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Natural Resource Stewardship and Science

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Natural Resource Report

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Abstract

In Rocky Mountain National Park, managers are concerned about informal trails resulting from off-trail travel in popular backcountry areas. The distribution of informal trails near water bodies raised questions for park managers about the potential impacts of different visitor activities, specifically hiking and angling use. This report examined the spatial behavior of hikers and anglers using GPS tracking and explored hiker experience preferences in relation to their spatial behavior. Anglers on average traveled farther and spent more time during their trip than hikers. Across all study locations, there was no difference in the amount of off-trail travel between hikers and anglers, however one location saw marked differences. Hikers with experiences preferences related to viewing scenic beauty and having an adventure were more likely to travel farther on trails whereas hikers with more varied experience preferences stayed closer to trailheads. With increasing park visitation likely bringing more diverse visitors, park managers need more resources to devote to exploring more diverse management actions.

Acknowledgments

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Introduction

Managers of national parks are often faced with trail systems that are busy with visitors participating in varied activities and have growing ecological impacts due to recreation. In Rocky Mountain National Park (ROMO) managers are concerned about informal (visitor-created) trails resulting from off-trail travel in popular backcountry areas. Informal trails form when visitors leave the formal, maintained trail system and explore new routes, resulting in trampled vegetation and compacted soils (Hammitt et al., 2015). ROMO managers have worked to better understand the condition and extent of informal trails in the Bear Lake region of the park and collaborated with researchers at Utah State University to map and assess these impacts. Results of these studies found that informal trails and related impacts were extensive and often near or leading to waterbodies (D'Antonio et al., 2013; Graham & Monz, 2019).

The distribution of informal trails near water bodies raised questions for park managers about the potential impacts of different visitor activities, specifically hiking and angling use. Because anglers need to leave the designated trails to fish and access the water, the concern is that they travel off-trail more than hikers and are subsequently creating more of the informal trails. Tracking the movements of visitors using GPS technology has become a relatively common way for researchers and park managers to understand how visitors are interacting with an area spatially and temporally (see Riungu et al., 2018). In fact, studies conducted at ROMO and Acadia National Park, GPS tracking has been used to estimate off-trail travel behavior of visitors (D'Antonio & Monz, 2016; Kidd et al., 2015).

Recent research has explored potential relationships between the spatial behavior of visitors and their experience preferences. Experience preferences can be thought of as reasons why someone chooses to engage in a particular activity, e.g. to view scenic beauty; to explore; etc. Beeco et al., (2013) found a relationship between travel style experience preferences and actual movement patterns of visitors driving on the Blue Ridge Parkway. Additionally Frey et al., (2018) and Sisneros-Kidd et al., (2021) found that multiple factors including experience preferences influenced visitor spatial behavior.

This report focuses on comparing the spatial behavior patterns of hikers and anglers in ROMO, specifically off-trail travel. In addition, this report explores how experience preferences may relate to spatial behavior on hiking trails.

Study Site

Rocky Mountain National Park (ROMO) is located in Colorado approximately 60 miles (100km) northwest of the capital, Denver. The land the park encompasses ranges in elevation from 6000ft to over 14,000 ft (1830-4270m) and includes a wide range of ecological communities from montane forests to alpine areas. Over 150 lakes can be found across these communities, some of which are a refuge for endangered species including the Colorado state fish, the Greenback cutthroat trout (*Oncorhynchus clarkii stomias*). Many lakes are accessible by trail and are popular destinations for both hikers and anglers. The Bear Lake Road corridor of ROMO is the most visited region of the park and contains multiple lakes connected by a network of trails (Figure 1). Three trailheads in the

Bear Lake Road corridor were chosen for survey administration because of their popularity and the sensitivity of the lakes they access. These trailheads are the Bear Lake, Fern Lake, and Glacier Gorge trailheads (Figure 2) and they can be accessed by both personal vehicles and the park shuttle. Both day hikers and anglers were included in the study because of their shared use of the same trails. Backcountry camping is uncommon in this region and due to GPS limitations, overnight users were excluded from the study.

