week.
- *Year* has no effect on trail use, and as a result was subsequently dropped from the model.
- *Weekend_FrSu* had a significant effect on trail use, but not as significant as *Weekend_SaSu* and subsequently was dropped from the model.

Table B3. Results of the final population-averaged negative binomial model predicting trail use.

	Coef.	S.E.	IRR	S.E.	z	*p* > *z*
Canyon						
Big Cottonwood Canyon	2.199	0.088	9.013	0.794	24.960	0.000
Little Cottonwood Canyon	1.841	0.119	6.303	0.751	15.460	0.000
Month						
February	-0.176	0.038	0.839	0.032	-4.580	0.000
March	-0.117	0.037	0.889	0.033	-3.170	0.002
April	-0.396	0.038	0.673	0.025	-10.500	0.000
May	0.569	0.053	1.766	0.093	10.780	0.000
June	1.281	0.063	3.599	0.226	20.440	0.000
July	1.378	0.056	3.968	0.222	24.630	0.000
August	1.019	0.054	2.772	0.149	18.930	0.000
September	1.089	0.054	2.972	0.159	20.350	0.000
October	0.695	0.054	2.005	0.108	12.960	0.000
November	-0.061	0.062	0.940	0.058	-1.000	0.320
December	-0.211	0.034	0.810	0.028	-6.170	0.000
Weekend (Saturday & Sunday)	0.701	0.020	2.016	0.040	35.000	0.000
Site ID						
4	1.145	0.045	3.141	0.143	25.210	0.000
5	-0.064	0.057	0.938	0.053	-1.130	0.259
6	1.009	0.147	2.743	0.405	6.840	0.000
7	0.474	0.056	1.607	0.090	8.450	0.000
8	0.618	0.045	1.855	0.084	13.720	0.000
9	-0.123	0.057	0.884	0.050	-2.170	0.030
10	-0.825	0.060	0.438	0.026	-13.860	0.000
11	0.370	0.233	1.447	0.337	1.590	0.112
14	0.202	0.109	1.223	0.133	1.850	0.064
15	0.433	0.111	1.542	0.171	3.910	0.000
16	2.002	0.109	7.406	0.809	18.320	0.000
17	0.492	0.120	1.635	0.197	4.090	0.000
19	3.110	0.084	22.418	1.879	37.110	0.000
20	4.317	0.084	74.962	6.279	51.540	0.000
22	0.932	0.071	2.539	0.181	13.080	0.000
25	1.677	0.073	5.348	0.389	23.070	0.000
26	0.222	0.077	1.248	0.096	2.900	0.004
27	-0.724	0.165	0.485	0.080	-4.390	0.000
28	-1.401	0.166	0.246	0.041	-8.450	0.000
29	1.112	0.092	3.039	0.280	12.050	0.000
30	1.673	0.112	5.330	0.597	14.940	0.000
33	0.903	0.119	2.467	0.295	7.570	0.000
34	0.063	0.120	1.065	0.128	0.530	0.599
35	-1.061	0.154	0.346	0.053	-6.890	0.000
36	0.640	0.108	1.896	0.205	5.930	0.000
38	1.677	0.086	5.350	0.459	19.560	0.000
39	1.972	0.085	7.188	0.614	23.070	0.000
40	2.873	0.083	17.684	1.459	34.820	0.000
41	5.258	0.101	192.128	19.335	52.250	0.000
42	1.116	0.114	3.052	0.346	9.830	0.000
43	0.645	0.101	1.906	0.192	6.410	0.000
44	0.000	(omitted)	1.000	(omitted)		
50	-1.100	0.108	0.333	0.036	-10.230	0.000
51	-0.027	0.102	0.974	0.100	-0.260	0.796
52	1.232	0.105	3.428	0.359	11.760	0.000
53	1.289	0.133	3.631	0.482	9.720	0.000
54	1.243	0.121	3.468	0.419	10.280	0.000
55	0.000	(omitted)	1.000	(omitted)		
_cons	1.664	0.082	5.282	0.431	20.400	0.000

n = 12,353, locations = 39, observations per location = 19 (min), 316.7 (mean), 959 (max)
Wald $chi^2(50)$ = 34,771.56, $p < 0.05$

The final model was used to predict trail use across all trail counter locations and days (using the *predict mu* postestimation command in Stata). An example of predicted trail use for one traffic counter location is shown in Figure B1. The predicted daily trail use values were

similar to the raw data from the trail counters (Table B1). We summed the predicted trail use data by year to estimate the Annual Average Daily Pedestrian Traffic required of the *Streetlight Data, Inc. Insights* platform.

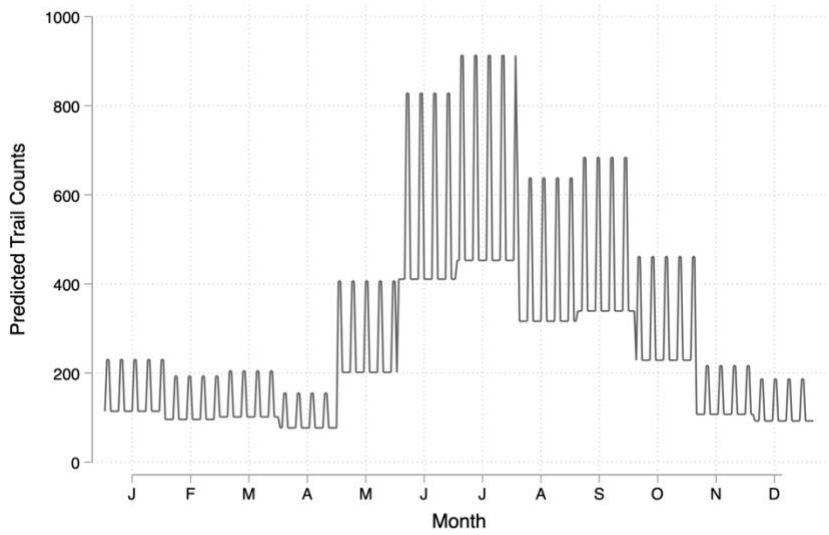

Figure B1. Estimated daily trail counts for White Pine Trail in Little Cottonwood Canyon.

Table B4. Estimated Annual Pedestrian Traffic (APT) and Annual Average Daily Pedestrian Traffic (AADPT) for each trail counter location.

Site Name	Site ID	Estimated APT	Estimated AADPT
Bear Trap	1	41,692	114
Cardiff Fork	4	130,964	359
Days Fork	5	39,098	107
Guardsman's Pass	6	114,374	313
Mill B North	7	66,983	184
Mill D North (2) – *Canyon Spur Road*	8	77,358	212
Mineral Fork	9	36,861	101
Silver Fork	10	18,265	50
Spruces	11	60,334	165
Broads Fork	50	9,702	27
Butler Fork	51	28,394	78
Gloria	53	105,864	290
Our Lady	14	35,671	98
Out Lady East	15	44,950	123
Albion Basion Road (1)	16	215,943	592
Albion Basion Road (2)	17	47,675	131
Porter Fork	19	103,701	284
Millcreek Canyon Winter Gate	20	346,764	950
Terraces	21	4,626	13
Rattlesnake	54	101,102	277
Lake Blanche	22	105,837	290
Donut Falls	25	222,958	611
Ferguson (1)	26	52,040	143
Ferguson (2)	27	20,206	55
Ferguson (3)	28	10,274	28
Catherine Pass	29	126,721	347
Cecret Lake - upper	30	155,403	426
Little Cottonwood Creek (1) – *lower*	33	71,939	197
Little Cottonwood Creek (2) – *upper*	34	31,055	85
Little Cottonwood Creek (3) – *upper*	35	10,090	28
Red Pine	36	55,294	151
Mount Aire	38	24,748	68
Wasatch Crest	39	33,249	91
Thayne's Canyon / Desolation	40	81,805	224
Millcreek Canyon Fee Station	41	888,756	2,435
Grandeur Peak (face)	42	14,117	39
Lambs Canyon (1) – *Parley's Canyon trailhead*	43	8,819	24
Albion Meadows – *upper*	44	4,626	13
Pipeline (middle)	55	29,157	80
White Pine (1) – *trailhead*	52	99,938	274

Appendix C: Differences in Mean Daily Trip Counts by Type of Day and Time of Day

Little Cottonwood Canyon

Little Cottonwood Creek

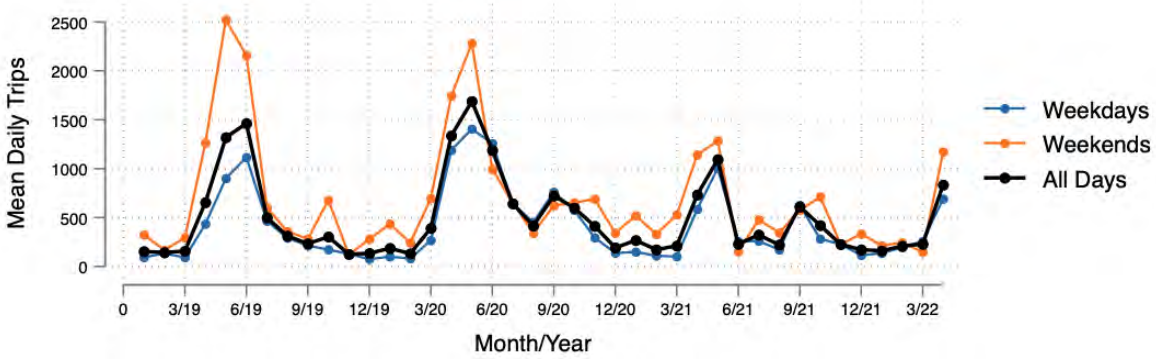

Figure C1. Little Cottonwood Creek (1) – *lower* trail use, by type of day.

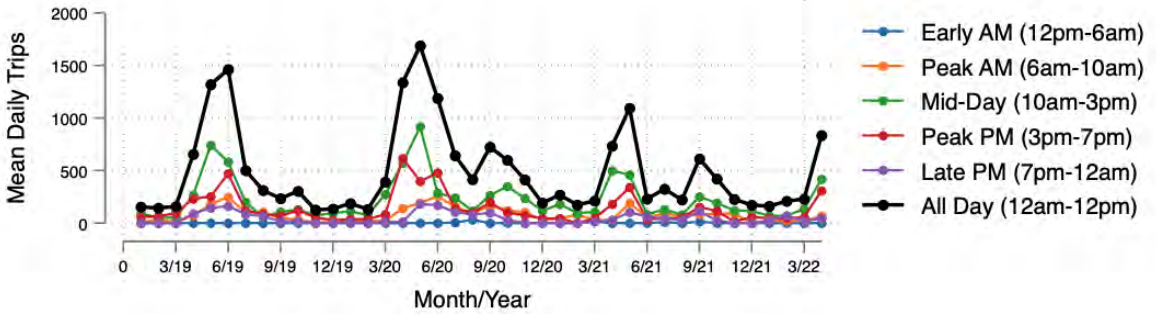

Figure C2. Little Cottonwood Creek (1) – *lower* trail use, by part of day.

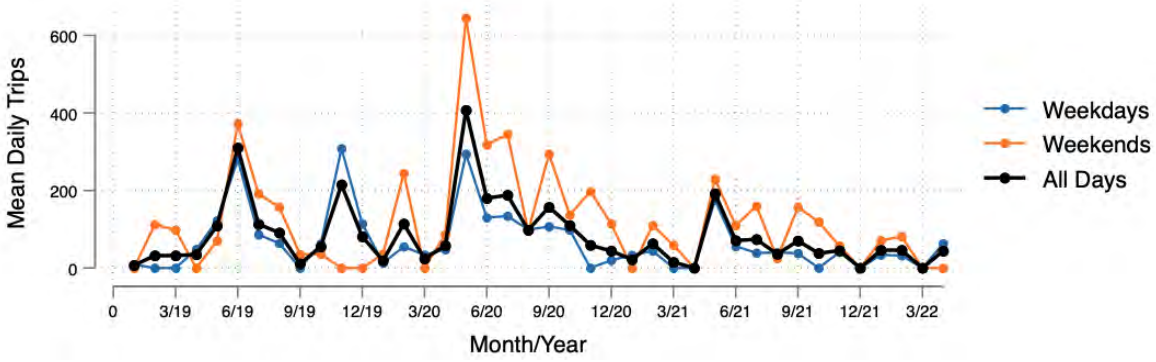

Figure C3. Little Cottonwood Creek (2) – *upper* trail use, by type of day.

