Executive Summary

Bats have been declining at an alarming rate because of white-nose syndrome and wind energy development. Massive mortality events from white-nose syndrome have been easy to identify at caves in mines in eastern North America. However, winter roosts with millions or thousands of bats are scarce in western North America; thus, documenting and responding to precipitous declines will be problematic for western land managers and biologists. Effort to identify where bats are roosting is the first step to conducting monitoring to assess such changes. One such effort is to identify bat roosts in cliff walls. Although many biologists understand bats use cliff systems, there have been few opportunities to identify such roosts without expensive telemetry research. An alternative is to collaborate with recreational rock climbers who know where bats roost, or to employ climbers to conduct surveys for bats. We conducted climber-based surveys in Jefferson County Open Space (JCOS) and City of Boulder Open Space and Mountain Parks (OSMP) to find roosting bats. Over approximately two months of surveying 50 climbing routes, climbers identified two roosts on OSMP lands, and received a citizen-science record from JCOS lands. Bats were identified using areas of the Amphitheater in Gregory Canyon, OSMP, and at Middle and West Walls of Tiers of Zion, JCOS. We discuss the results of our climber surveys, present challenges to such surveys, and suggest future survey techniques and directions.

Bat roosts along cliffs: using rock climbing surveys to understand roosting habitat of bats along the Front Range of Colorado. January 13, 2020 Final Report.

Robert A. Schorr, Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Abstract

Bats have been declining at an alarming rate because of white-nose syndrome and wind energy development. Massive mortality events from white-nose syndrome have been easy to identify at caves in mines in eastern North America. However, winter roosts with millions or thousands of bats are scarce in western North America; thus, documenting and responding to precipitous declines will be problematic for western land managers and biologists. Effort to identify where bats are roosting is the first step to conducting monitoring to assess such changes. One such effort is to identify bat roosts in cliff walls. Although many biologists understand bats use cliff systems, there have been few opportunities to identify such roosts without expensive telemetry research. An alternative is to collaborate with recreational rock climbers who know where bats roost, or to employ climbers to conduct surveys for bats. We conducted climber-based surveys in Jefferson County Open Space (JCOS) and City of Boulder Open Space and Mountain Parks (OSMP) to find roosting bats. Over approximately two months of surveying 50 climbing routes, climbers identified two roosts on OSMP lands, and received a citizen-science record from JCOS lands. Bats were identified using areas of the Amphitheater in Gregory Canyon, OSMP, and at Middle and West Walls of Tiers of Zion, JCOS. We discuss the results of our climber surveys, present challenges to such surveys, and suggest future survey techniques and directions.

Keywords: bats, citizen-science, cliffs, climbers, conservation, cracks, crevices

Introduction

Bats are the second most diverse mammalian order with approximately 1,400 species (Burgin et al. 2018), and they contribute to human economy in pest control savings, provide medicine for cardiac patients, pollinate food and beverage resources, and likely limit insect disease transmission (Fernandez et al. 1999, Boyles et al. 2011, Kunz et al. 2011). Despite this diversity, and the size of some known populations, much of our understanding of bats' roosting requirements comes from roosts associated with human activity, such as buildings, dwellings, and mines (Voigt et al. 2016). Additionally, there are numerous roosts associated with geological features, such as caves, where human visitation and exploration have added to our understanding of roosting needs (Furey and Racey 2016). A vast majority of the large cave and mine bat populations are known from eastern North America, with sporadic, large colonies known from western North America. However, many of those eastern populations have experienced unprecedented declines (Frick et al. 2010).

Large mortality events at wind turbine facilities (Arnett and Baerwald 2013), and the discovery of a novel disease called white-nose syndrome (WNS; Frick et al. 2016), have caused eastern bat populations to decline by the millions (Ingersoll et al. 2013). When WNS was discovered in the northeast U.S., local populations were nearly exterminated with upwards of 99% mortality (Frick et al. 2010). The scale of some mortality events made detection relatively easy, and because many large populations at mines and caves had been monitored regularly for decades, many of the WNS-associated mortality events were obvious (Frick et al. 2016). Continued monitoring of known infection sites, and new monitoring at many caves and mines in eastern North America have allowed biologists to understand how the disease is expanding westward (Foley et al. 2011). Although visits to over-wintering cavernicolous bat colonies in eastern North America have been useful for understanding and projecting WNS spread, this likely will not be the tool that identifies WNS or WNS spread in western North America (Lorch et al. 2016). In the West, there is a paucity of large, hibernating bat colonies in caves and mines, and identifying when mortality factors impact populations will be more challenging (Weller et al. 2018). Similar to how WNS was first documented the East and in Washington State, biologists may need observations from citizen scientists (Frick et al. 2016).