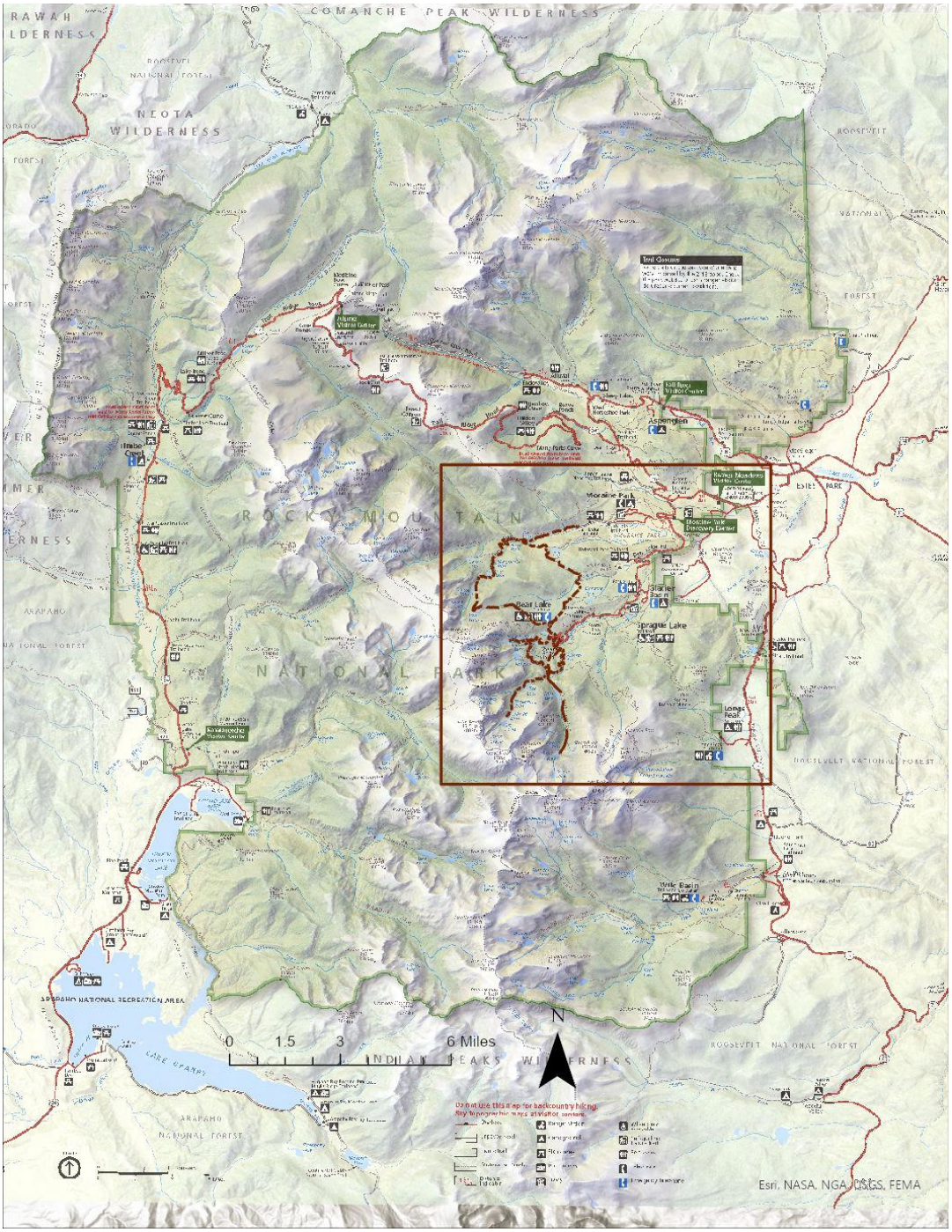

Figure 1. Location of trail of interest in Rocky Mountain National Park.

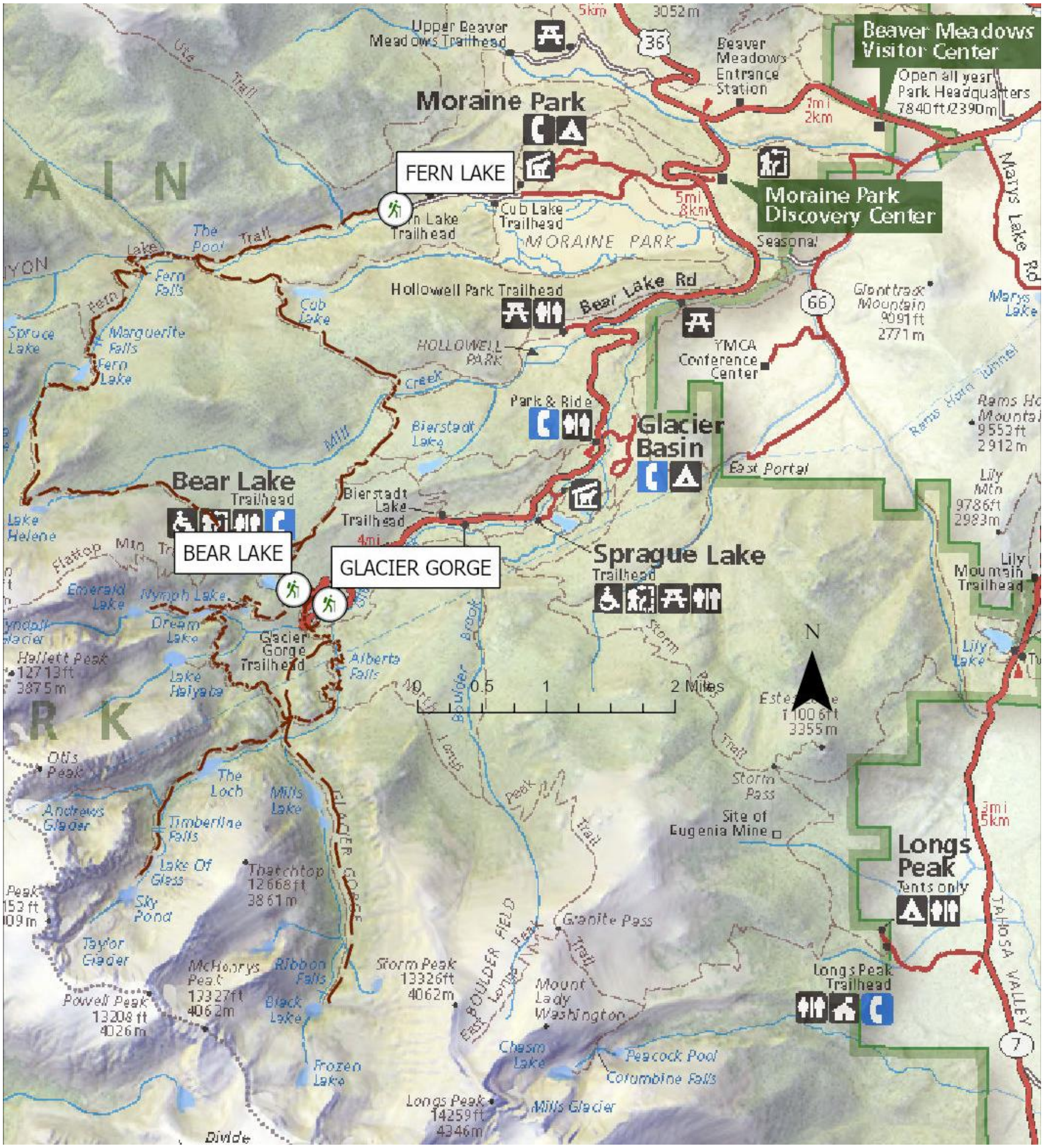

Figure 2. Study trailhead locations in Rocky Mountain National Park.

Methods

During July 2017, researchers from Utah State University collected data on hikers and anglers at the Fern Lake, Glacier Gorge, and Bear Lake trailheads (Figure 2). Trail users were invited to participate in the study which involved carrying a GPS unit during their trip that day and completing a post-experience survey upon their return (D'Antonio et al., 2013). Visitor groups (of 1 person or more) were intercepted according to a stratified random sampling plan designed to randomly select visitors as they arrived across the sampling period. Sampling periods consisted of a 6-hour block stratified by mornings and afternoons, weekdays and weekends which were sampled equally resulting in 8 sampling periods. Morning sampling periods were from 7am to 1pm and afternoon sampling periods spanned the hours of 1pm to 6pm. The duration of sampling across the day was chosen to align with the park's shuttle schedule. If the visitor group had more than one person, only one visitor who was 18 years of age or older per group was eligible to participate in the survey and was chosen randomly to minimize volunteer bias (Montello & Sutton, 2013). For visitors who declined to participate, a brief series of questions was asked to assess non-response bias.

GPS Tracking

Visitors who agreed to participate in the study were given a Garmin eTrex10 GPS unit which a researcher would clip to a backpack or clothing. GPS units were programmed to record location every 5 seconds. The participants would then embark on their trip for the day and upon their return to the trailhead, they would exchange their GPS unit for a survey questionnaire. Participants who returned to the trailhead after researchers had gone placed their GPS unit in a designated, locked drop box and did not respond to the questionnaire. Each GPS track was saved with a unique code used to maintain participant anonymity and pair the GPS data with the survey responses if applicable.