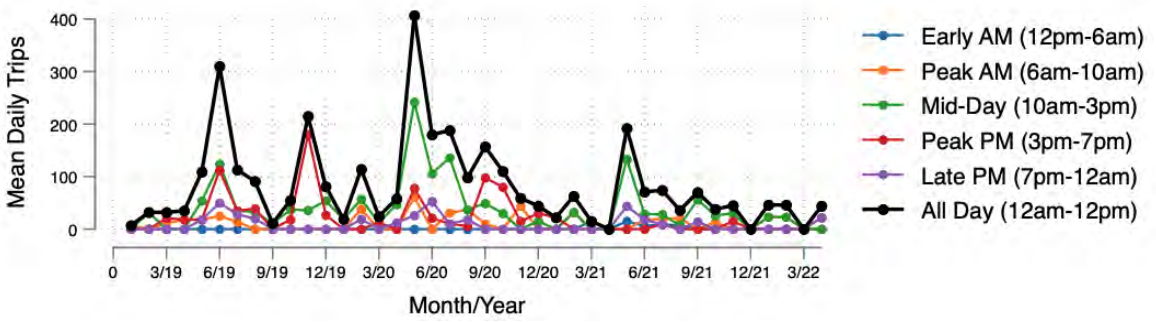

Figure C4. Little Cottonwood Creek (2) – *upper* trail use, by part of day.

White Pine

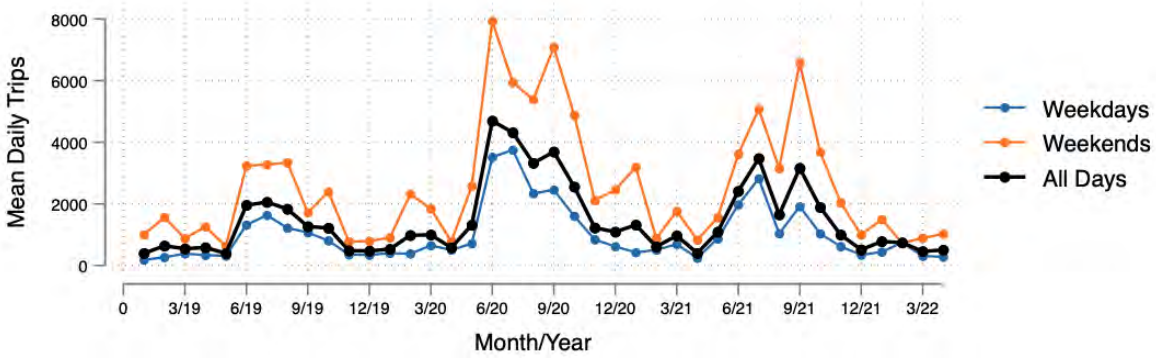

Figure C5. White Pine (1) – *trailhead* trail use, by type of day.

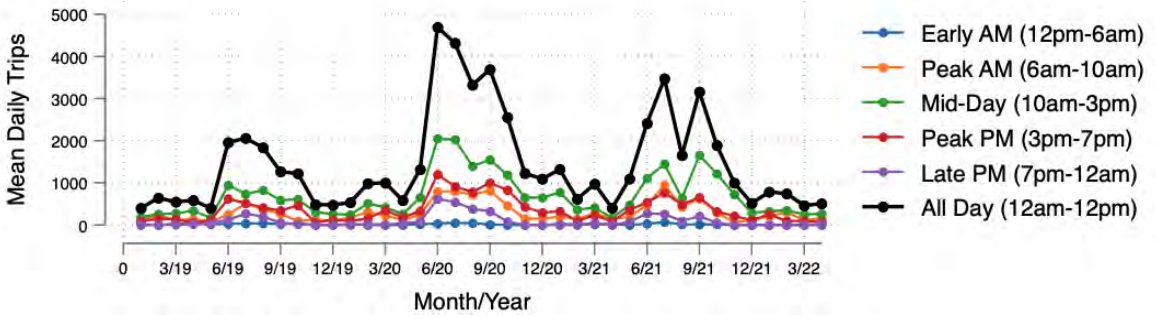

Figure C6. White Pine (1) – *trailhead* trail use, by part of day.

Red Pine

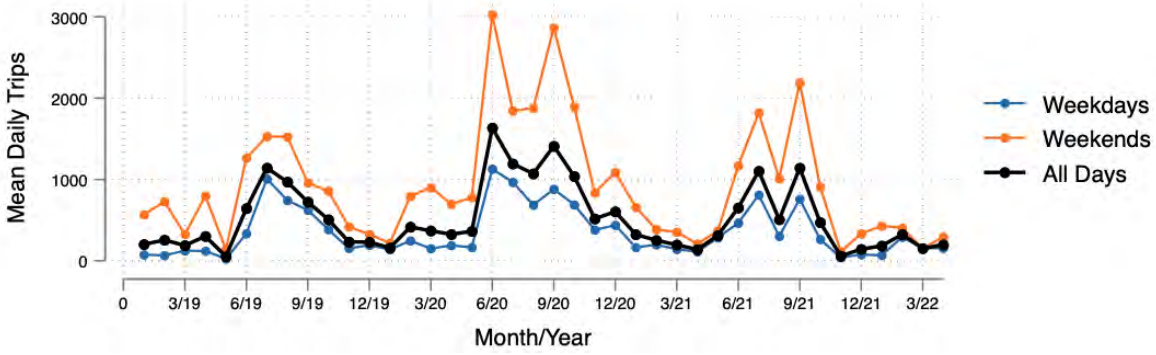

Figure C7. Red Pine trail use, by type of day.

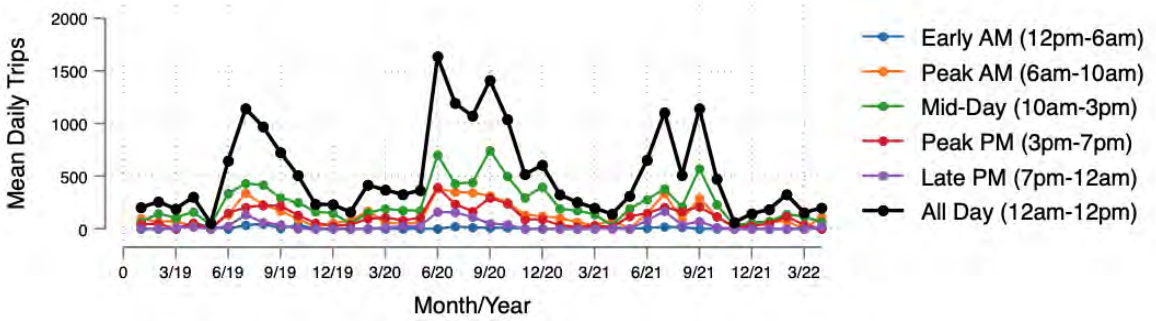

Figure C8. Red Pine trail use, by part of day.

Alta-Brighton Loop Trail – Alta trailhead

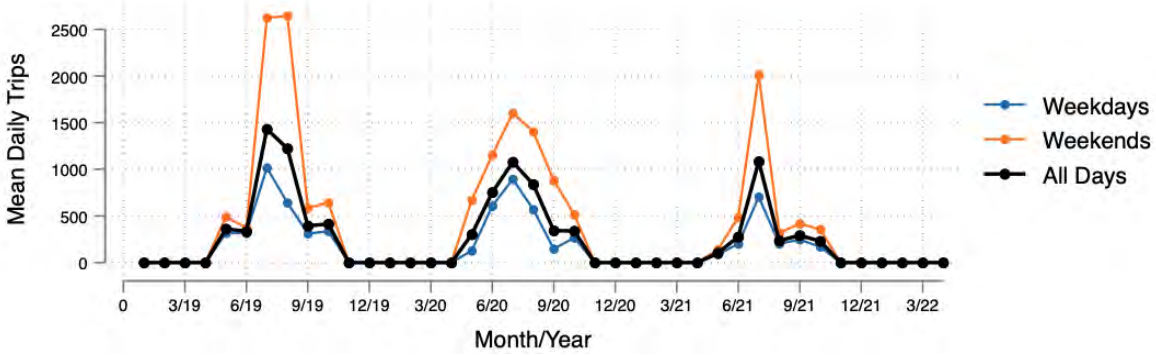

Figure C9. Alta-Brighton Loop Trail – *Alta trailhead* use, by type of day.

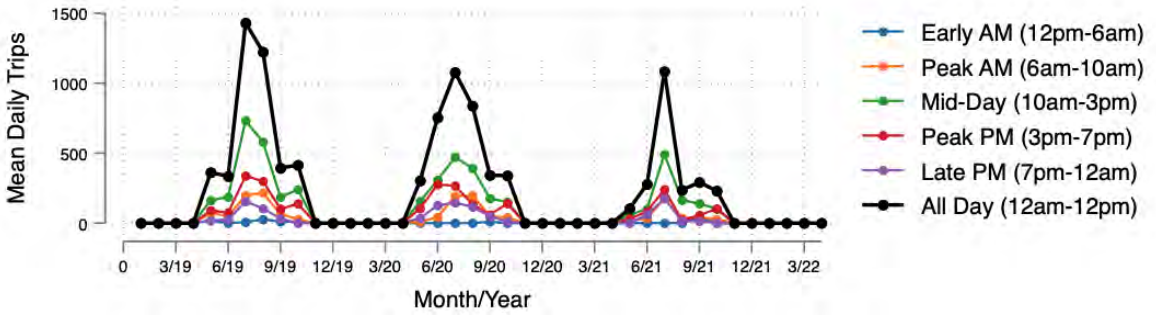

Figure C10. Alta-Brighton Loop Trail – *Alta trailhead* use, by part of day.

Albion Basin

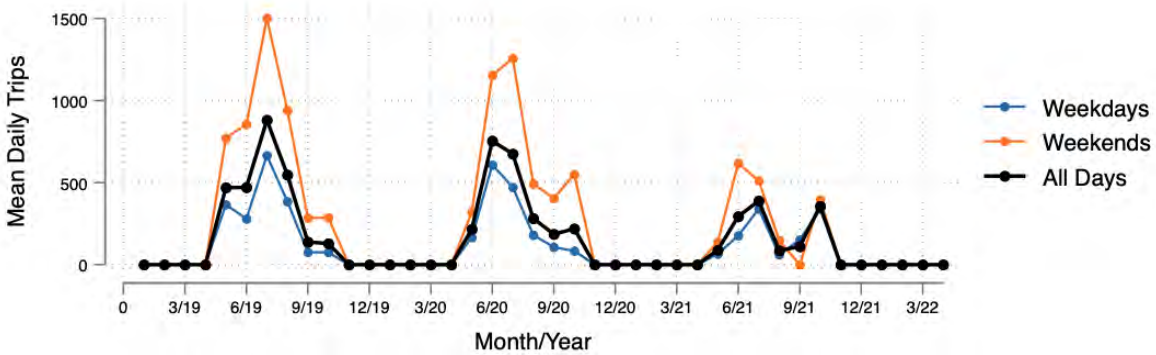

Figure C11. Albion Basin Road pedestrian use, by type of day.

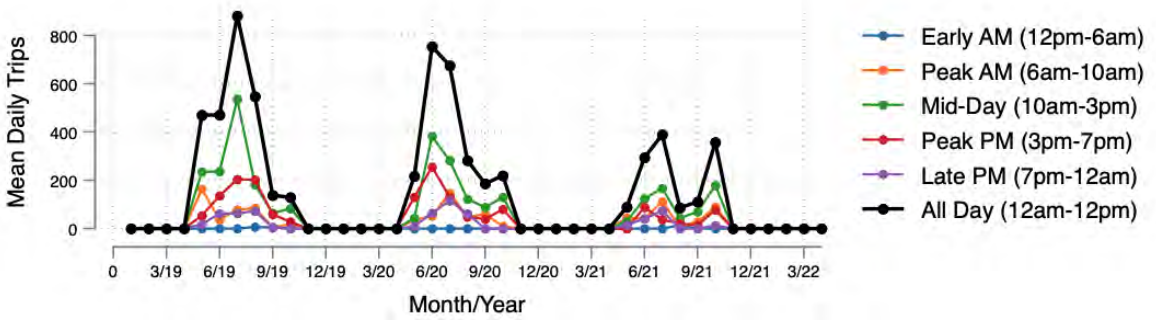

Figure C12. Albion Basin Road pedestrian use, by part of day.

