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Determining the Relative Annual Mountain Climbing Frequency on Colorado's 14,000-foot Peaks

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The signature of Colorado's Rocky Mountains are the 58 named mountain peaks that exceed an elevation of 14,000 feet (4267 m), referred to as the "Fourteeners." For decades, 53 or 54 peaks were widely accepted as

Fourteeners, but all US Geological Survey-named, recognized, and frequented Fourteeners are included here to bring the total to 58. This article documents factors that affect mountain climbing in Colorado, USA, and discusses the potential for adverse environmental impacts from the increasing number of climbers visiting the Fourteeners, presumably from the

adjacent major population center of the Denver, CO, metropolitan area. The first goal was to determine from summit registers the amount of climbers (Fourteener-visits) on any given 14,000-foot peak by month and by year. The second goal identified distance and accessibility factors that have a significant effect on relative annual mountain climbing frequency. Findings provide important insights on identifying potential preservation needs and tourism management within heavily visited rural mountain environments.

Keywords: Climbing; Colorado Rocky Mountains; Fourteener-visits; mountain tourism; peakbaggers; United States.

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Introduction

The Colorado Rocky Mountains are part of the North American backbone, stretching 5000 km from Alaska through western Canada, the United States, and northern Mexico. Colorado, USA's impressive uplift showcases 58 peaks over 14,000 feet (4267 m), or "Fourteeners," as referred to by climbers. Fourteeners in the Rocky Mountain State are now visited by an estimated 500,000 people annually (Kenworthy 2001; Roach 2004; Borneman and Caudle 2005; CFI 2008). Whereas some of the more remote peaks appear flawless and pristine (Figure 1), increased recreational use has critically impacted many peaks and alpine basins.

Population growth, contributing to sheer numbers of climbers, is the common explanation for the increased visitation to the Fourteeners. From the population, a specific type of person is progressively becoming an adventure seeker and thus the driving force behind the rising visits to the mountains. This phenomenon has transformed what had been primarily the domain of the early mountaineer looking for a technical climbing challenge to the playground of the "peakbagger" (Borneman and Lampert 1998; Blake 1999, 2002). Peakbagging implies that the mountains are collectibles, with climbers and hikers devoted to completing all of the peaks (technical or nontechnical) in a meticulous, scripted fashion. Most peakbaggers are nature-loving enthusiasts, people looking for a way to enter the mountains, escaping

the city and suburbs. Fourteener popularity continues to soar, pushing hikers of all levels of experience into the danger zone above the magical 14,000-foot (4267 m) elevation (Blake 2002) and into potentially unsustainable trail and route degradation. Consequently, effective ways of managing these peaks and their pristine wilderness areas can be formulated in the most efficient manner if visitation is properly assessed and understood.

Human–environmental interactions on Colorado Fourteeners

The first objective of this article focuses on determining the relative annual mountain climbing frequency (RAMCF) of the highest peaks in Colorado. As the 58 Fourteeners within the mountains of Colorado are continually pressured by climber-visits each year, logic assumes most of the visitors are coming from the nearby population centered in the Denver metropolitan region. But why are there so many people venturing into Colorado's high country for a hike or climb to any of the highest summits? Distance from a mountain to higher concentrations of people could be a significant factor. Thus, the second objective of this study accounts for factors that influence the RAMCF of each Fourteener.

Literature on Fourteener-specific studies for these goals is scarce, especially regarding any climbing frequency values associated with the peaks. The Colorado Fourteeners Initiative (CFI) estimates climber-visits, yet no values are absolutely confirmed. One particular case

FIGURE 1 The Maroon Bells in the Elk Range near Aspen, CO, are a signature for the pristine alpine beauty of Colorado's Fourteeners. (Photo by Jon Kedrowski, August 2006)



study was performed by members of the Rocky Mountain Field Institute (RMFI) in the Sangre de Cristo Range of southern Colorado addressing the restoration efforts on Humboldt Peak (Hesse 2000). The information presented in the case of Humboldt Peak provided a good overall physical description of what is occurring on all of the Fourteeners. However, the study failed to directly address values indicating climber-visits to Humboldt Peak.

The exponential increase in climbers to each Fourteener is causing many adverse erosional and environmental dynamics to occur on the peaks at accelerated rates (Hesse 2005; Kedrowski 2006). The RAMCF for Colorado's Fourteeners are initially determined in this article. The frequency values are evaluated in a systematic and comprehensive manner to address an important gap in the literature.