Survey

Visitors who returned their GPS units to researchers were invited to participate in the post-experience survey designed for their chosen activity. Visitors who had visible fishing gear (such as poles, waders, or nets) were identified as anglers and given the angler version of the survey instrument. Visitors without specialized equipment were identified as hikers and provided with the hiker version of the survey. The two survey instruments were largely identical though anglers were asked additional questions specific to fishing. Both versions of the survey consisted of pre-approved questions by the Office of Management and Budget (*Programmatic Clearance for NPS-Sponsored Public Surveys Pool of Known Questions*, 2015). The survey was self-administered via tablet, though paper and verbal versions were also available. All mediums provided the survey instrument in English. A full report of survey responses can be found in *Post-experience Survey of Backcountry Anglers and Hikers in Rocky Mountain National Park* (Graham et al., In progress).

This report focuses on one section of the survey questionnaire which asked participants to rate the importance of a list of recreation related experience items. Hikers rated 14 items and anglers rated the same 14 items plus 7 additional fishing related items. Each item was rated on a scale from 1 being "Not at all important" to 5 being "Extremely important." The experience items were known to be related to 5 experience groups: Connecting with nature, having an adventure, viewing scenic beauty,

experiencing solitude, and enhancing personal relationships. The fishing related experience items were known to be related to 2 fishing experience groups: achieving catch goals and having an enjoyable fishing experience. The experience items and related experience groups were sourced from the *Programmatic Clearance for NPS-Sponsored Public Surveys Pool of Known Questions* (2015).

Analysis

Initial error checks were performed on the GPS tracks to remove errant points using Microsoft Excel. Track speeds were calculated from the distance traveled between data points and time elapsed. If speeds were faster than someone would be typically walking or jogging (>6mph) then the corresponding data points were removed. GPS tracks were then cleaned in ArcGIS v10.5 (Esri Inc., 2017) to remove excess points that GPS units were collecting at trailheads either before they were handed out or after they were returned. After cleaning, GPS point time stamps were used to calculate time-spent for each track using ArcGIS Pro v2.7 (Esri Inc., 2021). Also, GPS point data was converted to lines and the length calculated to determine distance traveled for each track. Time-spent and distances traveled were compared in SPSS v27 (IBM, 2020).

While on-site, researchers would carry a GPS unit along the centerline of each trail to log a calibration track where all points were known to be on-trail. Using ArcGIS Pro the average distance the calibration points were from a sub-meter accuracy GPS tracked trail line was calculated and resulted in a 10m wide buffer around the trail that acted as the threshold for on-trail vs off-trail tracks. Because sub-meter accuracy trail data was available only up to the Loch and Mills Lake, tracks beyond those locations were excluded from the off-trail analyses. Using the calculated threshold, the proportion of GPS points that were off-trail was calculated in ArcGIS Pro and the differences in off-trail proportions were analyzed in SPSS. The distance each off-trail point was from the trail buffer was calculated using the Euclidean Distance and Zonal Statistics tools in ArcGIS Pro. SPSS was used to compare the average distances of off-trail points. The density distribution maps of off-trail tracks were created by the Kernel Density tool in ArcGIS Pro.

Survey responses were recorded using the Qualtrics mobile application survey platform (Qualtrics Labs, Inc., 2017) accessed via tablet. Though visitors were not required to answer every question, responses from visitors who agreed to participate, but then declined before they had finished the survey were considered incomplete and removed prior to analysis. Because of the small number of anglers in the study, only the hiker responses were analyzed in this report. Rather than use the predetermined experience groups, hiker responses were analyzed to discover unique experience groups based on the data. The analysis of hiker responses was performed in SPSS where principal components factor analysis used the experience item ratings from all respondents to determine how experience items would group together. Experience items with similar ratings were grouped together into factors. The degree to which an experience item is correlated with each factor is quantified by its factor loading value. Items that had factor loading values lower than 0.4 were considered to not be strongly correlated with that factor and were excluded from the results for legibility. Once the experience items were grouped into factors, each respondent was assigned a score for each factor based on their experience item ratings within that group.

Respondents' factor scores were merged with their GPS tracks. In ArcGIS Pro a multivariate cluster analysis was used to spatially group GPS tracks into clusters with similar factor scores. The GPS track clusters were spatially joined with a grid to visually display the cluster groups.

Results

The total number of GPS tracks obtained from hikers was 45, and the number of GPS tracks for anglers was 28. The number of GPS tracks that had associated survey responses was 45 for hikers and 18 for anglers, which resulted from some anglers returning to the trailhead after researchers had left the site for the day and therefore not being able to complete the survey.

GPS Tracking

Anglers walked significantly farther distances overall compared to hikers ($p<.001$). Anglers walked 8937 meters (5.6 miles) on average and hikers walked 5509 meters (3.4 miles) on average (Table 1). Hikers walked approximately the same distance on each trail, no significant differences were found in the mean distance traveled by hikers on the Bear Lake, Fern Lake or Glacier Gorge trails (Table 2). Anglers traveled significantly farther on the Fern Lake trail (12753 meters, 7.9 miles) compared to the Bear Lake (5544 meters, 3.4 miles) and Glacier Gorge trails (8160 meters, 5.1 miles) (Table 2). The distances anglers traveled on the Bear Lake and Glacier Gorge trails were not significantly different.

Table 1. T-test showing significant differences between hiker and angler distances traveled.

Independent samples T-test	Hiker (n=45)	Angler (n=28)	T-stat (DF)	P value
Overall mean distance traveled in meters (SE mean)	5509.47 (572.85)	8936.86 (835.16)	3.497 (71)	<.001

Equal variances assumed

Table 2. One-way ANOVA showing hiker and angler distance traveled by trailhead location.

One-way ANOVA	Bear Lake trailhead (Hiker n=19, Angler n=11)	Fern Lake trailhead (Hiker n=10, Angler n=11)	Glacier Gorge trailhead (Hiker n=16, Angler n=6)	F-stat (DF)	P value
Hiker mean distance traveled in meters (SE mean)	5475.03 (685.55)	6005.29 (1130.55)	5240.48 (1242.22)	.118 (2)	.889
Angler mean distance traveled in meters (SE mean)	5544.19 (764.34)[a]	12753.13 (1090.79)[b]	8160.25 (1179.41)[a]	15.326 (2)	<.001

Note: Means followed by the same superscript letter are not significantly different at alpha 0.05 using LSD multiple comparison procedure.

On average, hikers spent significantly less time on their trip than anglers ($p<.0001$). Hikers spent approximately 2 hours and 30 minutes, while anglers spent nearly double that time (4 hours and 30 minutes) (Table 3). Hikers also spent approximately the same amount of time on each trail, ranging from 2 hours and 8 minutes on the Fern Lake trail to 2 hours and 45 minutes on the Bear Lake trail

(Table 4). Anglers spent significantly different amounts of time (p<.0001) on the trails. The 6 hours and 27 minutes anglers spent on the Fern Lake trail was significantly more than the 2 hours and 39 minutes spent on the Bear Lake trail, but not different from the 4 hours and 22 minutes spent on the Glacier Gorge trail. The time spent on the Bear Lake and Glacier Gorge trails by anglers was not significantly different from each other (Table 4).