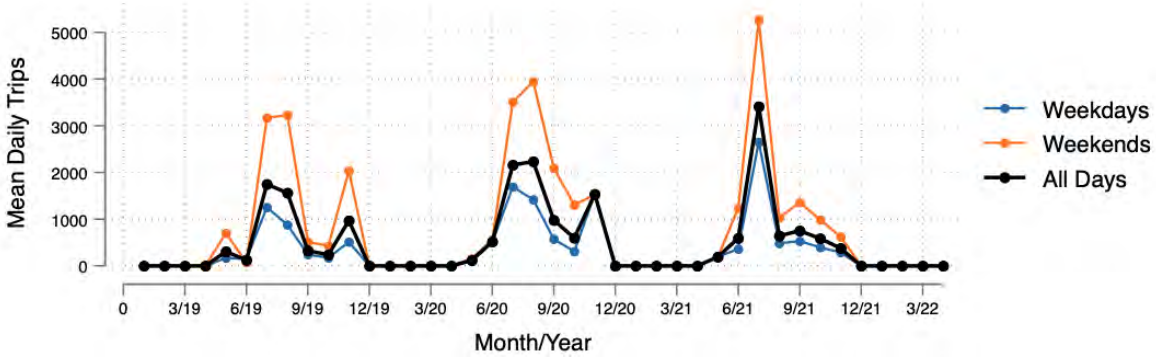

Figure C13. Albion Meadows (lower) trail use, by type of day.

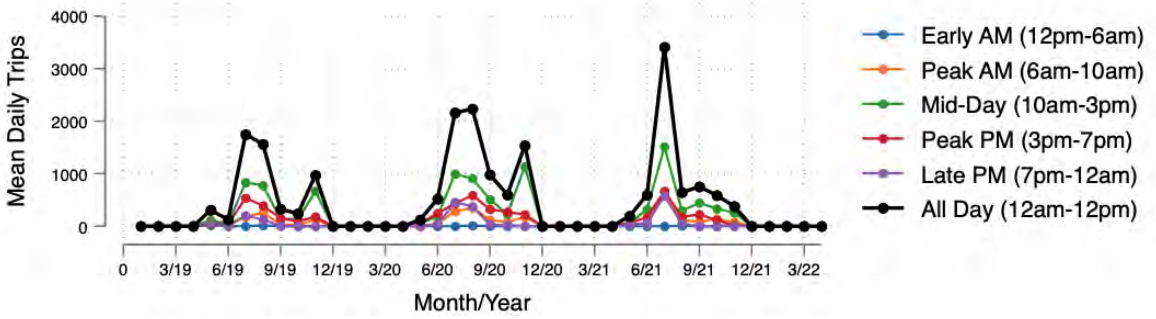

Figure C14. Albion Meadows (lower) trail use, by part of day.

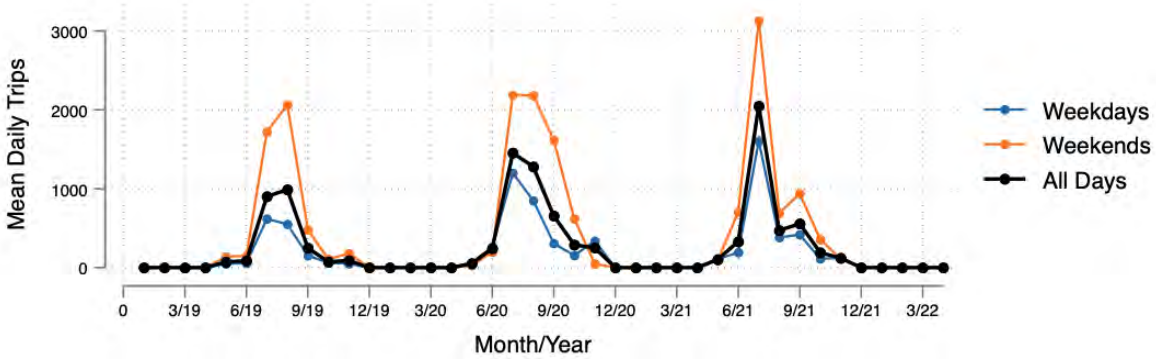

Figure C15. Albion Meadows (upper) trail use, by type of day.

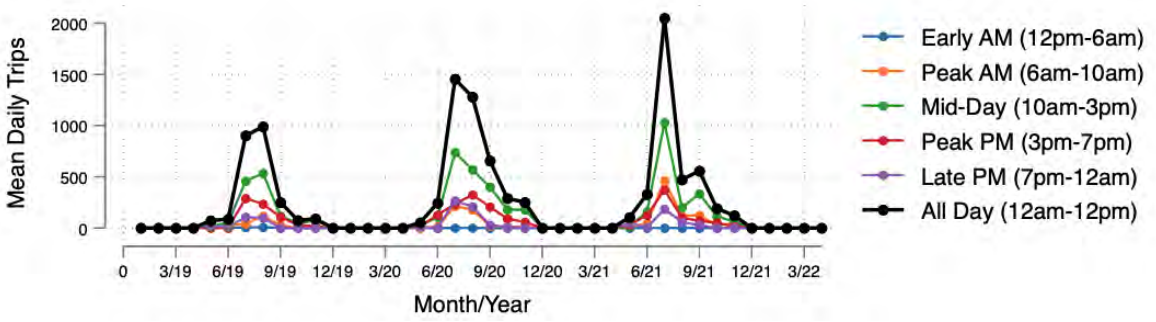

Figure C16. Albion Meadows (upper) trail use, by part of day.

Cecret Lake

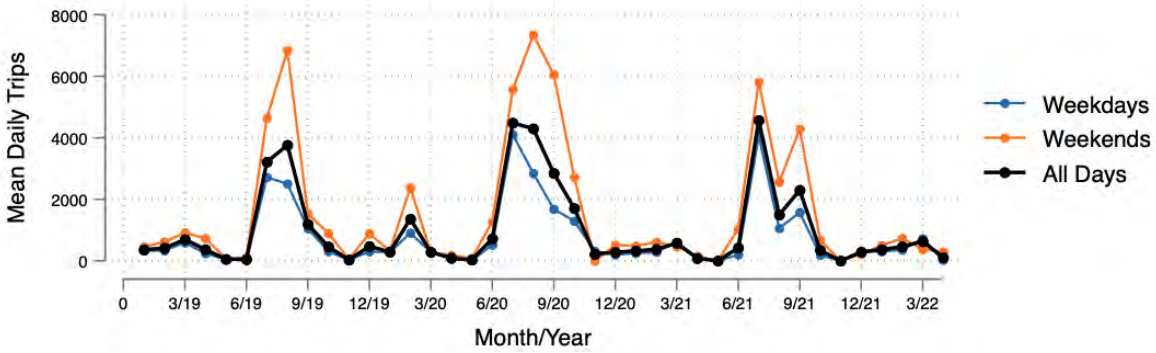

Figure C17. Cecret Lake – *upper* trail use, by type of day.

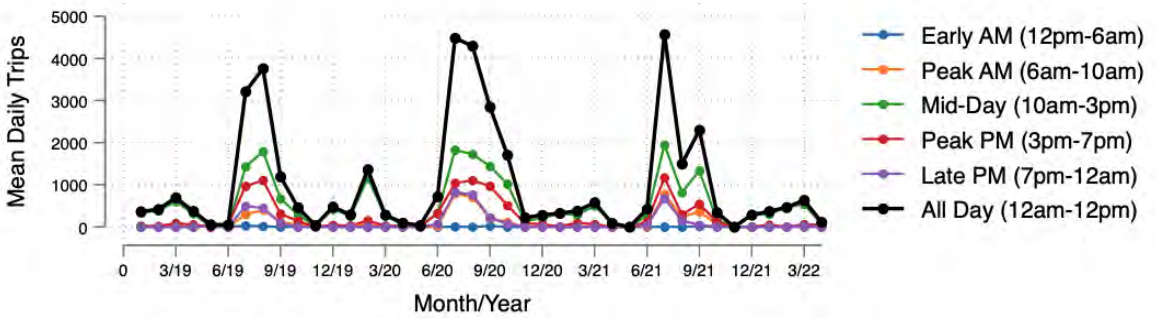

Figure C18. Cecret Lake – *upper* trail use, by part of day.

Big Cottonwood Canyon

Ferguson Canyon

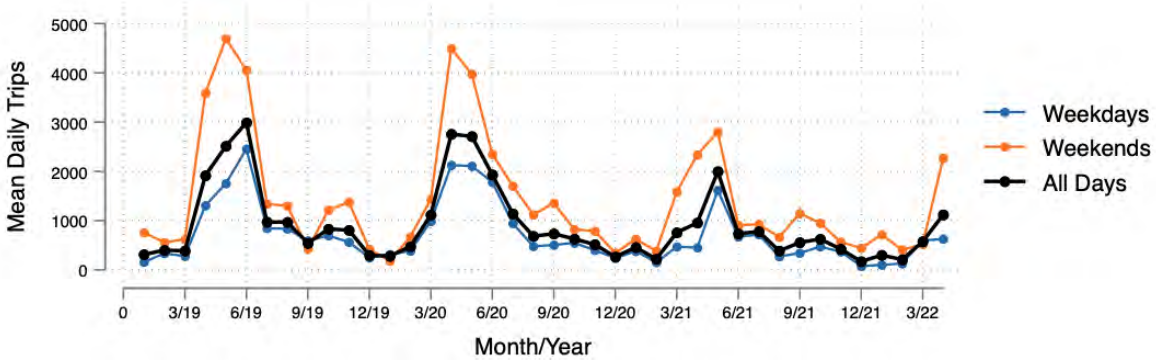

Figure C19. Ferguson Canyon trail use, by type of day.

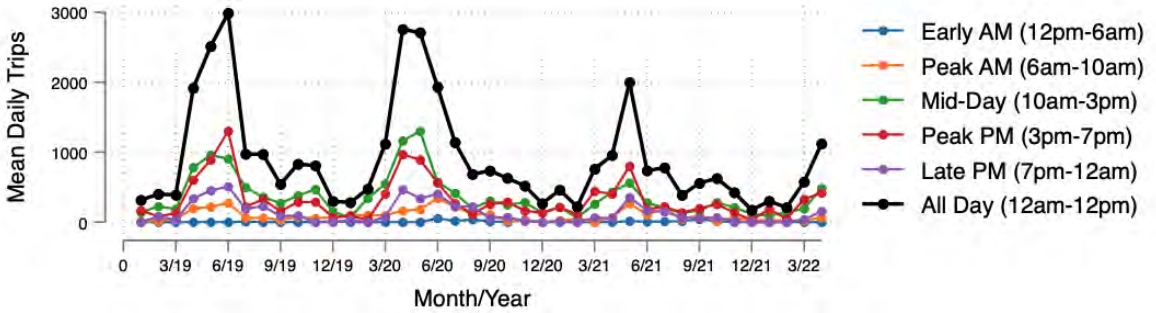

Figure C20. Ferguson Canyon trail use, by part of day.

Mt. Olympus

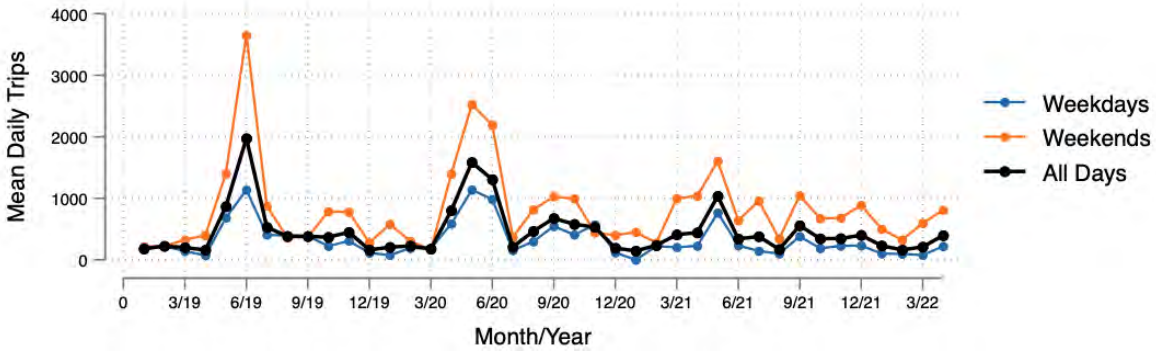

Figure C21. Mt. Olympus trail use, by type of day.

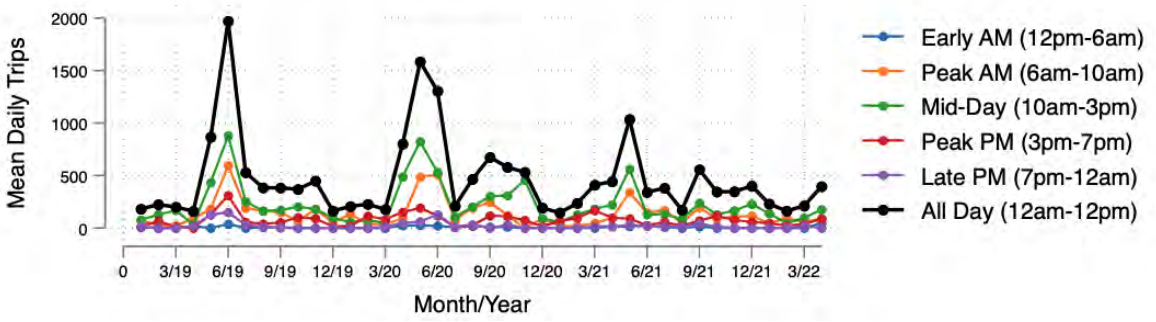

Figure C22. Mt. Olympus trail use, by part of day.