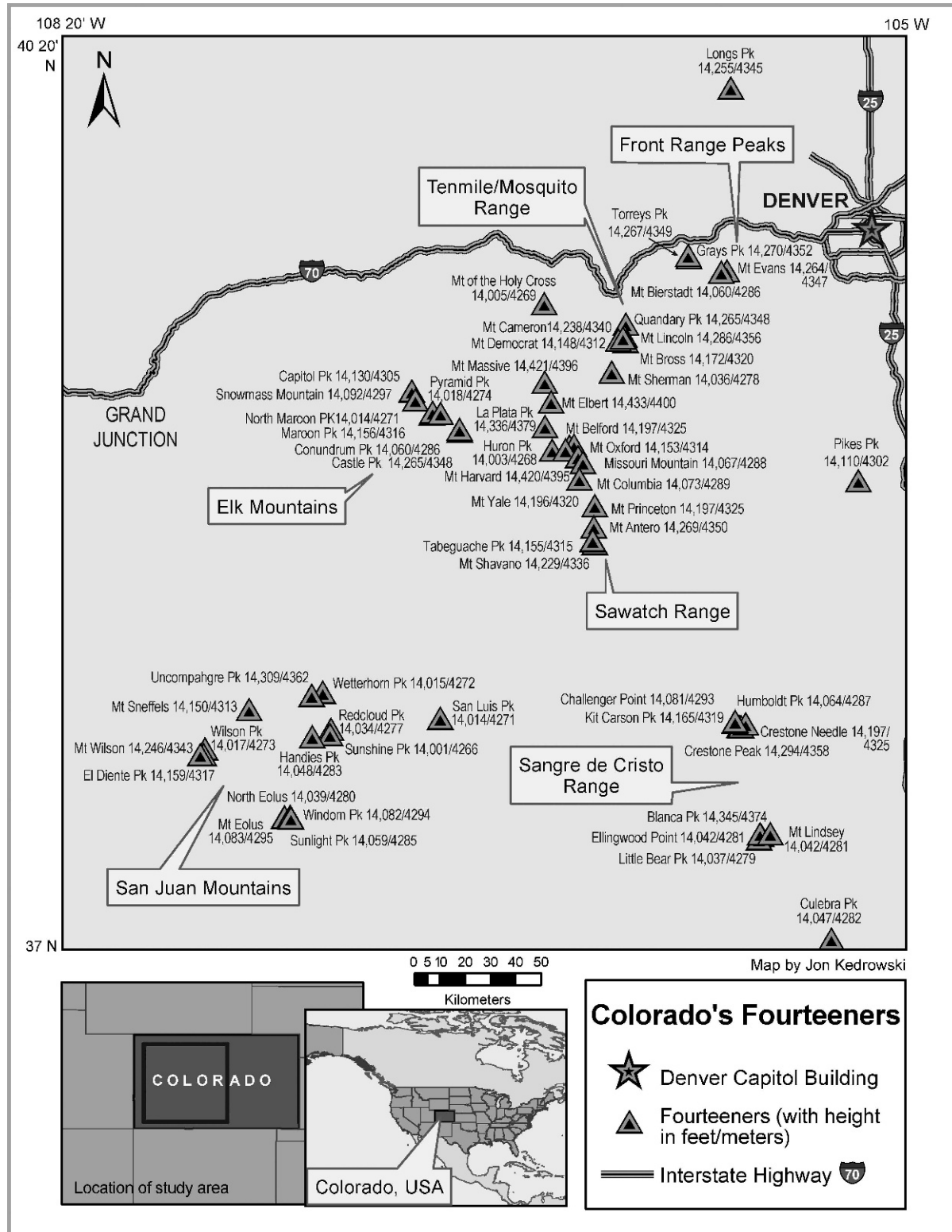
Hypothesis

The peaks within close proximity to a major population center are likely to have more visitors. As the population of Colorado eclipses 5 million residents by 2010, nearly 80% of those people will reside along the Front Range plains within close proximity to Denver (Vaske et al 2001), the center of an urban metropolis that is steadily growing in population. This agglomeration of people on the eastern side of the mountains is a clear factor in the continuing accessibility to the peaks of Colorado as the

means of outdoor scenery, tourism, and recreation. Given this development, it is essential to better understand the reasons why there are more visits to Fourteeners closer to the Front Range of Colorado than the peaks that are tucked away further to the west and southwest (Figure 2). For example, one would speculate that a peak such as Mount Bierstadt (Front Range) is going to have significantly more hikers than a peak such as El Diente (San Juan Range). The obvious reason is that Bierstadt is less than 50 miles (80 km) from the center of the Denver metropolitan area, whereas El Diente is more than 200 miles (321 km) from Denver. Additionally, El Diente is a peak that has a climbing difficulty rating of Class 3 for its standard/easiest route without a trail leading to the summit. By contrast, Bierstadt is only a Class 2 hike with a trail reaching all the way to the top (Box 1). Logic assumes that more climbers, and thus more impact, will occur on Bierstadt.