Table 3. T-test showing significant differences between time spent by hikers and anglers.

Independent samples T-test	Hiker (n=45)	Angler (n=28)	T-stat (DF)	P value
Overall mean time spent (SE mean)	2:28:26 (0:15:17)	4:30:52 (0:27:33)	3.883	<.0001

Equal variances not assumed Levenes' test f=7.3 p=.009

Table 4. One-way ANOVA showing time spent by hikers and anglers by trailhead location.

One-way ANOVA	Bear Lake trailhead (Hiker n=19, Angler n=11)	Fern Lake trailhead (Hiker n=10, Angler n=11)	Glacier Gorge trailhead (Hiker n=16, Angler n=6)	F-stat (DF)	P value
Hiker mean time spent (SE mean)	2:45:15 (0:22:59)	2:08:07 (0:23:35)	2:21:10 (0:30:24)	.480 (2)	.622
Angler mean time spent (SE mean)	2:39:14 (0:27:20)[a]	6:27:15 (0:32:07)[bc]	4:22:09 (0:55:25)[ac]	12.436 (2)	<.0001

Note: Means followed by the same superscript letter are not significantly different at alpha 0.05 using Games-Howell multiple comparison procedure.

Off-trail Travel

Overall, there was no difference (p>.05) in proportion of off-trail tracks between hikers and anglers (Table 5). On average hikers were off-trail 23% (.227) of the time and anglers were off-trail 31% (.307) of the time (Table 5). Both hikers and anglers had trail-to-trail differences in proportion of off-trail tracks. Hikers traveled off-trail significantly less (p<.05) on the Fern Lake trail than the other two trails (Table 6). Hikers were off-trail approximately 7% (.068) of the time on average on the Fern Lake trail while they traveled off-trail 26-28% of the time on the Glacier Gorge and Bear Lake trails (Table 6). The proportion of off-trail tracks for anglers was significantly less (p<.05) on the Bear Lake trail compared to the Fern Lake trail (Table 6). On average anglers traveled off-trail 18% of the time on the Bear Lake trail and 44% of the time on the Fern Lake trail. The proportion of off-trail tracks for anglers on the Glacier Gorge trail was not significantly different from either of the other trails.

Table 5. T-test showing no differences between proportion of off-trail tracks of hikers and anglers overall.

Independent samples T-test	Hiker (n=45)	Angler (n=28)	T-stat (DF)	P value
Overall mean proportion of off-trail tracks (SE mean)	0.227(.026)	.307(.042)	-1.726(71)	.110

Note: Equal variances not assumed Levene's test f=4.117, p=.046

Table 6. ANOVA showing proportion of off-trail tracks of hikers and anglers between trailhead locations.

One-way ANOVA	Bear Lake trailhead (Hiker n=19, Angler n=11)	Fern Lake trailhead (Hiker n=10, Angler n=11)	Glacier Gorge trailhead (Hiker n=16, Angler n=6)	F-stat (DF)	P value
Hiker mean proportion of off-trail tracks (SE mean)	.280(.040)[a]	.068(.023)[b]	.261(.040)[a]	6.848(2)	.003
Angler mean proportion of off-trail tracks (SE mean)	.180(.021)[a]	.440(.080)[b]	.296(.085)[ab]	4.761(2)	.018

Note: Means followed by the same superscript letter are not significantly different at alpha 0.05 using Games-Howell multiple comparison procedure.

The distance that hikers and anglers traveled off-trail differed significantly ($p<.0001$) where hikers traveled approximately 22m off-trail and anglers were approximately 41m off-trail on average (Table 7). The distance hikers traveled off-trail differed significantly between trailhead locations ($p<.001$) (Table 8). Hikers traveled 23m away from the Bear Lake trail on average and approximately 18m away from the Fern Lake and Glacier Gorge trails. The distance anglers traveled away from trails also differed significantly by location ($p<.0001$). Anglers traveled approximately 14m away from the Bear Lake trail, 21m away from the Glacier Gorge trail, and 61m away from the Fern Lake trail on average (Table 8).

Table 7. T-test showing average distance hikers and anglers traveled off-trail.

Independent samples T-test	Hiker (n=9641)	Angler (n=14110)	T-stat (DF)	P value
Average Euclidian distance away from trail in meters (SE mean)	21.5 (.238)	40.8 (.422)	39.9 (21356)	<.0001

Equal variances not assumed, Levene's test f=3866, p=0.00.

Table 8. ANOVA showing average distance traveled off-trail by hikers and anglers between trailhead locations.

One-way ANOVA	Bear Lake trailhead (Hiker n=7339, Angler n=1378)	Fern Lake trailhead (Hiker n=471, Angler n=7262)	Glacier Gorge trailhead (Hiker n=1831, Angler n=5470)	F-stat (DF)	P value
Hiker average Euclidian distance away from trail in meters (SE mean)	22.5 (.283)[a]	18.0 (.977)[b]	18.1 (.463)[b]	31.3 (2)	<.001
Angler average Euclidian distance away from trail in meters (SE mean)	13.5 (.430)[a]	61.0 (.723)[b]	20.9 (.213)[c]	1485 (2)	<.0001

Note: Means followed by the same superscript letter are not significantly different at alpha 0.05 using Games-Howell multiple comparison procedure.

The distribution of where hikers and anglers went off-trail are shown by the density of off-trail tracks in Figures 3 and 4. Higher densities of off-trail points are shown in red and lower densities are shown in yellow. Higher densities of off-trail tracks for hikers are seen at the three lakes (Nymph, Dream, Emerald) from the Bear Lake trailhead, the Alberta Falls area and the Loch from the Glacier Gorge trail. Medium off-trail densities occur around Mills Lake and Lake Haiyaha. Relatively low off-trail densities were seen on the Fern Lake trail (Figure 3).

Angler off-trail track density was relatively less than hikers generally as seen by the predominance of yellow and orange colors in Figure 4 rather than orange and red in Figure 3. The higher density off-trail areas for anglers were the Loch and Mills and Jewel Lakes from the Glacier Gorge trail. The density of off-trail tracks on the Bear Lake trail was relatively low for anglers. There were several locations of medium densities of off-trail angler tracks on the Fern Lake trail. The medium density areas are focused around Fern, Spruce and Loomis Lakes, as well as near the trailhead (Figure 4).