Broads Fork

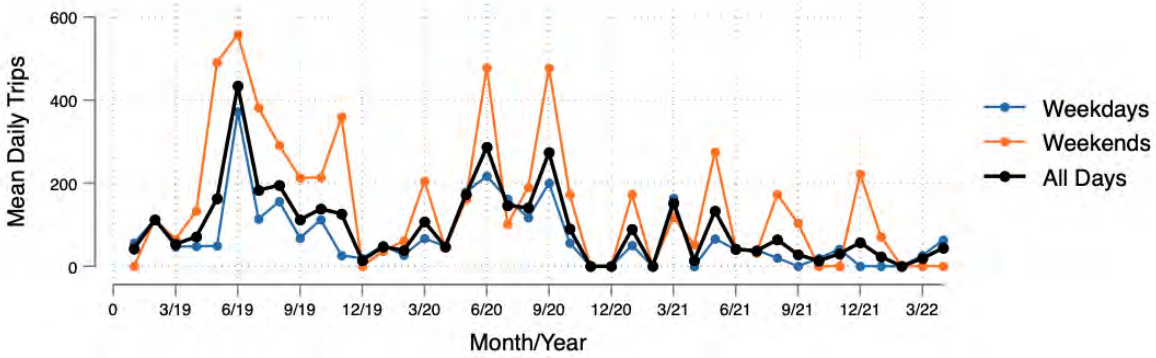

Figure C23. Broads Fork trail use, by type of day.

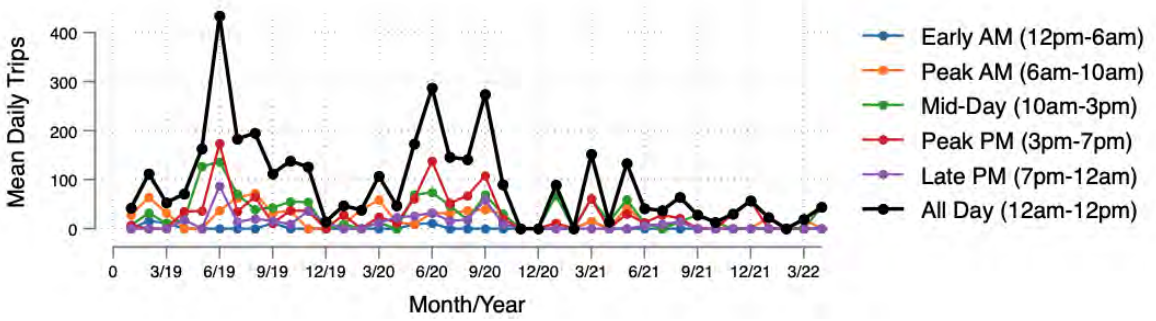

Figure C24. Broads Fork trail use, by part of day.

Lake Blanche

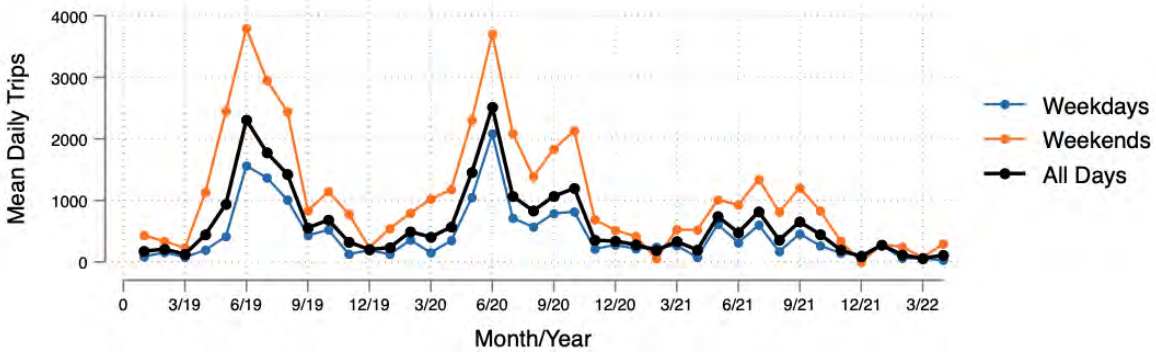

Figure C25. Lake Blanche trail use, by type of day.

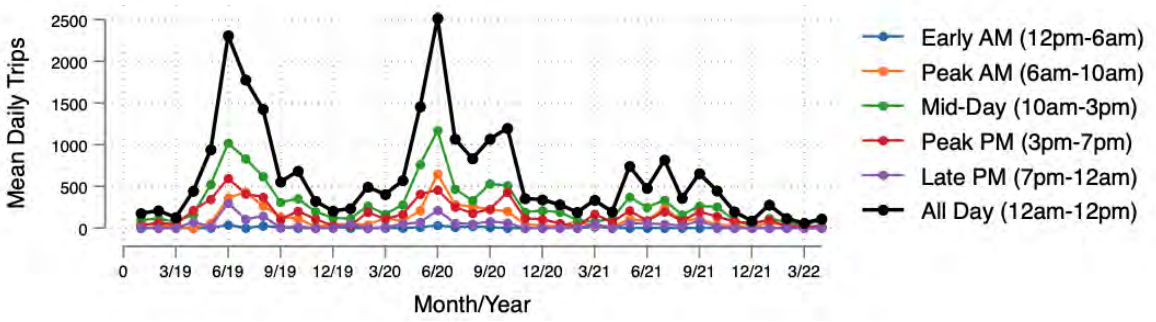

Figure C26. Lake Blanche trail use, by part of day.

Mill B North Fork

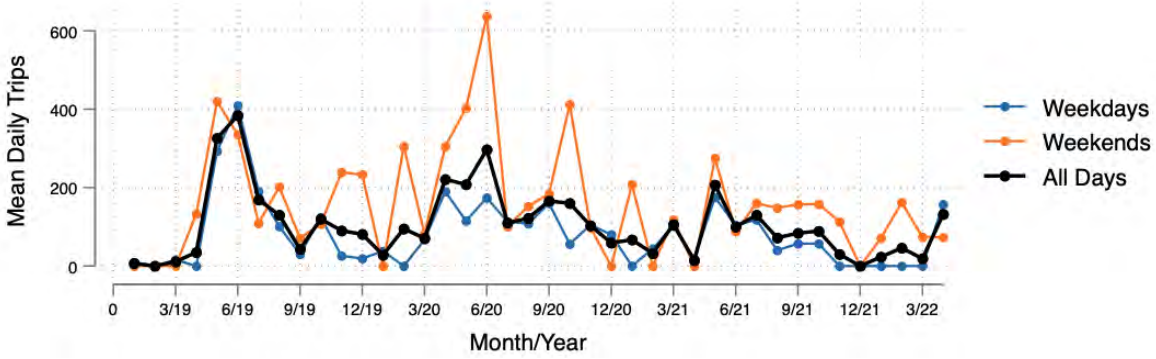

Figure C27. Mill B North Fork trail use, by type of day.

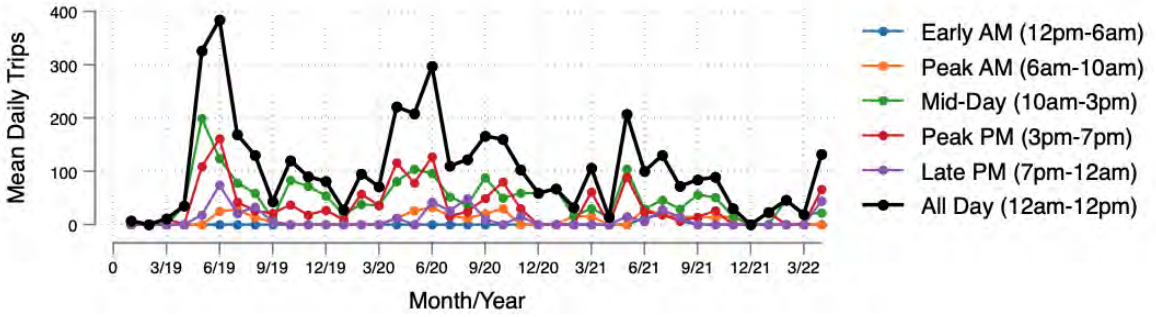

Figure C28. Mill B North Fork trail use, by part of day.

Mineral Fork

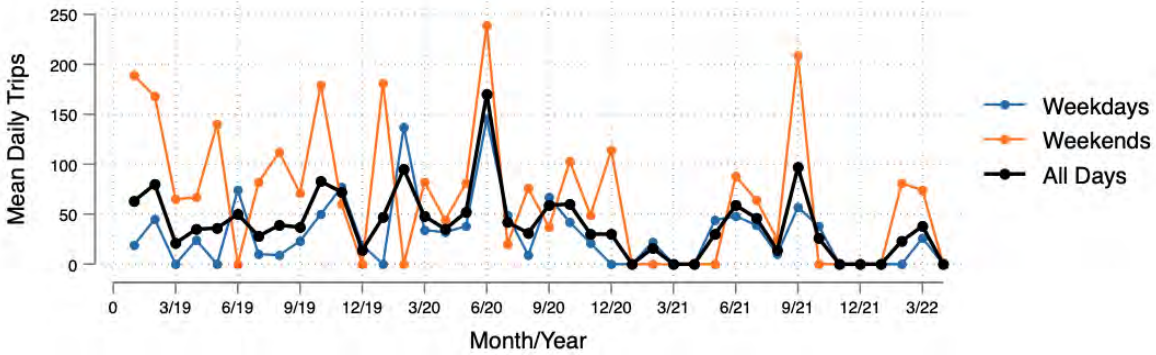

Figure C29. Mineral Fork trail use, by type of day.

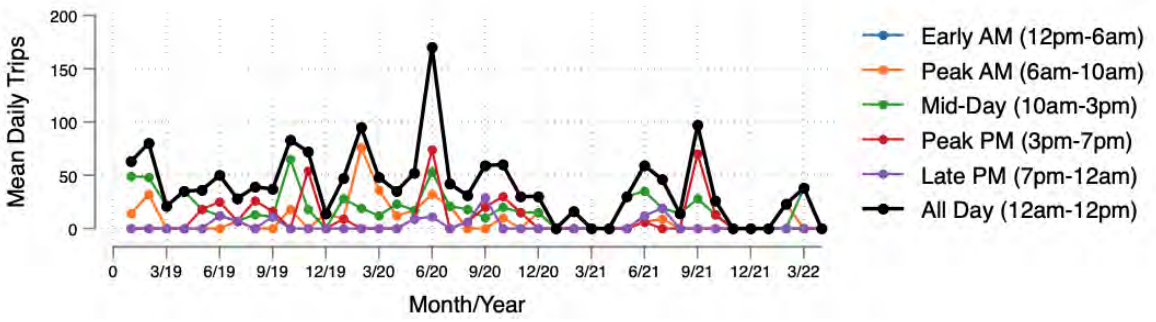

Figure C30. Mineral Fork trail use, by part of day.

Butler Fork

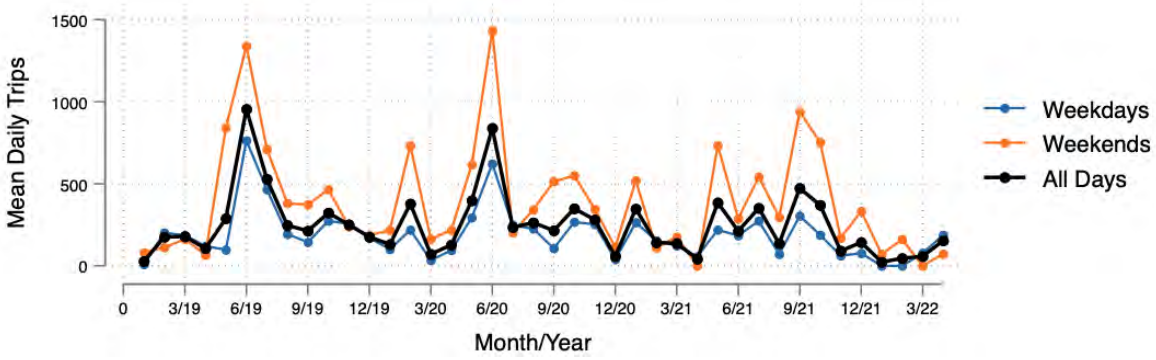

Figure C31. Butler Fork trail use, by type of day.