In reference to environmental impact, a major factor would be if overnight camping is involved, a topic not within the scope of this article but that has been addressed in prior analysis (Kedrowski 2006). Although there are other factors that affect RAMCF and the multidimensional nature of travel decision-making leading to environmental degradation (Matlack 1993), distance from any peak to the nearest urban area is likely to be a predominant explanatory factor, along with climbing difficulty and trail status. Prior studies have

FIGURE 2 Colorado's Fourteeners. (Map by Jon Kedrowski)



BOX 1: Climbing difficulty classifications for Colorado's Fourteeners

Class 1 – Trail hiking or any hiking across open country that is no more difficult than walking on a maintained trail. The parking lot at the trailhead is easy Class 1, groomed ski trails are midrange Class 1, and some of the big step-ups on the rocks near the top of the Barr Trail of Pikes Peak are difficult Class 1.

Class 2 – Steep trail and/or climber's trail hiking, or off-trail hiking. Class 2 usually means bushwhacking or hiking on a talus or loose rock slope. You are not yet using handholds for upward movement. Occasionally, the rating Class 2+ is used for a pseudoscrumbling route where you will use your hands but do not need to search very hard for handholds. Most people are able to downclimb Class 2+ terrain facing out and without the use of hands, while using superb balance and careful stepping.

Class 3 – The easiest climbing (not hiking) category. People usually call this “scrambling.” You are beginning to look for and use handholds for upward movement. Basic climbing techniques are used, which are noticeably past the level of any walking movements. Although you are using handholds, you do not have to look very hard to find them. Occasionally putting your hand down for balance while crossing a talus slope does not qualify as Class 3. That is still Class 2. About half of the people feel the need to face in toward the rock while downclimbing Class 3.

Class 4 – This level of climbing is within the realm of “technical climbing.” You are not just using handholds; you have to search for, select, and test them. You are beginning to use muscle groups not involved with hiking, those of the upper body and abdominals in particular. Movement at Class 4 is more focused, thoughtful, and slower. Many people prefer to rappel down a serious Class 4 pitch that is exposed rather than to downclimb it. Many Class 3 routes in California would be rated at a Class 4 in Colorado.

Class 5 – Technical climbing and nothing less. You are now using a variety of climbing techniques, not just cling holds. Movements may involve stemming with your legs, cross-pressure with your arms, pressing down on handholds as you pass them, edging on small holds, smearing, chimneying, jamming, and heel hooks. A lack of flexibility will be noticeable, and can hinder movement, and any movement at Class 5 or above totally occupies the mind of the individual. Most people choose to rappel down Class 5 pitches.

It is important to note that the standard routes on Colorado's Fourteeners included in this study range from Class 1 to Class 4, but all classes of climbing have been included to give the average person a better explanation of what is out there on Colorado's Fourteeners as a whole, even if it is not a part of the routes examined here.

examined “distance decay” and the socioeconomic, demographic, and locational characteristics of greenway users (Furuseth and Aultman 1991; Lindsey 2004). Similarly, adventure tourism research related more specifically to mountaineering and risk has answered questions about the accessibility of mountains (Mackay 1988; Ewert and Schreyer 1990), why people venture into high alpine environments (Ewert 1985), and what motivates them to climb (Ewert 1993, 1994). Thus, the simple factors analyzed here in regard to Colorado's Fourteeners address gaps in the literature specific to mountaineering in a spatial sense to help further understand the human components of the prior adventure tourism frameworks.

Methods

Study area

Colorado's 58 summits over 14,000 feet (4267 m) comprise 6 distinct mountain ranges (Figure 2): Front Range, Tenmile/Mosquito, Sangre de Cristo, Elk Mountains, Sawatch, and San Juan. All ranges combine to create the Fourteeners Region, a total land area of 23,000 km² covering the entire western portion of the

state of Colorado. Spatially, all 58 peaks except Long's in Rocky Mountain National Park are south of Interstate 70 and west of Interstate 25, between 37°N and 40°N latitude and 105°W and 108°W longitude.

Analysis of RAMCF

To address the research objectives, this study examined relationships between the number of people who climb to the summit of any given 14,000-foot peak (RAMCF) and the following explanatory factors: (1) the distance (accessibility) of the Fourteener to the largest (and nearest) urban center, (2) the distance from the summit to the nearest paved road, (3) the length of trail from the easiest accessible trailhead on the standard/easiest route, (4) the level of difficulty of climbing a Fourteener, and (5) the elevation of the trailhead for the standard route on each peak. “Fourteener-visits” and “RAMCF” are 2 terms with similar meaning and are used interchangeably in this article. Note: a logical, direct driving distance (km) from Denver to trailheads was not used as a variable for this study. Unfortunately, this potential variable was recognized after all data were collected in the field. See the Discussion section for further details.