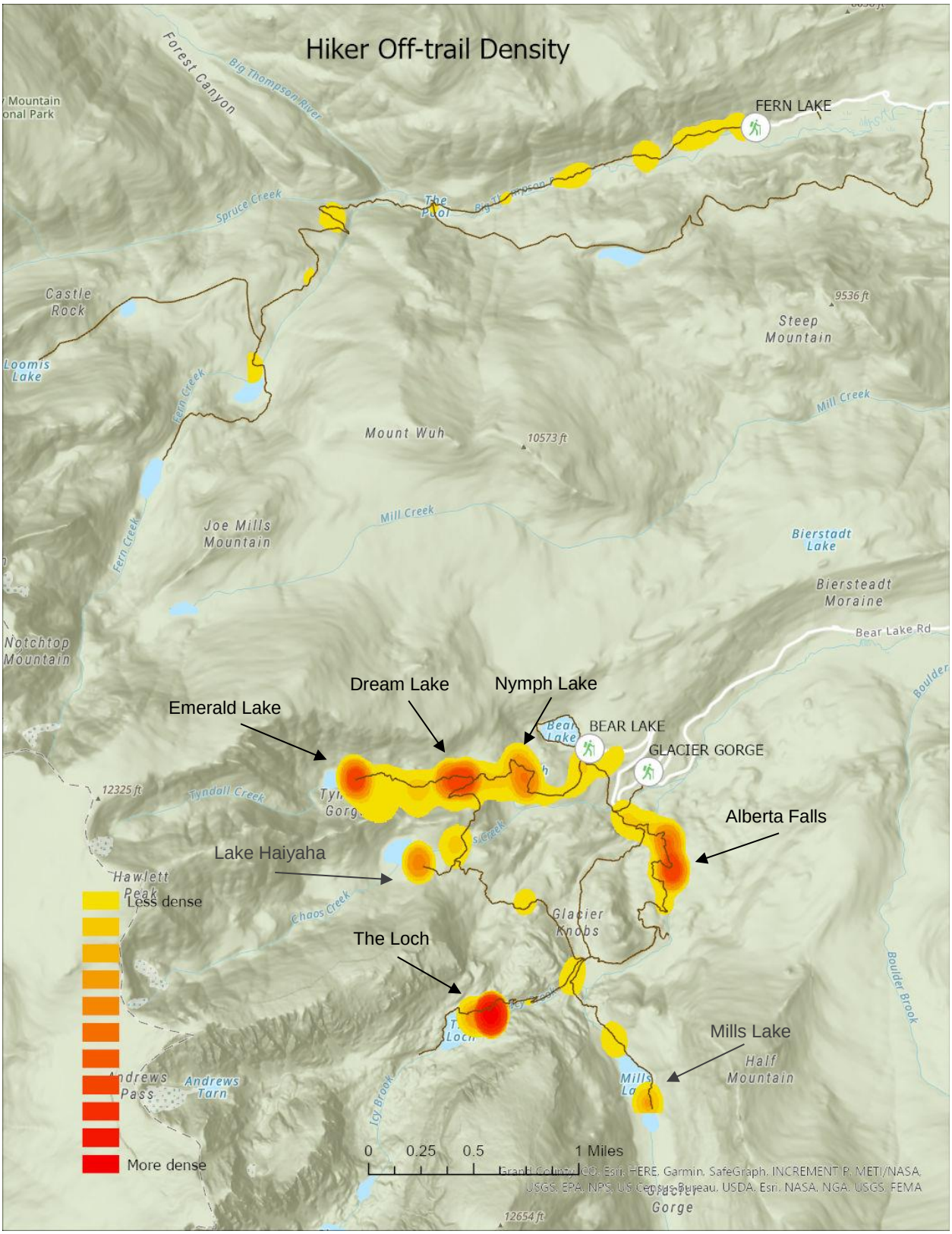

Figure 3. Density of hiker off-trail travel.

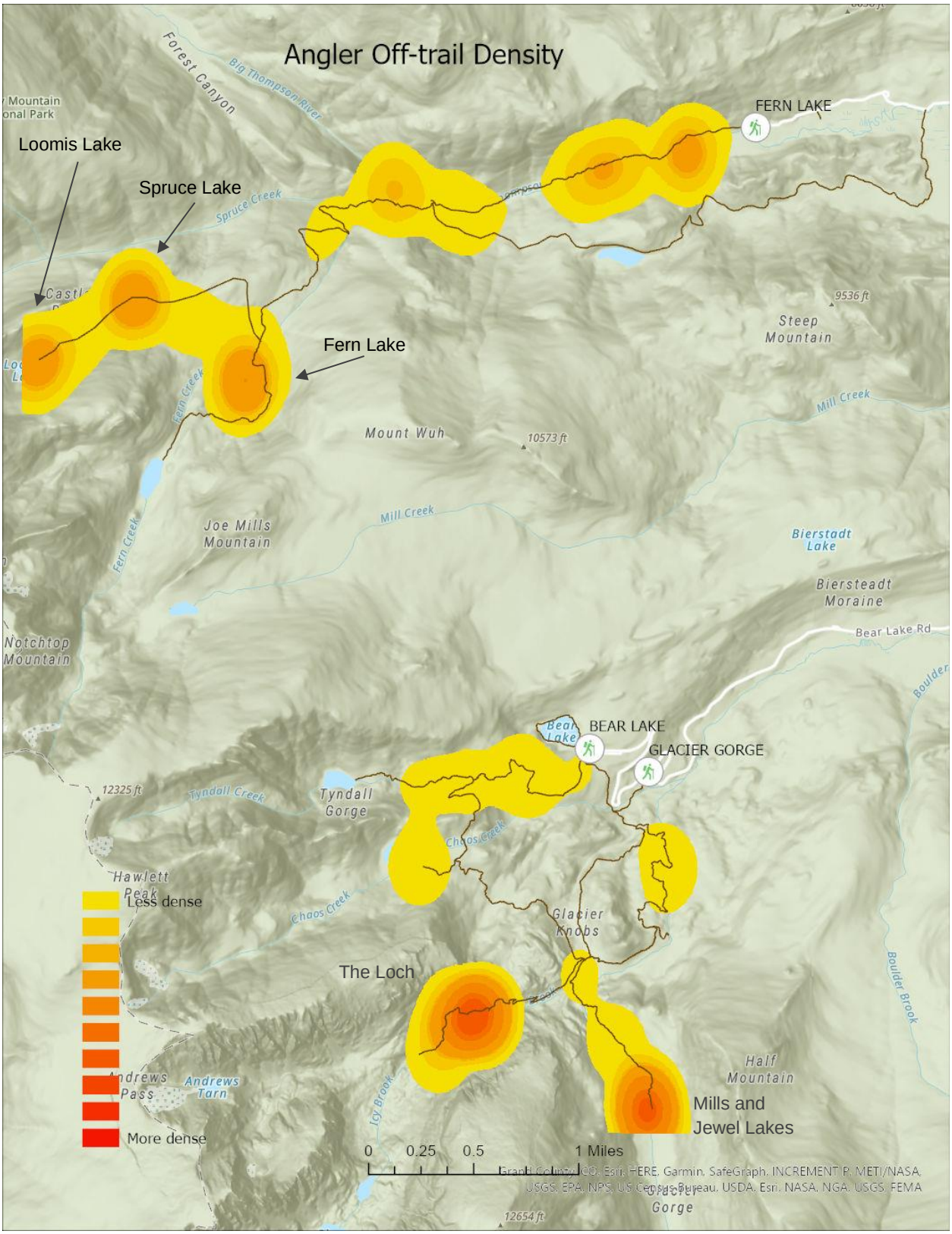

Figure 4. Density of angler off-trail travel.