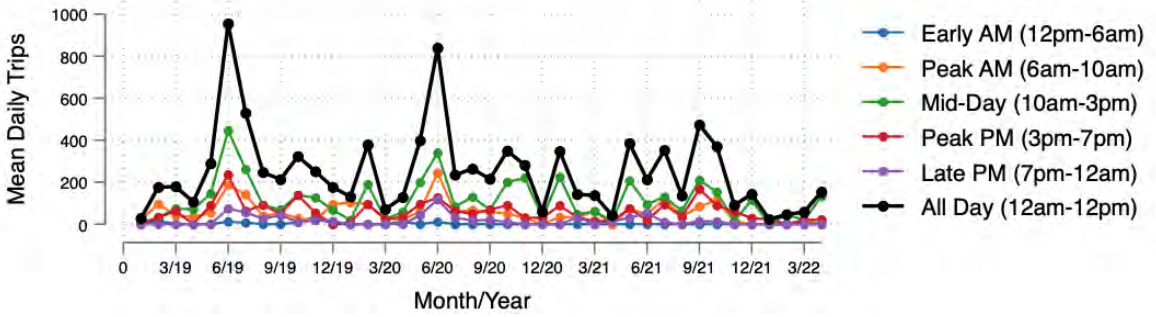

Figure C32. Butler Fork trail use, by part of day.

Cardiff Fork

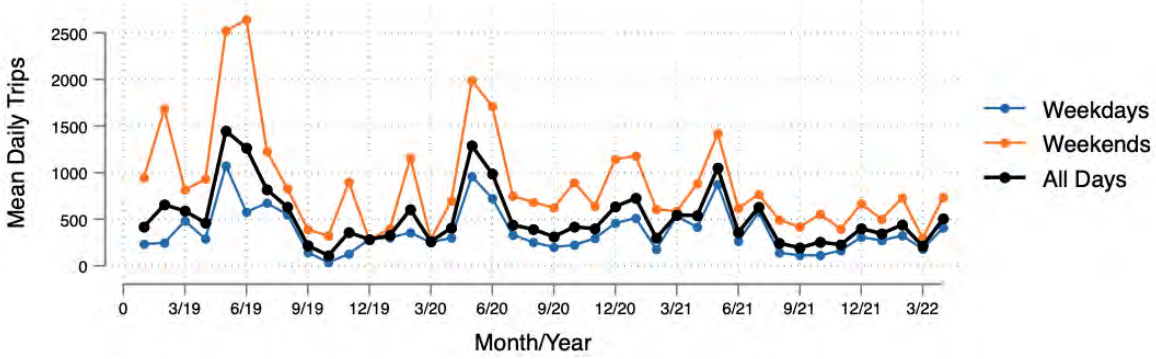

Figure C33. Cardiff Fork trail use, by type of day.

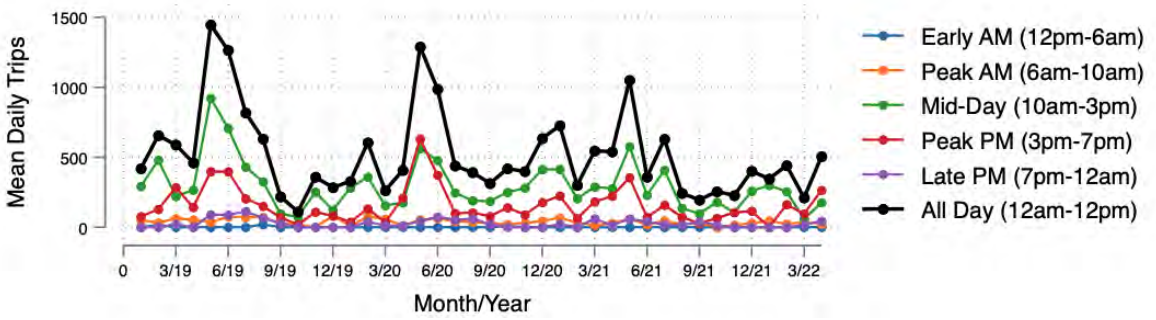

Figure C34. Cardiff Fork trail use, by part of day.

Donut Falls

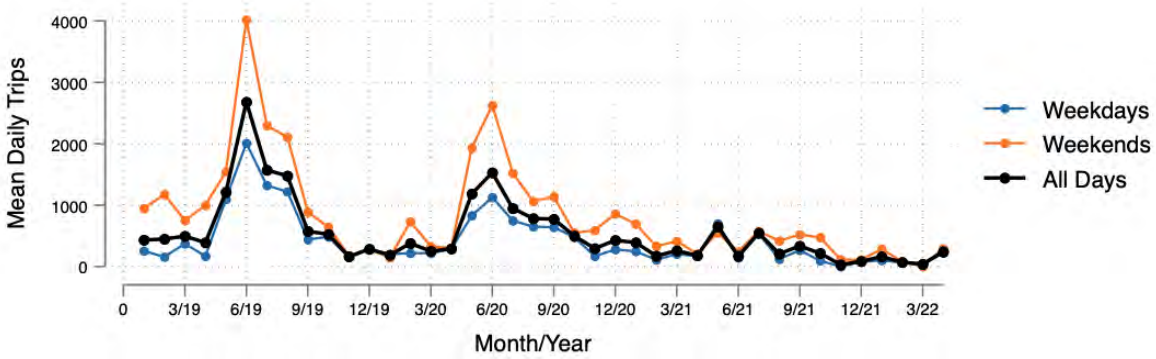

Figure C35. Donut Falls trail use, by type of day.

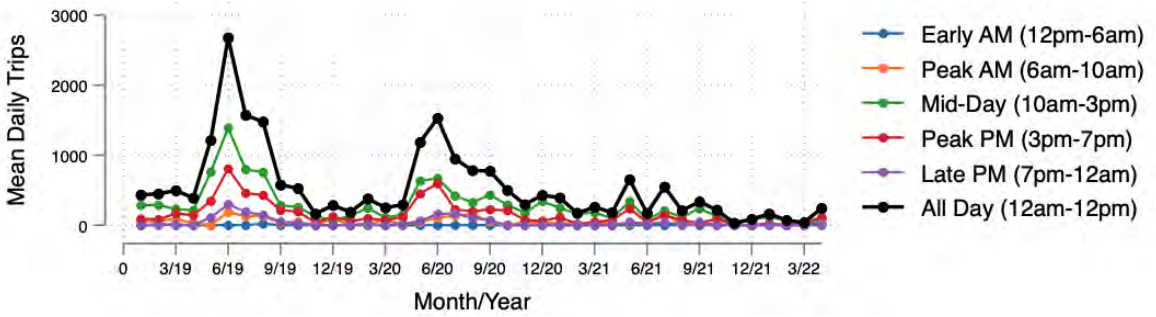

Figure C36. Donut Falls trail use, by part of day.

Mill D North Fork

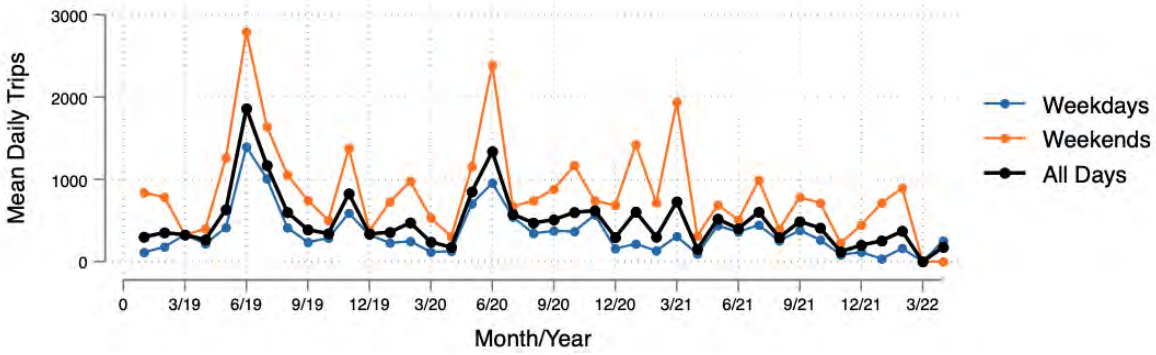

Figure C37. Mill D North Fork (1) – *trailhead* use, by type of day.

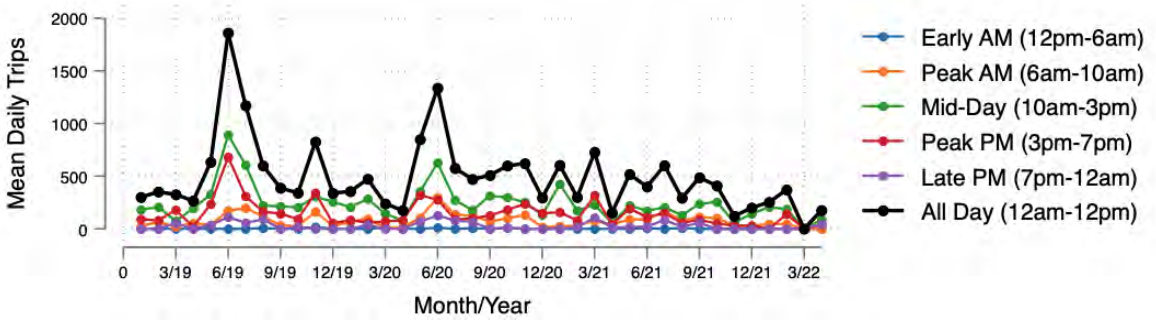

Figure C38. Mill D North Fork (1) – *trailhead* use, by part of day.

Days Fork

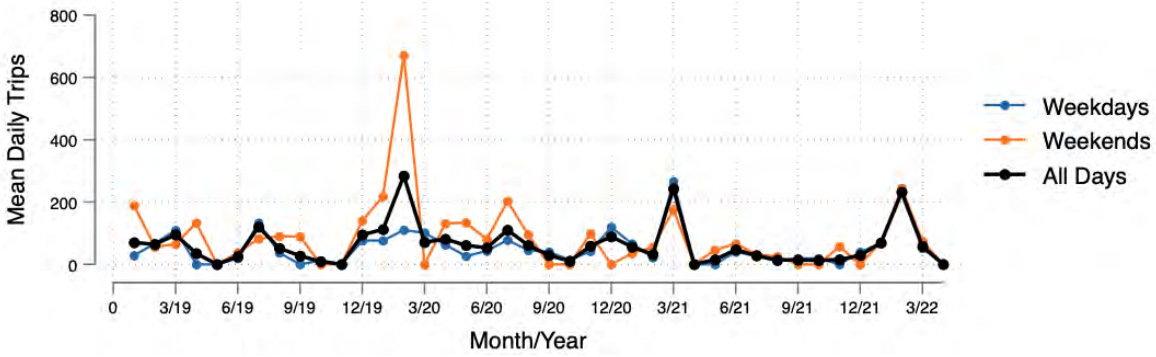

Figure C39. Days Fork trail use, by type of day.

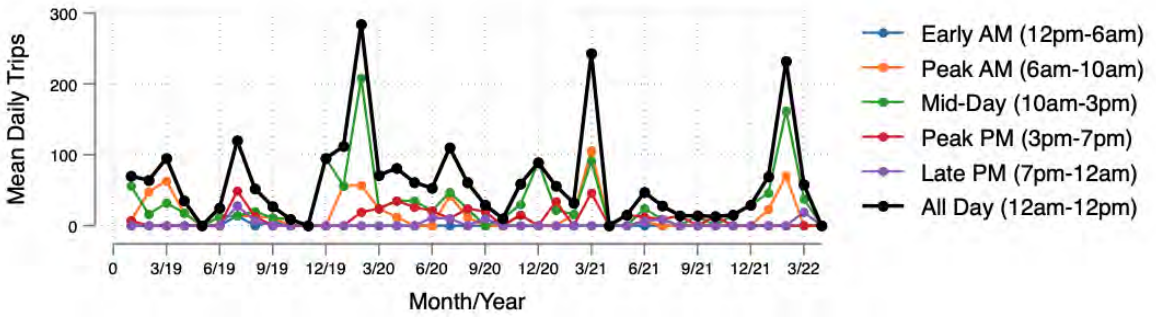

Figure C40. Days Fork trail use, by part of day.