TABLE 1 Criteria used to classify yearly and monthly archival annual climbing frequencies to RAMCF for Colorado's Fourteeners.

Relative climbing frequency value <i>Fourteener-visits</i>	Yearly archival frequency (number of climbers); <i>n</i> = 28	Highest monthly archival frequency (number of climbers); <i>n</i> = 25
<i>Low</i>	0–500	0–50
<i>Moderate</i>	501–1500	51–300
<i>High</i>	1501+	301+

Sources of data and collection

The archive data collection and the fieldwork conducted during this project represent the first attempt to collect data for all 58 named Fourteener peaks systematically. The archival data collection from the Colorado Mountain Club (CMC) Archives in Golden, CO, for all peaks was performed in May 2005. Data for field variables (ie trail length and summit global positioning system [GPS] waypoints) were collected from physical trail and route fieldwork on each standard route of the 58 Colorado Fourteeners from 1 June 2005–11 August 2005.

Study limitations

The key variable, the number of people recorded as climbing to the top of any particular Fourteener (a *Fourteener-visit*), was collected from the CMC Archives and analyzed to determine which peaks were climbed how many times per year from people recorded in the Fourteener summit logs for each specific mountain.

During the summer climbing months (May–October), when peaks are relatively snow free, people who reach the top of any peak open a summit log and sign it with their name, hometown, date of summit, and comments. Collection of an annual climbing frequency value for each peak in years 1995–2004 was the most effective way to formulate RAMCF because it accounts for the overall number of visits, therefore representing an aggregate measure of the overall annual impact to any Fourteener. Using annual time frames minimizes some of the limitations of collecting accurate data for the entire year from all summit registers, especially during the winter months, when registers may become buried under snow and are unlikely to be signed by a successful climber. Another problem is that some people climbing to the summits of the peaks do not sign the register either for personal reasons or because there may not actually be a register available.

A separate option for this study could have been to use US Department of Agriculture Forest Service trailhead counters or sign-in registers, which are present at some trailheads. For example, Mount Bierstadt has utilized an electronic counter and a signable user trailhead register at Guanella Pass since 2005. An estimated 75% of Colorado Fourteener trailheads in this study were

observed to have a trailhead sign-in register. These data were not used for various logistical reasons. First, the registers are not collected and deposited at the same location, such as the CMC Archives, and are difficult to access. Second, similar limitations to the summit registers exist with registration log paper and willing signers at trailheads. Third, a person will impact the mountain if they did not make the summit, but summit registers enable an isolation of the backcountry users' purpose, whereas trailhead registers do not always indicate destination, purpose, or peak climbed. The lack of consistent data and the nature of availability are reasons why the trailhead register data were not incorporated into this analysis. The annual climbing frequency values must, therefore, be recognized as minimum impact values that could underestimate the total annual environmental impact of climbers.

Determining RAMCF from the summit registers

For this project, RAMCF for each of the Fourteeners were classified into 3 qualitative categories: *low*, *moderate*, and *high*. Peaks with a complete year of climbing records or at least 2 complete months of climbing records during the climbing season months (1 May–31 October) were classified accordingly based on criteria summarized in Table 1. Peaks with *low* RAMCF were climbed by 0–50 climbers per month and 0–500 climbers per year. *Moderate* RAMCF peaks were climbed by 51–300 climbers per month and 501–1500 climbers per year. *High* RAMCF peaks were defined as peaks exceeding 300 climbers per month and 1500 climbers per year. Two factors were used to determine this classification based on the quantitative values for each peak obtained from the CMC Archives: (1) yearly archival climbing frequency and (2) monthly archival climbing frequency. For almost half of the peaks, the summit registers from the CMC Archives contain at least 2 complete years of climbing records, with some peaks having 3 or more years of complete data within the years 1995–2004.

Twenty-eight of the 58 Fourteeners included in this study were classified under yearly archival frequency, having at least 2 years of complete climbing records, and therefore were assigned a RAMCF to be used in the statistical analysis. If a peak did not have 2 complete years of archival data, in the case of 25 Fourteeners, then

TABLE 2 Descriptive statistics for the factors affecting RAMCF of Colorado's Fourteeners ($n = 58$).