Experience Preferences

Hiker experience ratings were found to compose four experience groups or factors (Table 9). Factor 1 contains experience items such having an adventure and viewing lakes and streams and the factor is therefore referred to as Viewing scenic beauty/Having an adventure. Factor 2 contains experience items such as being alone and being away from crowds and is therefore named Experiencing solitude. Factor 3 contains experience items such as family recreation and share this place with family and friends and is named Enhancing personal relationships. Factor 4 contains experience items such as experiencing a sense of connection with nature and is named Connecting with nature.

Table 9. Amount to which each experience scale item corresponds to each factor via factor loading values.

	Factor Loading Values			
Experience Scale Item	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
View mountains	0.777			
Experience excitement	0.773			
Have an adventure	0.753			
Be in a beautiful place	0.702			0.445
View lakes and streams	0.547			
Experience new and different things	0.519		0.420	
Be alone		0.854		
Experience solitude		0.849		
Be away from crowds of people		0.718		
Share this place with family and friends			0.795	
Family recreation			0.720	
Foster a connection with others in your group			0.589	0.513
Be outdoors				0.769
Experience a sense of connection with nature				0.654

Note: Kaiser-Meyer-Olkin measure of sampling adequacy = .745. Factor loading values less than 0.4 were suppressed to aid visualization and interpretation. Extraction method: Principal Component Analysis. Rotation method: Varimax with Kaiser Normalization. Rotation converged in 9 iterations.

The multivariate cluster analysis conducted on each respondents' factor scores and GPS tracks resulted two clusters, a Viewing scenic beauty/Having an adventure cluster and an Enhancing personal relationships cluster. Figures 5 and 6 show where these clusters occur spatially. Closer to the trailheads, the clusters are mixed and shown by the green colors. Farther from the trailheads, only the Viewing scenic beaty/Having an adventure cluster occurs and is shown in dark blue.

Figures 5 and 6 also show the clusters in relation to the off-trail track density. There does not appear to be much of a correlation between the experience clusters and high density of off-trail tracks.

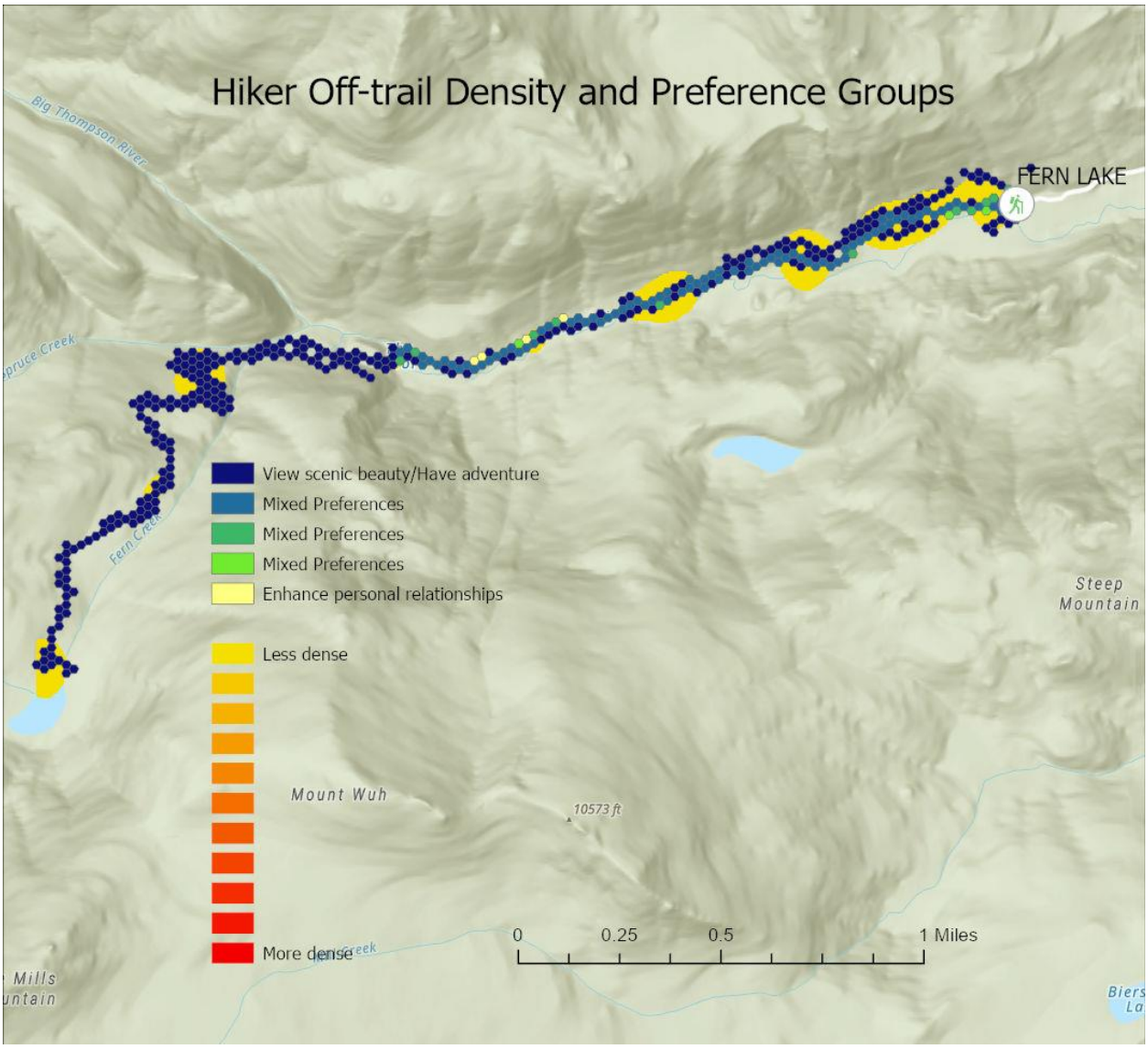

Figure 5. Hiker experience preference clusters and off-trail travel density at Fern Lake trail.