Wasatch Crest

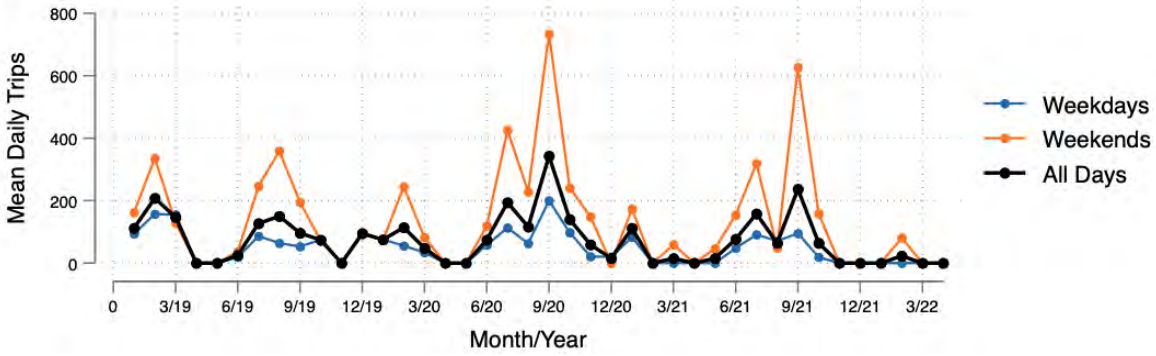

Figure C41. Wasatch Crest trail use, by type of day.

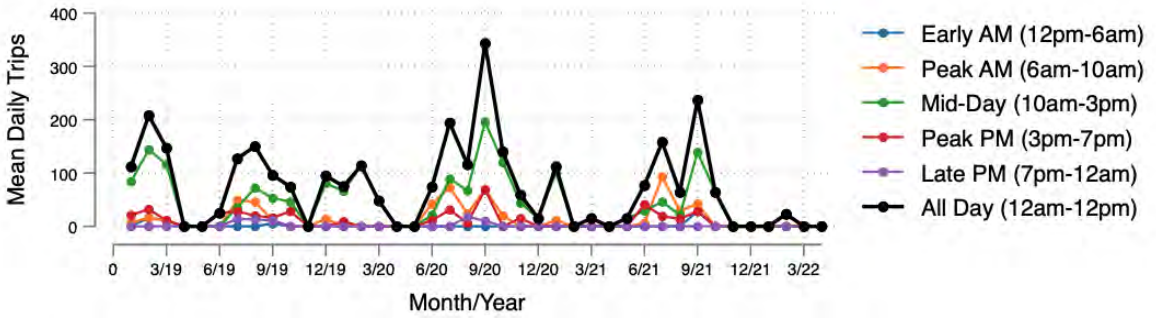

Figure C42. Wasatch Crest trail use, by part of day.

Silver Fork

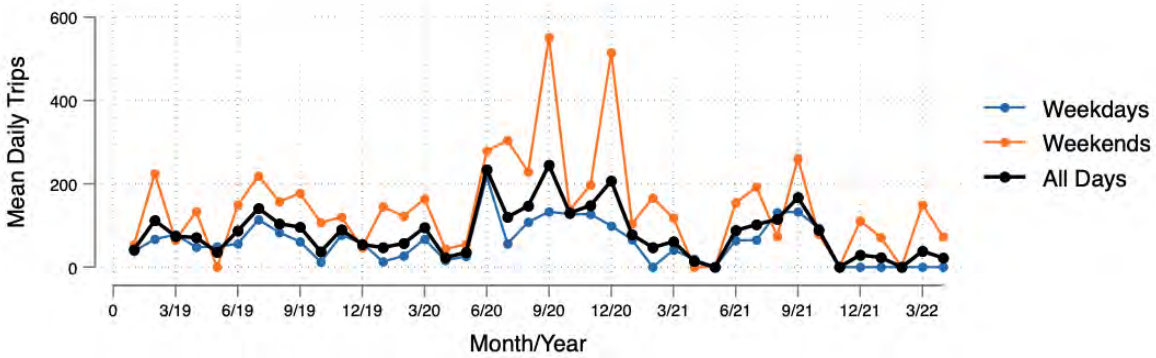

Figure C43. Silver Fork trail use, by type of day.

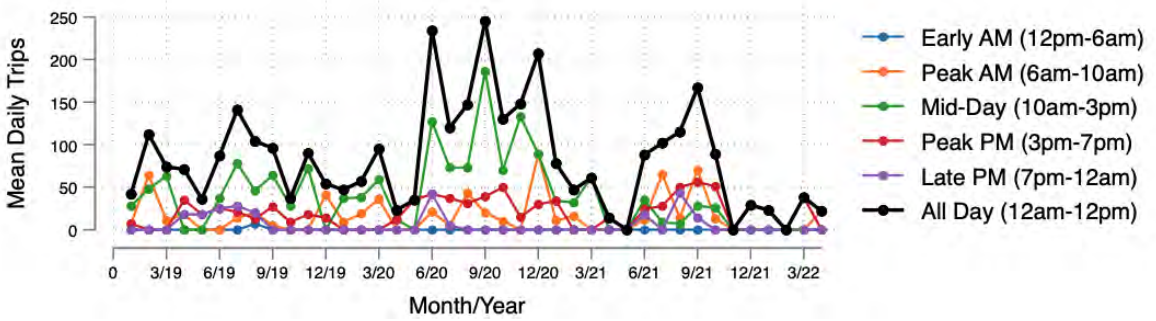

Figure C44. Silver Fork trail use, by part of day.

Guardsman's Pass

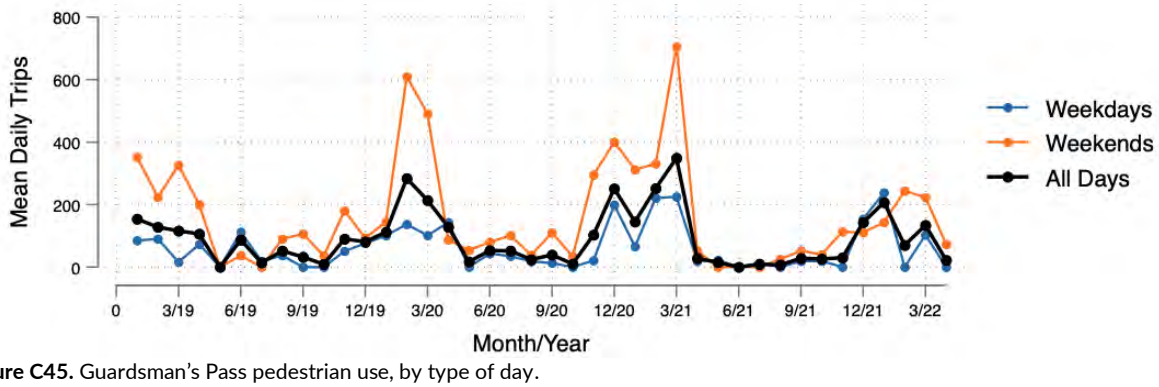

Figure C45. Guardsman's Pass pedestrian use, by type of day.

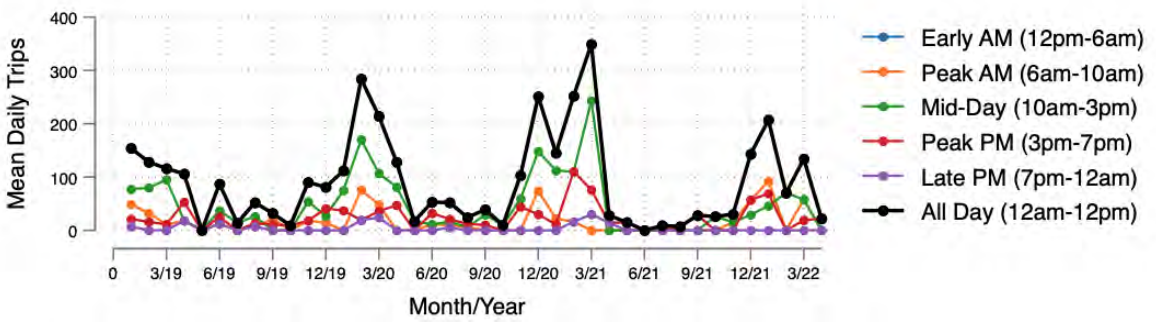

Figure C46. Guardsman's Pass pedestrian use, by part of day.

Brighton Lakes

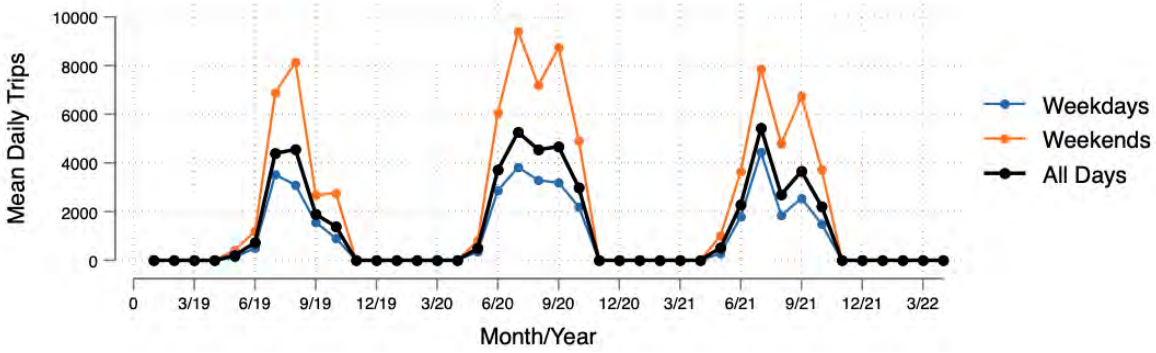

Figure C47. Brighton Lakes trail use, by type of day.

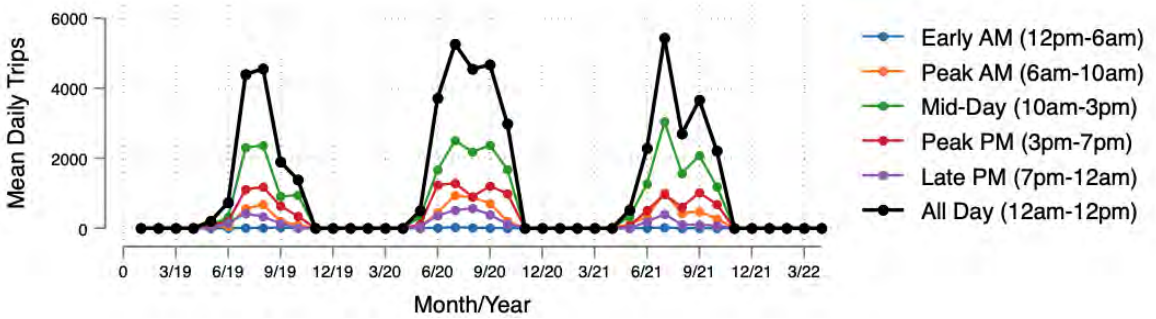

Figure C48. Brighton Lakes trail use, by part of day.

Lake Mary – Twin Lakes Reservoir

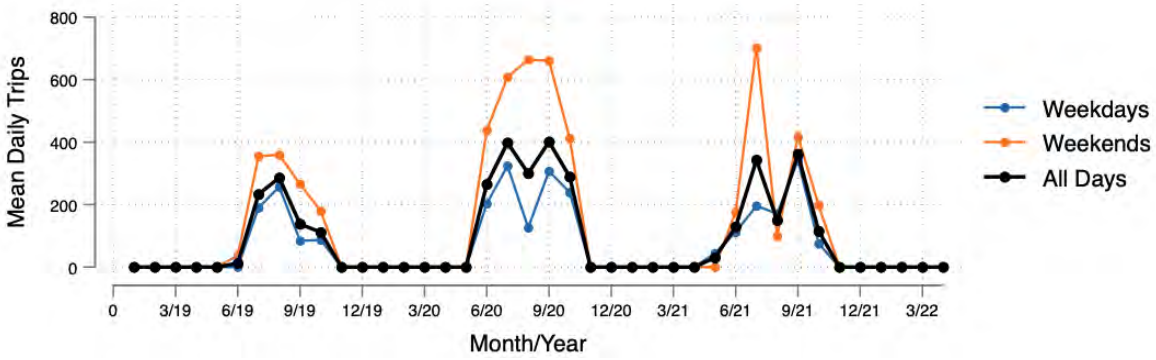

Figure C49. Lake Mary – Twin Lakes Reservoir trail use, by type of day.

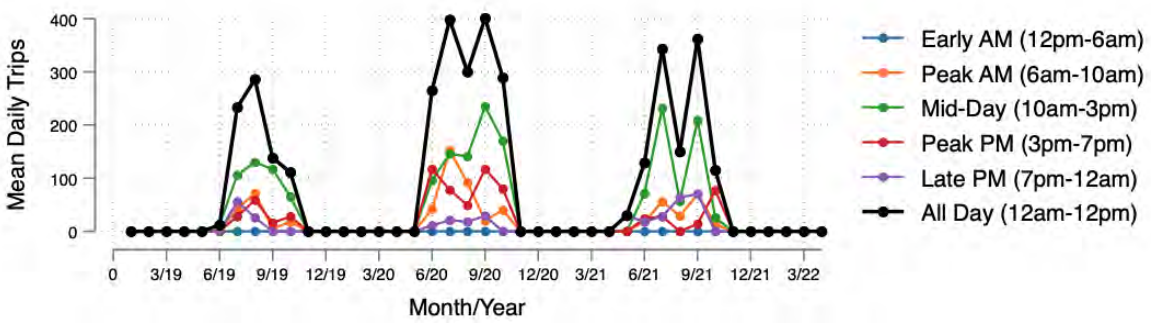

Figure C50. Lake Mary – Twin Lakes Reservoir trail use, by part of day.