Dependent variables RAMCF factors	Mean	Standard deviation	Max	Min
Direct distance from Denver (miles/km)	122.53/197.19	51.19/82.38	209/336.35	36.50/58.74
Direct distance from summit to nearest paved road (miles/km)	5.01/8.06	2.47/3.97	9.60/15.45	0.10/0.16
Length of trail/route from trailhead to summit (miles/km)	5.35/8.61	2.08/3.35	10.20/16.41	1.56/2.51
Class and standard route climbing difficulty	2.35	0.77	4.00	1.00
Elevation of peak's trailhead (feet/meters)	9999.48/3048	1156.33/352	12048/3672	8000/2438

Max, maximum; Min, minimum.

monthly archival frequency from at least 2 summer months (June–September) was used to classify (Table 1).

Five peaks (Mount Cameron, North Eolus Peak, Challenger Point, Mount Evans, and Pikes Peak) did not have sufficient summit registers in either the CMC Archives or on their summits. Therefore, a special classification scheme was implemented for determining their RAMCF status. Cameron, North Eolus, and Challenger are subsummits of nearby peaks and thus were assigned RAMCF values based on their nearest neighboring peak. For example, Mount Cameron is climbed most often when Mount Lincoln is climbed (Borneman and Lampert 1998; Dawson 1999a, 1999b; Roach 2004). In fact, most people cross directly over

Cameron's summit (14,238 feet) on their way to reach the higher Mount Lincoln (14,286 feet). Therefore, Cameron was assigned the same value as Lincoln (both *moderate*) for their relative annual climbing frequency. The same logic was used for North Eolus, which is located within close proximity to Eolus Peak. Challenger Point (14,081 feet) is a mere 350 m from the summit of Kit Carson (14,265 feet) with a 301-foot (92 m) drop to the connecting saddle between the peaks (Bueler 2000; Roach 2004), and both are classified as *moderate*. Pikes Peak and Mount Evans have thousands of visitors each year, both by their standard routes to the summit and other means of transportation (roads and railroads to the summit). Thus both peaks were rated *high* with regard to RAMCF.

TABLE 3 Comparison of group means for RAMCF of Colorado's Fourteeners (3 groups total, $n = 58$).

Variables	RAMCF			ANOVA	
	$n = 26$ HI	$n = 18$ MOD	$n = 14$ LOW	F-value	P-value
Direct distance from Denver (miles/km)	98.40/158.35	130.23/209.58	149.41/240.45	5.98	0.0044**
Direct distance from summit to nearest paved road (miles/km)	4.06/6.53	5.67/9.12	5.91/9.51	3.82	0.027*
Length of trail/route from trailhead to summit (miles/km)	4.82/7.76	5.12/8.24	6.62/10.65	3.90	0.026*
Class and standard route climbing difficulty	1.85	2.53	3.07	20.33	2.45×10^{-7} **
Elevation of peak's trailhead (feet/m)	10379.19/3163	9913.94/3021	9404.29/2866	3.61	0.033*

HI, *high*; MOD, *moderate*; LO, *low*.

* $P < 0.05$; ** $P < 0.01$

TABLE 4 Colorado's 53 official (58 unofficial) Fourteeners and assigned RAMCF values (refer to Table 1 for listings of actual climber numbers for *low* [LO], *moderate* [MOD], and *high* [HI]), based on summit register collection and statistical analysis, listed in order of Fourteeners Environmental Degradation Index (FEDI) value ranks (Kedrowski 2006).

FEDI rank	Name of peak	RAMCF value	Mountain range	FEDI rank	Name of peak	RAMCF value	Mountain range
1	Evans	HI (1)	Front	30	Elbert	HI (1)	Sawatch
2	Longs	HI (1)	Front	31	Harvard	HI (1)	Sawatch
3	Blanca	HI (1)	Sangre de Cristo	32	Crestone Pk	LO (3)	Sangre de Cristo
4	Castle	HI (1)	Elk	33	Bross	HI (1)	Tennile/Mosquito
5	Pikes	HI (1)	Front	34	Conundrum ^{a)}	LO (3)	Elk
6	Humboldt	HI (1)	Sangre de Cristo	35	Uncompaghire	HI (1)	San Juan
7	Democrat	HI (1)	Tennile/Mosquito	36	Challenger	MOD (2)	Sangre de Cristo
8	Columbia	HI (1)	Sawatch	37	Kit Carson	MOD (2)	Sangre de Cristo
9	Antero	HI (1)	Sawatch	38	Little Bear	LO (3)	Sangre de Cristo
10	Sherman	HI (1)	Tennile/Mosquito	39	N. Eolus ^{a)}	LO (3)	San Juan
11	Ellingwood	LO (3)	Sangre de Cristo	40	Quandary	HI (1)	Tennile/Mosquito
12	Sneffels	MOD (2)	San Juan	41	Shavano	MOD (2)	Sawatch
13	Wilson Pk	MOD (2)	San Juan	42	Redcloud	HI (1)	San Juan
14	Cameron ^{a)}	MOD (2)	Tennile/Mosquito	43	Sunshine	HI (1)	San Juan
15	Huron	MOD (2)	Sawatch	44	Wetterhorn	MOD (2)	San Juan
16	Sunlight	MOD (2)	San Juan	45	Tabeguache	MOD (2)	Sawatch
17	Torreys	HI (1)	Front	46	La Plata	MOD (2)	Sawatch
18	Windom	MOD (2)	San Juan	47	San Luis	HI (1)	San Juan
19	Eolus	MOD (2)	San Juan	48	Handies	HI (1)	San Juan
20	Yale	HI (1)	Sawatch	49	N. Maroon Pk ^{a)}	LO (3)	Elk
21	Lincoln	MOD (2)	Elk	50	Missouri	MOD (2)	Sawatch
22	Grays	HI (1)	Front	51	Maroon Pk	LO (3)	Elk
23	Massive	HI (1)	Sawatch	52	Oxford	MOD (2)	Sawatch
24	Lindsey	LO (3)	Sangre de Cristo	53	Belford	HI (1)	Sawatch