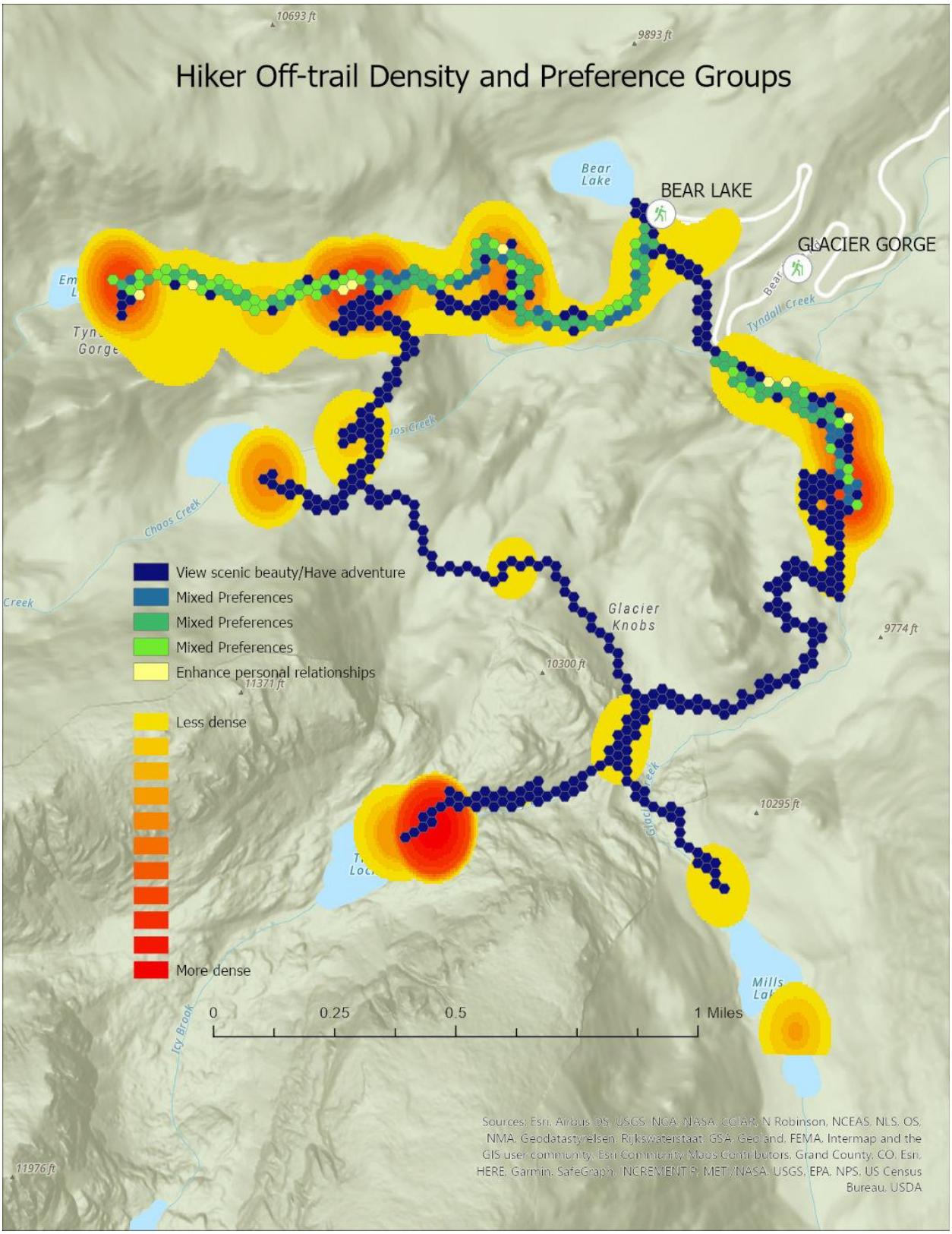

Figure 6. Hiker experience preference clusters and off-trail travel density at Bear Lake and Glacier Gorge trails.

Discussion

The proportion of off-trail tracks was drastically different on the Fern Lake trail between hikers and anglers. Anglers traveled off-trail nearly 45% of the time while hikers traveled off-trail around 7% of the time. Additionally, anglers were found to travel off-trail about three times farther compared to hikers. Comparatively, park-wide, the volume of hikers far surpasses the number of anglers where in ROMO 8% of visitors reported participating in fishing, while nearly 60% of visitors reported hiking (Blotkamp et al., 2011). Though it is not known how this proportion of hikers to anglers holds up on the Fern Lake trail, the amount to which anglers are traveling off-trail there still suggests that anglers may be creating more of the off-trail impacts that were mapped in 2016 (Graham & Monz, 2019).

The distribution of off-trail track density shows that both hikers and anglers had higher densities of off-trail tracks around the Loch. Interestingly, anglers had similar off-trail track density around the Loch and Mills Lake, but hikers had much lower densities at Mills Lake compared to the Loch. Both lakes are just over 2.5 miles from the Glacier Gorge trailhead and are known as popular day hiking destinations. If it is assumed that anglers are traveling off-trail at the Loch and Mills Lake to go fishing, then it seems that hikers may be engaging in different activities at the Loch compared to Mills Lake. On-site observations at both the Loch and Mills Lake may illuminate potential differences in visitor behavior. In fact, the Interagency Visitor Use Management Council recommends understanding how visitors are specifically using an area before engaging in management actions so the root of the issue can be addressed (*Visitor Capacity Guidebook, Managing the Amounts and Types of Visitor Use*, 2019).

The off-trail density distribution (Figure 4) also shows that anglers were traveling off-trail at Fern Lake, Spruce Lake, and Loomis Lake. This pattern of behavior differed from what researchers were expecting. Visitors were expected to travel beyond Fern Lake to Odessa Lake rather than Spruce and Loomis Lakes. All three lakes are open to catch-and-release fishing and Odessa Lake is a shorter hike. The pattern of angler off-trail travel at Spruce Lake may be a concern for park managers because the east & southeast portions of the lake & adjacent wetlands are closed to visitor access to protect habitat for the closely monitored boreal toad (*Bufo boreas boreas*) (National Park Service, 2016).

Though this study did not venture to predict off-trail behavior from visitor experience preferences and Sisneros-Kidd et al., (2021) describe the complexities and challenges around doing so, some potential relationships between off-trail track density and visitor experience preferences can be explored. In Figures 5 and 6, the dark blue areas are farther from the trailheads which suggests two things; first, that hikers who travel farther on these trails have more homogeneous experience preferences, second, hikers who travel farther on trails are more likely to prefer the experience of Viewing scenic beauty/Having an adventure. Conversely, the green colors in Figures 5 and 6 show that hikers that stay closer to trailhead have more diverse experience preferences. A similar pattern was seen in a study of visitors to the Florida National Scenic Trail. The study found that visitors who chose to recreate at the wildland-urban interface, closer to the neighborhoods, had experience preferences, setting preferences, and place meaning that differed from visitors who chose to recreate

farther into the wildland portion of the trail, farther away from the neighborhoods (Kil et al., 2014). Specifically, wildland visitors were more likely to prefer risk-taking which seems to fit with the hikers who traveled farther on trails in ROMO being more likely to prefer having an adventure.