Catherine Pass

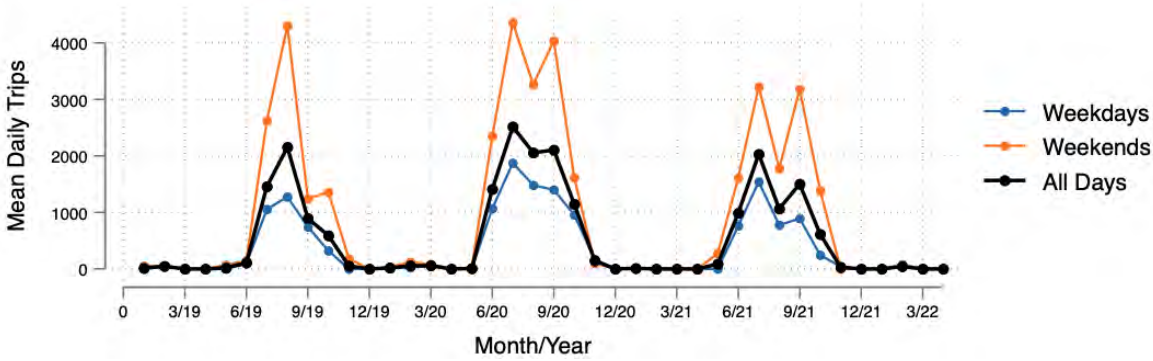

Figure C51. Catherine Pass pedestrian use, by type of day.

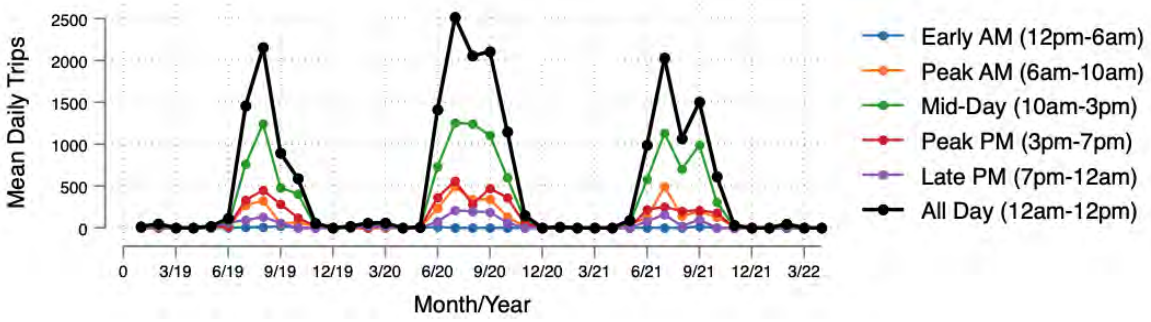

Figure C52. Catherine Pass pedestrian use, by part of day.

Millcreek Canyon

Neff's Canyon

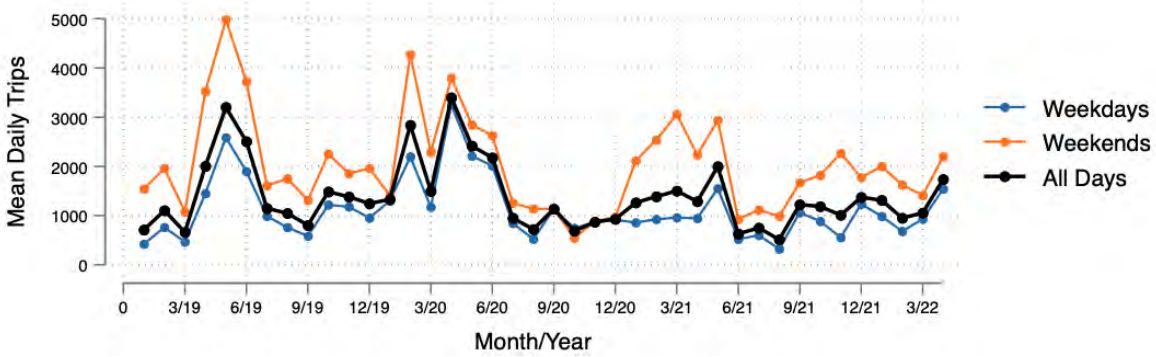

Figure C53. Neff's Canyon trail use, by type of day.

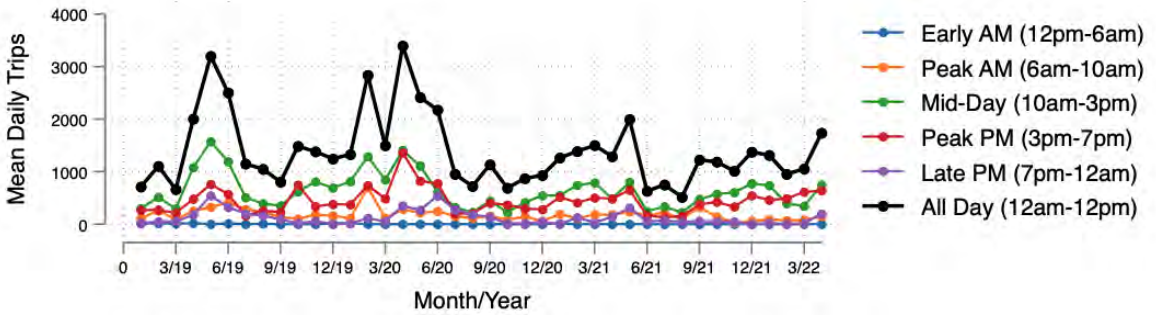

Figure C54. Neff's Canyon trail use, by part of day.

Rattlesnake Gulch

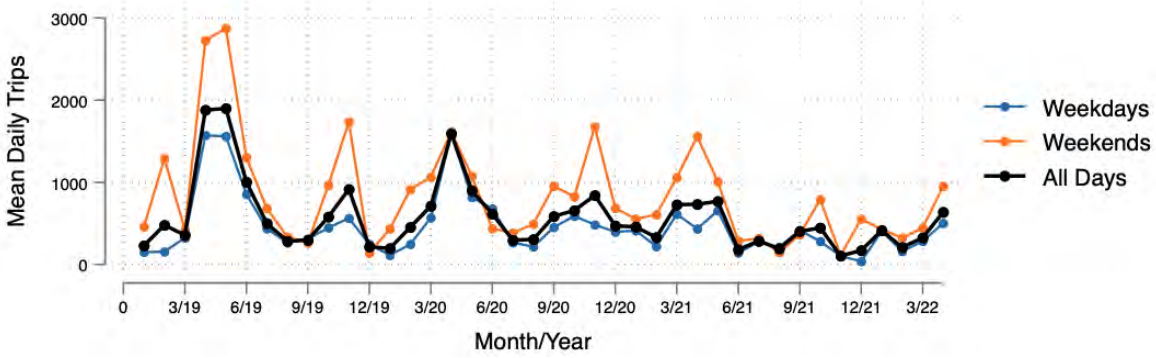

Figure C55. Rattlesnake Gulch trail use, by type of day.

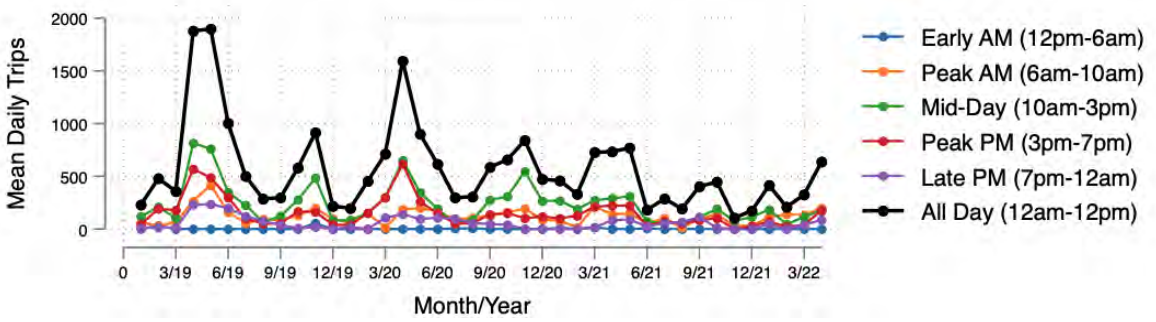

Figure C56. Rattlesnake Gulch trail use, by part of day.

Grandeur Peak (face)

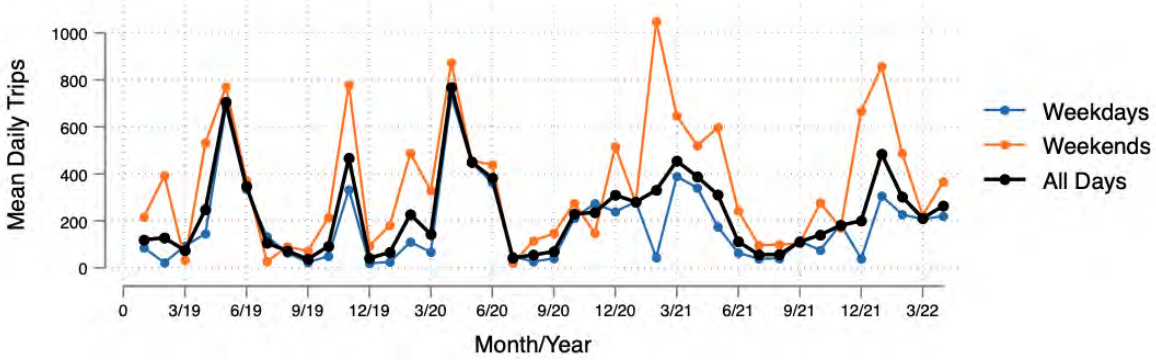

Figure C57. Grandeur Peak (face) trail use, by type of day.

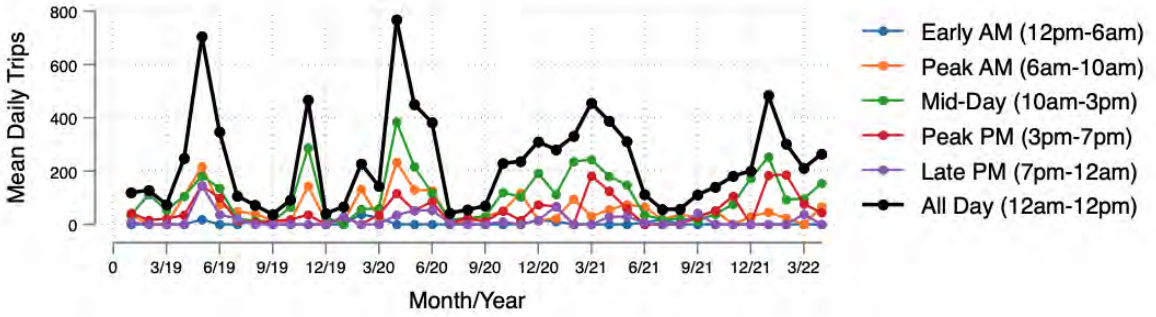

Figure C58. Grandeur Peak (face) trail use, by part of day.

Grandeur Peak (from Millcreek Canyon)

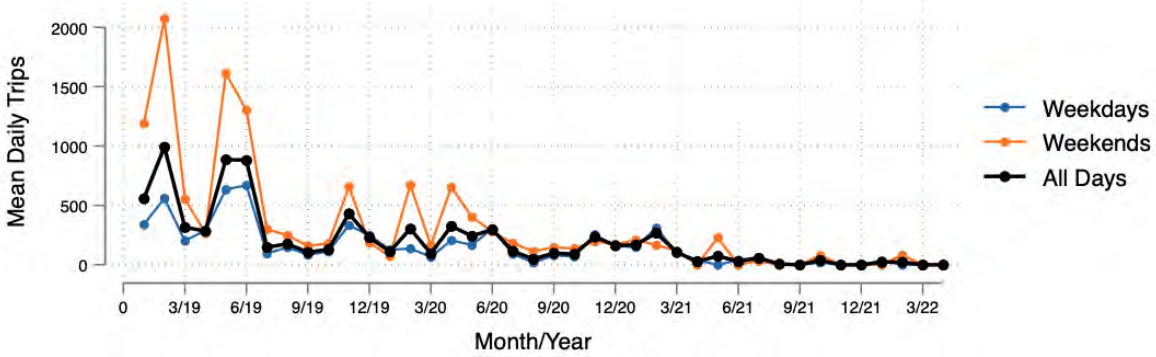

Figure C59. Grandeur Peak (from Millcreek Canyon) trail use, by type of day.