TABLE 4 Continued.

FEDI rank	Name of peak	RAMCF value	Mountain range	FEDI rank	Name of peak	RAMCF value	Mountain range
25	Princeton	HI (1)	Sawatch	54	Capitol	LO (3)	Elk
26	Holy Cross	MOD (2)	Sawatch	55	Mt Wilson	LO (3)	San Juan
27	Pyramid	MOD (2)	Elk	56	Snowmass	LO (3)	Elk
28	Crest. Needle	LO (3)	Sangre de Cristo	57	El Diente ^{a)}	LO (3)	San Juan
29	Bierstadt	HI (1)	Front	58	Culebra	LO (3)	Sangre de Cristo

^{a)} "Unofficial" Fourteeners, but included in this study.

Variable descriptions and data collection

The key variable of interest, *Fourteener-visits*, represents the number of people that have signed the registers at the top of each Fourteener and was organized into 3 qualitative categories: *high*, *moderate*, and *low*.

Explanatory variables include accessibility factors impacting the number of *Fourteener-visits* to any particular peak, described as follows:

1. **Distance** (miles/km): to the center of the nearest (most significant) urban center (Denver; the Colorado State Capitol building was the measuring point).
2. **Accessibility** (miles/km): direct distance from the summit to the nearest paved road.
3. **Trail/route length** (miles/km): distance from the trailhead to the summit (standard route).
4. **Climbing difficulty**: the easiest route to the summit. All the peaks have an easiest route classified as a qualitative variable (1, 2, 2.5, 3, or 4). Climbing classifications are fully defined in Box 1.
5. **Trailhead** (feet/m): the elevation of the peak's trailhead for the standard route.

A Delorme atlas/gazetteer (2002) and a Magellan Sportrak Pro[®] global positioning system were used to accurately measure and record relevant factors that affect the RAMCF of Colorado's Fourteeners. GPS waypoints were taken from the summit of each Fourteener and from the steps of the State Capitol building in Denver, and an accurate calculation was made from these coordinates to determine the direct distance (as the crow flies) from each peak to the center of the Denver metropolitan area. Direct distance from the nearest paved road to the summit was collected via GPS. The trail length factors and the trailhead elevation for the standard route on each peak were determined by climbing and measuring the exact route from trailhead to the summit using the GPS. Climbing difficulty factors were recorded from a Fourteeners guidebook by Roach (2004).

Results

Descriptive statistics for factors affecting RAMCF

The effect of each variable collected on the *Fourteener-visits* was evaluated using analysis of variance (ANOVA) testing for difference of means and Pearson-Product correlation analysis. Descriptive summary statistics for the factors that affect RAMCF for the state's 58 named summits over 14,000 feet are provided in Table 2. The average distance of any Fourteener from the Denver metropolitan area is 122 miles (197 km). El Diente (14,159 feet) is the furthest peak from Denver, a direct distance of 209 miles (336 km). Mount Evans (14,264 feet) is located nearest Denver at only 36.5 miles (58 km). The mean direct distance for all the peaks to the nearest paved

TABLE 5 Pearson-product correlation values between variables that effect RAMCF of Colorado's Fourteeners.