The 'mixed preferences' zones overlap with routes to popular destinations including The Pool along the Fern Lake trail, and Alberta Falls on the Glacier Gorge trail and the Emerald Lake trail from the Bear Lake trailhead. This diversity in visitors who go to popular destinations that are near trailheads may become even more diverse as overall visitation to the park increases. Participants in outdoor recreation generally have become more diverse over the last decade (*2020 Outdoor Participation Report*, 2020) and visitation to ROMO has increased by 1 million visits between 2014 and 2019 – 2020 visitation was lower due to Covid-19 related closures (*NPS Stats*, 2021). Increasing visitor diversity has been a goal for the National Park Service – through the Find Your Park campaign – though it appears that visitors with diverse preferences are relatively spatially confined in ROMO in a relatively predictable way.

Conclusions and Recommendations

Understanding the similarities and differences in on-site visitor behavior at these seemingly similar destinations may well be essential to effective management. For example, visitors may be traveling off-trail more at the Loch because they are trying to take photos that don't have any other visitors visible, but at Mills Lake visitors may not be looking for photo opportunities. In this case, park managers may want to employ a messaging campaign aimed at educating visitors on how to appropriately wait their turn to take photos. However, if visitors are found to be exploring for photoshoots at both locations the same messaging may not be effective at preventing off-trail impacts.

Managing increasing volumes and increasingly diverse hikers will likely need a suite of tools, and this study provides a starting point where park managers can test new and diverse management actions focused around destinations close to trailheads, such as messaging on-site, online, or on park maps and pamphlets. In fact, the questionnaire administered to hikers and anglers in this study also asked about where they gathered information about the park. The *Post-experience Survey of Backcountry Anglers and Hikers in Rocky Mountain National Park* (Graham et al., In progress) reports that hikers primarily used ROMO maps and pamphlets, which may be effective communication tools to encourage visitor behavior changes.

As parks continue to grapple with the effects of the Covid-19 pandemic as well as continued visitation demand and related impacts, more resources are already needed for effective visitor management, specifically to diversify the content and methods of messaging, education, and interpretation.

Literature Cited

2020 Outdoor Participation Report. (2020). Outdoor Foundation. https://outdoorindustry.org/resource/2020-outdoor-participation-report/

Beeco, J. A., Huang, W.-J., Hallo, J. C., Norman, W. C., McGehee, N. G., McGee, J., & Goetcheus, C. (2013). GPS Tracking of Travel Routes of Wanderers and Planners. *Tourism Geographies*, *15*(3), 551–573. https://doi.org/10.1080/14616688.2012.726267

D'Antonio, A., & Monz, C. (2016). The influence of visitor use levels on visitor spatial behavior in off-trail areas of dispersed recreation use. *Journal of Environmental Management*, *170*, 79–87. https://doi.org/10.1016/j.jenvman.2016.01.011

D'Antonio, A., Monz, C., Newman, P., Lawson, S., & Taff, D. (2013). Enhancing the utility of visitor impact assessment in parks and protected areas: A combined social–ecological approach. *Journal of Environmental Management*, *124*, 72–81. https://doi.org/10.1016/j.jenvman.2013.03.036

Esri Inc. (2017). *ArcGIS Desktop* (10.4) [Computer software].

Esri Inc. (2021). *ArcGIS Pro* (2.7) [Computer software].

Frey, E., Demps, K., Pauli, B., & Heath, J. A. (2018). Group Characteristics Influence Distribution Patterns of Off-Road Vehicle Recreation within a Complex Trail System in Southwest Idaho. *Leisure Sciences*, *40*(3), 131–150. https://doi.org/10.1080/01490400.2017.1408510

Graham, R., Miller, A., & Monz, C. (In progress). *Post-experience survey of backcountry hikers and anglers in Rocky Mountian National Park* [Natural Resource Report].

Graham, R., & Monz, C. (2019). *An assessment of informal trails and sites in riparian areas in Rocky Mountain National Park* [Project Summary].

Hammitt, W., E., Cole, D., N., & Monz, C., A. (2015). *Wildland Recreation: Ecology and Management* (3rd ed.). John Wiley & Sons, Inc.

IBM. (2020). *Statistical Package for the Social Sciences* (Version 27) [Computer software].

Kidd, A. M., Monz, C., D'Antonio, A., Manning, R. E., Reigner, N., Goonan, K. A., & Jacobi, C. (2015). The effect of minimum impact education on visitor spatial behavior in parks and protected areas: An experimental investigation using GPS-based tracking. *Journal of Environmental Management*, *162*, 53–62. https://doi.org/10.1016/j.jenvman.2015.07.007

Kil, N., Stein, T. V., & Holland, S. M. (2014). Influences of wildland-urban interface and wildland hiking areas on experiential recreation outcomes and environmental setting preferences. *Landscape and Urban Planning*, *127*, 1–12.

Montello, D. R., & Sutton, P. C. (2013). *An Introduction to Scientific Research Methods in Geography and Environmental Studies* (2nd ed.). Sage.

National Park Service. (2016). *Fishing*. https://www.nps.gov/romo/planyourvisit/fishing.htm

NPS Stats. (2021). National Park Service Visitor Use Statistics. https://irma.nps.gov/Stats/

Programmatic Clearance for NPS-Sponsored Public Surveys Pool of Known Questions. (2015). National Park Service Social Science Program. https://www.nps.gov/subjects/socialscience/programmaticclearance.htm

Qualtrics Labs, Inc. (2017). *Qualtrics Surveys*.

Riungu, G. K., Peterson, B. A., Beeco, J. A., & Brown, G. (2018). Understanding visitors' spatial behavior: A review of spatial applications in parks. *Tourism Geographies*, *20*(5), 833–857. https://doi.org/10.1080/14616688.2018.1519720

Sisneros-Kidd, A. M., D'Antonio, A., Monz, C., & Mitrovich, M. (2021). Improving understanding and management of the complex relationship between visitor motivations and spatial behaviors in parks and protected areas. *Journal of Environmental Management*, *280*, 111841. https://doi.org/10.1016/j.jenvman.2020.111841

Visitor Capacity Guidebook, Managing the Amounts and Types of Visitor Use. (2019). https://visitorusemanagement.nps.gov/

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