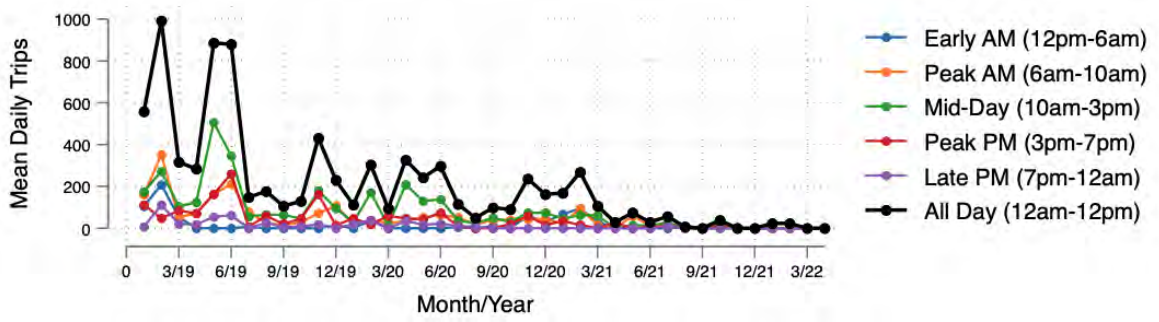

Figure C60. Grandeur Peak (from Millcreek Canyon) trail use, by part of day.

Thayne's Canyon/Desolation

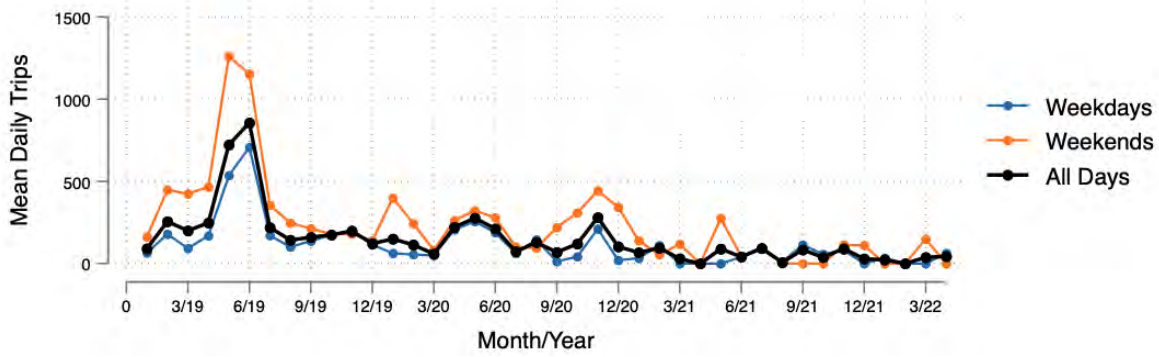

Figure C61. Thayne's Canyon/Desolation trail use, by type of day.

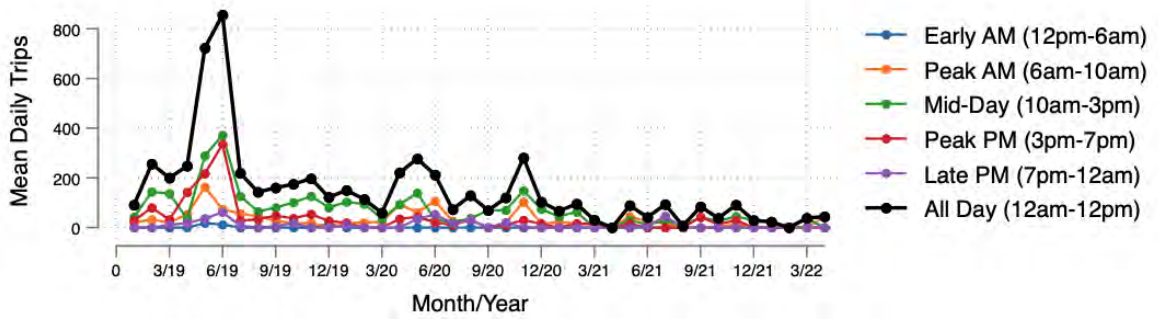

Figure C62. Thayne's Canyon/Desolation trail use, by part of day.

Pipeline (upper)

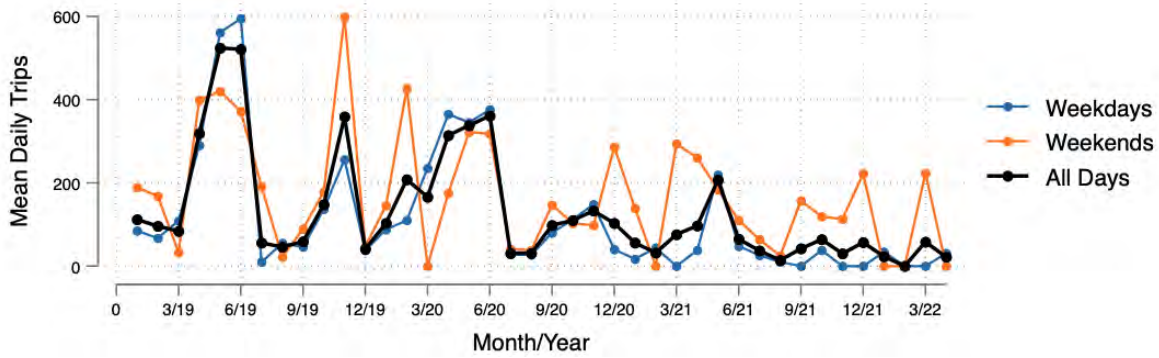

Figure C63. Pipeline (upper) trail use, by type of day.

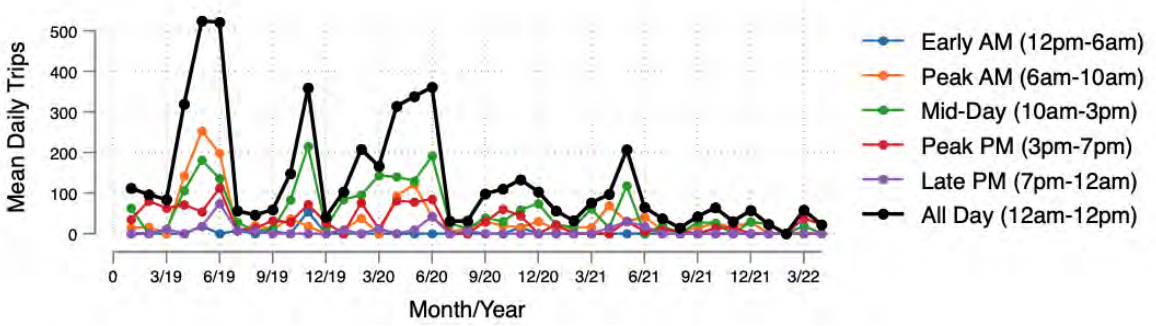

Figure C64. Pipeline (upper) trail use, by part of day.

Lamb's Canyon

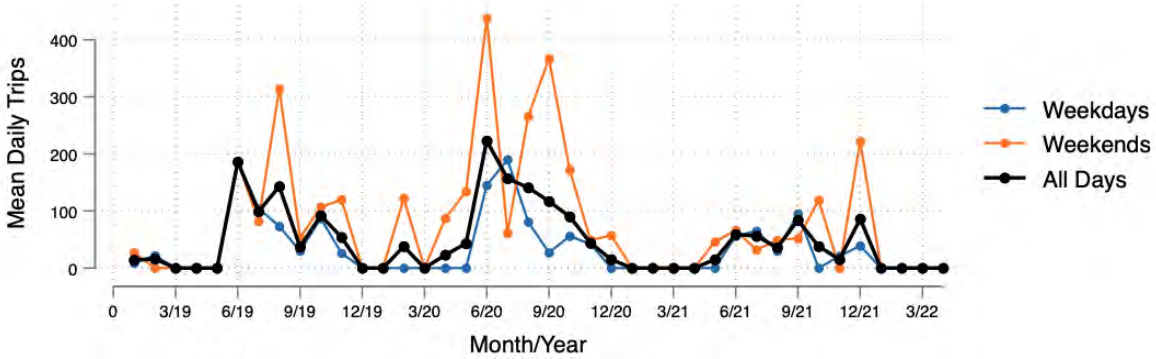

Figure C65. Lamb's Canyon (1) – *Parley's Canyon trailhead* trail use, by type of day.

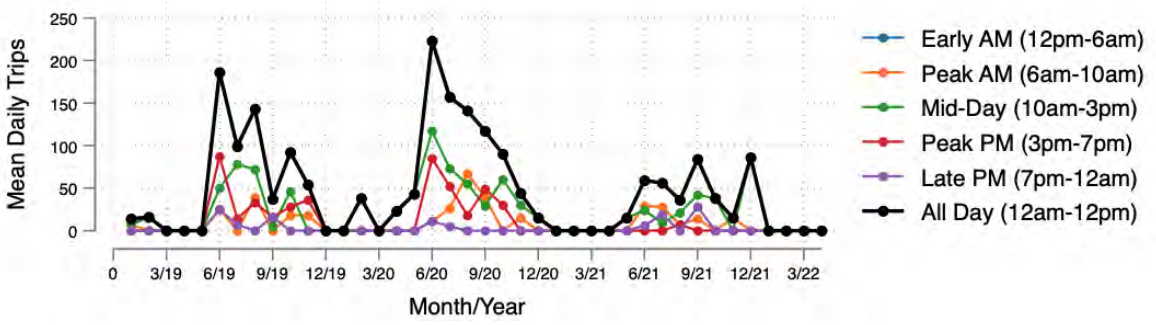

Figure C66. Lamb's Canyon (1) – *Parley's Canyon trailhead* trail use, by part of day.

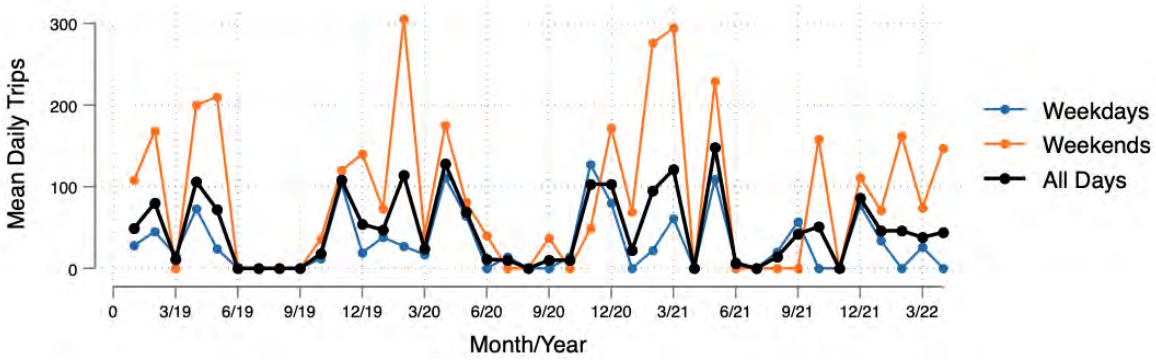

Figure C67. Lamb's Canyon (2) – *Millcreek Canyon side* trail use, by type of day.

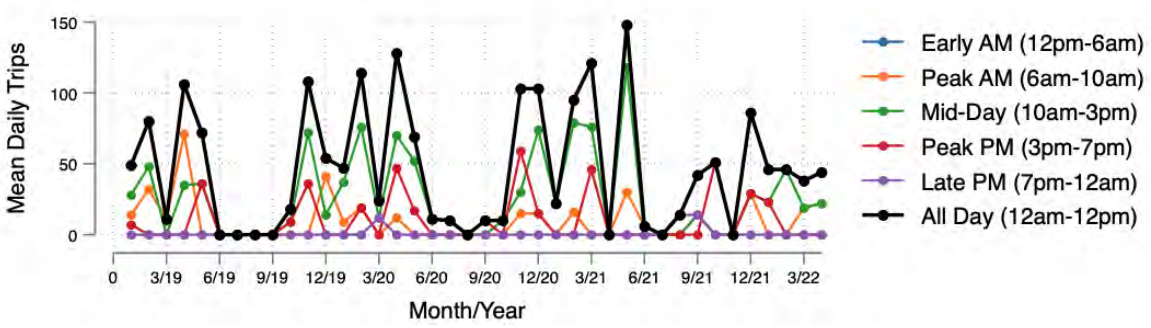

Figure C68. Lamb's Canyon (2) – *Millcreek Canyon side* trail use, by part of day.