	RAMCF yearly (1995–2005)	Direct distance (miles/km) from Denver	Direct distance summit the nearest paved road (miles/km)	Length of trail/route from trailhead to summit (miles/km)	Class and standard route climbing difficulty	Elevation of peak's trailhead (feet/m)
RAMCF yearly (1995–2005)	1.000					
Direct distance (miles/km) from Denver	0.419	1.000				
	0.001**					
Direct distance from summit the nearest paved road (miles/km)	0.325	0.672	1.000			
	0.006**	0.000**				
Length of trail/route from trailhead to summit (miles/km)	0.327	0.305	0.421	1.000		
	0.006**	0.010*	0.001**			
Class and standard route climbing difficulty	0.651	0.443	0.235	0.335	1.000	
	0.000**	0.000**	0.038*	0.005**		
Elevation of peak's trailhead (feet/meters)	−0.340	−3.14	0.374	−0.873	−0.415	1.000
	0.004**	0.008**	0.002**	0.000**	0.001**	

* $P < 0.05$; ** $P < 0.01$

road is just more than 5 miles (8 km); Windom (14,082 feet) is located a maximum of 9.6 miles (15 km) from the nearest paved road and Mount Evans (14,264 feet) the minimum of 0.1 mile (0.16 km). The average length of the standard route from trailhead to the summit for the Fourteeners is 5.35 miles (8.6 km). The longest standard route/trail is found in the Elk Range approaching Snowmass Mountain (14,092 feet), a distance of 10.2 miles (16 km). The shortest standard route/trail is Mount Bross (14,172 feet), only 1.56 miles (2.5 km) in length. The average elevation of the trailheads for the Fourteeners is just below 10,000 feet (3050 m). The highest standard route trailhead is located at Kite Lake (12,048 feet/3672 m) in Park County for climbing Democrat, Cameron, Lincoln, and Bross, whereas the lowest trailhead for a standard route on a Fourteener is the Lake Como trailhead at 8000 feet (2438 m) near Alamosa, accessing the standard routes on Little Bear, Blanca, and Ellingwood, in the Sangre de Cristos. The mean level of difficulty for the 58 peaks evaluated in this study is 2.35. The most difficult standard routes on Colorado's Fourteeners do not exceed a Class 4 in climbing difficulty, as 6 Class 4 climbs on Fourteeners were evaluated (Little Bear, Capitol, North Maroon, Pyramid,

Wilson, and Sunlight), whereas the easiest standard routes are Class 1.

Comparison of group means to classify RAMCF

Group averages for each variable on the basis of *Fourteener-visits* were classified into 3 categories (*low*, *moderate*, and *high*). The results are summarized in Table 3, which provides the number of peaks in each group, the group means for each of the 5 climbing frequency variables, the test statistic (F-value), and the probabilities associated with the ANOVA test for difference in means between the groups. All 5 variables in this analysis yield large F-values and small *P*-values, enabling rejection of the null hypothesis of equal means ($\alpha = 0.05$), thus concluding that the group means for all 5 variables included are significantly different from each other (Table 3).

The nature of change in mean values across the 3 groups further explains RAMCF for the Fourteeners. According to Table 3, the means of 4 variables (distance from Denver, distance from the summit to the nearest paved road, length of trail/route, and route difficulty) not only differ significantly between groups but also tend to increase across groups as RAMCF increases from *low* to *high*. Conversely, the mean trailhead elevation tends to decrease gradually, as RAMCF drops from *high* to *low*.

Therefore, a quantitative coding scheme was used in the next phase of the analysis to examine the associations between *Fourteener-visits* and the 5 explanatory factors. The 3 qualitative categories of RAMCF were coded as 1 (*high*), 2 (*moderate*), and 3 (*low*), respectively, to facilitate the next step of the statistical analysis. A complete list of Colorado's 58 Fourteeners and their assigned RAMCF values are in Table 4.

In Table 4, a peak must rise at least 300 feet (92 m) above the saddle that connects it to the nearest Fourteener peak (if another exists nearby) to be classified as "official." This guideline has been in use in Colorado for years and is accepted in all the climbing guidebooks (Borneman and Lampert 1998; Dawson 1999a, 1999b; Bueler 2000; Roach 2004). The following 5 peaks are not official because they do not fit this criteria, but they are noted in Table 4 because they are named and recognized on US Geological Survey maps: Mount Cameron, rises 138 feet above its saddle with Mount Lincoln; El Diente, rises 259 feet above its saddle with Mount Wilson; Conundrum Peak, rises 240 feet above its saddle with Castle Peak; North Eolus, rises 179 feet above its saddle with Mount Eolus, and North Maroon Peak, rises 234 feet above its saddle with Maroon Peak.

Correlation analysis results

The second step focused on assessing the strength and direction of the relationship between RAMCF (coded as 1, 2, or 3) and the 5 explanatory variables. Pearson-Product correlation analysis was utilized for this purpose, because the descriptive skewness and kurtosis measures of the variables analyzed did not suggest significant departures from normality. The correlation matrix obtained from the explanatory variables and RAMCF are provided in Table 5. In the table, the first column demonstrates a significant correlation between each explanatory factor and the values for the coded variable of RAMCF for the years of interest (1995–2004). Four of the 5 were positively correlated, whereas the fifth variable (elevation of the peak's trailhead) was negatively correlated with RAMCF. These correlations are all significant at a 99% ($P < 0.01$) level of confidence.

A logical explanation can be provided for the correlation between each variable and the dependent variable of RAMCF, or *Fourteener-visits*, as seen in Table 5. Direct distance from the center of the Denver metropolitan area was positively correlated with RAMCF, verifying that peaks closer to Denver are more likely to be climbed than those further distant. Direct distance from the summit of a Fourteener to the nearest paved road was also positively correlated with RAMCF, indicating the more "accessible" a paved road is to the top of a Fourteener, the more frequently the peak is climbed. Similar positive correlations are shown for both length of the trail and difficulty of the trail on the standard route. The shorter the trail and the lower the level of climbing difficulty, the higher the RAMCF, thus the higher the number of *Fourteener-visits*

recorded in the summit registers. Finally, the fifth variable, elevation of a peak's trailhead, was negatively correlated with RAMCF, which implies that standard Fourteener routes starting at higher trailheads are climbed more frequently than those starting at lower trailheads.

Discussion

The goal of this research was to better understand the extent of RAMCF for the trails and routes visited by the increasing number of climbers for any given Colorado Fourteener. The 5 explanatory factors—distance from a major urban center (Denver), distance from the nearest paved road, length of trail on the standard route, climbing route difficulty, and elevation of the trailhead—indicated a statistically significant effect on RAMCF. The correlation analysis shows that climbing route difficulty has the most significant impact on RAMCF. More people tend to hike up the easy Class 1, 2, and 2.5 routes that exist on 42 of the 58 Fourteeners and shy away from the dangers and difficulties associated with Class 3 and 4 climbs for the remaining 16 peaks. A fair assumption based on these findings is that the typical "Fourteener enthusiast" or "peakbagger" resides in the city and is unlikely to be a hard-core mountaineer. Most people that climb the Fourteeners prefer to tackle the easy climbs first, save the tough climbs for last, or may never approach the difficult and dangerous peaks. Data collected revealed that more than 90% of the climbs on any of the Fourteeners occur during the months of May–October and primarily during July, August, and September. During these periods, people from the Denver metropolitan area, adjacent suburbs, and cities of the I-25 corridor climb only when the peaks are almost snow free.

Regardless of proximity to Denver, all peaks are being climbed at increasing levels, likely influenced by a variety of factors, with unique "place-dependent" circumstances. A need exists for more research using more factors and data that account for some of the place-dependent circumstances. Given the potential on the heavily-visited peaks is high for degradation, new factors, especially those of accessibility, may contribute to degradation on most of the peaks. Direct distance from Denver was used as a variable in this study to represent accessibility for each of the Fourteeners. For example, driving distance from Denver to each peak's standard route trailhead could serve as a new variable to be analyzed. Some peaks are more isolated than others simply because they have to be accessed by longer driving distances resulting from Colorado's very rough topography. Most people do not desire to drive long distances to trailheads for access to Fourteeners; therefore they will be more likely to climb a peak with a trailhead that requires less driving time, indicating easier accessibility, higher climbing

frequencies, and possibly a higher level of degradation overall.

Assessing the personal visitor experience of Fourteener-enthusiasts as a predictor of RAMCF is yet another research option. A “Fourteeners Attractiveness Index” could be developed from surveying Fourteener-enthusiasts to find out what characteristics of these peaks draw a person to any given Fourteener. Are most climbers attracted to the steep, dangerous, and cliff-banded peaks or the easy-to-access, nontechnical hiking Fourteeners? Do most people prefer to drive more than 2 hours or less than 2 hours to climb a Fourteener? Many additional questions could be answered by simply surveying Fourteener-enthusiasts to further identify some of the factors that influence how the peaks are climbed and how often they are climbed.

Conclusion

This study can be expected to improve the ways organizations may classify and recognize the current levels of climbers and hikers to mountain environments. Future protection and trail construction, including maintenance of existing trails and routes, can be better understood and performed with the results and outcomes of this project. If we know which peaks have the highest annual visitation we can better plan to help sustain those specific areas. The findings from this project can serve as a guide for organizations such as the US Forest Service, Bureau of Land Management (BLM), CMC, CFI, and other management groups to preserve the mountains and their routes for future generations.

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