Bats have long been known to use cracks and crevices as roosting resources (Bogan et al. 2003). Many of these roosting discoveries have come from radio-telemetry studies or happenstance encounters (Chambers et al. 2011, Schorr and Siemers 2013, Johnson et al. 2017). That is changing, however, as several citizen-science initiatives have improved understanding of bat roost use (Hayes 2012), and national parks conduct active climber surveys to find bats (Knecht and Lyons-Gould 2016, Knecht and Mandanna 2017, Knecht and Lyons-Gould 2018). One bat-focused citizen science initiative is a collaboration between rock climbers and bat biologists called Climbers for Bat Conservation (CBC; Davis et al. 2017), that has produced new bat roosting records from ten states (pers. obs.). Recreational climbers have volunteered bat observations to help biologists understand bat biology and uncover large bat colonies. Because of the support and enthusiasm for CBC, we proposed to use active rock climbing surveys to look for bat populations at locations along the Front Range of Colorado. We conducted acoustic, visual and climbing surveys to understand: 1. The feasibility of using active climbing surveys to find bat roosts; 2. Refine and test survey methodology for use during climbing surveys; and 3. Provide local land managers information about where bat roosts exist at open-space lands along the Front Range of Colorado.

Methods

Study site. Sampling for bats occurred at climbing routes at City of Boulder Open Space and Mountain Parks (OSMP) lands and Jefferson County Open Space lands (JCOS) (Figure 1). Routes that were accessible and within the climbing expertise of student climbers (typically under 5.11 on the Yosemite Decimal System) were selected non-randomly for sampling.

Passive evening surveys. Prior to climbing, routes or crags were visited to assess the presence of bats in the area. During an evening prior to climbing most cliff faces were video recorded using infrared thermal camera (ATN THoR-HD 384, ATN Corporation, San Francisco, California) to film bats as they fly near the route or crag. Also, hand-held ultrasonic recorders (EchoMeter Touch 2, Wildlife Acoustics, Inc., Maynard, Massachusetts) were used to identify bat species vocalizing in the area. Passive surveys took place after sunset, and researchers recorded wind speed (mph) and temperature (˚F) using a weather meter (Kestrel 2500 Weather Meter, Kestrel Instruments, Boothwyn, Pennsylvania) and night sky brightness (Sky Quality Meter, Unihedron Grimsby, Ontario).

Active climbing surveys. We (MDM, BAH) climbed routes to look for bats in cracks along a climbing route (Figures 2 – 4). At the route, we estimated the aspect of the wall and the route using a compass (Suunto MC-2G, Suunto, Vantaa, Finland). Based on the overall height of the climb, we subsampled the route at four equal distances starting from the ground level. For example, for a 12-m (40-ft) route, climbers collected data at 3 m (10 ft), 6 m (20 ft), 9 m (30 ft), and near the top (12 m). Sampling in this way guaranteed the route was sampled at regular intervals along the route (Figures 2 – 4). When no crack was available for sampling, we selected the nearest crack to where the height interval occurred. Few routes were surveyed while climbing up the route, but most were surveyed from the top to the bottom by “top-roping” from an anchor. When at a crack, we used endoscopic cameras (Milwaukee M12, Grāef Tool, Brookfield, Wisconsin, or Teslong NTS150, Teslong Technology Limited, Shenzhen, China) to look for bats or evidence of bats, such as guano. We recorded the crack characteristics, including height (ft), width (in) and orientation (diagonal, horizontal, or vertical). When a bat was discovered, we used infrared thermometers (Extech IR Thermometer 42510A, Extech Instruments, Nashua, New Hampshire) to record temperatures in cracks and used the endoscopic camera to record video or pictures of the bat. All data were recorded on data sheets while in the field (Figure 5).

Results

Forty-five climbing routes were climbed to look for bats, with 42 locations receiving passive evening surveys (Table 1). Twenty-three climbing surveys were conducted at 21 routes on OSMP lands, and 27 climbing surveys were conducted at 27 routes on JCOS lands (Table 2). Acoustic or thermal imaging video were recorded at 24 JCOS climbing crags and at 18 OSMP crags. Climbing surveys were conducted on routes that ranged in difficulty from 5.2 to 5.11 YDS, with a majority in the routes in the 5.7 YDS (n = 15) or 5.10 YDS (n = 9) difficulty. Three routes were climbed twice.

A bat was observed along two climbing routes (Standard Inside East Face, Trident) in OSMP's Gregory Canyon (Figure 6; Table 3). Bats were found roosting at 12.8 m (42 ft; Standard Inside East Face) and at 10.7 m (35 ft; Trident) height from the base of the climb. The bats were found in narrow crevices 0.7 cm (0.3 in) and 1.0 cm (0.4 in) that were wider where the bat was roosting (Figure 6), and each route had a 70˚ (eastward) aspect that matched the aspect of the wall. The temperatures within the crevices where bats were roosting were 39˚C (93˚F) and 28˚C (83˚F). Evidence of bats (guano) was seen at Thin Crack and Trident routes in Gregory Canyon.

Smartphone ultrasonic acoustic recorders documented a host of bat species flying near climbing routes (Table 3). Hoary bats (*Lasiurus cinereus*), eastern red bat (*Lasiurus borealis*), silver-haired bats (*Lasionycteris noctivagans*), big brown bats (*Eptesicus fuscus*), western small-footed bats (*Myotis ciliolabrum*), long-eared myotis (*Myotis evotis*), little brown bats (*Myotis lucifugus*), and Brazilian free-tailed bats (*Tadarida braziliensis*) were recorded. However, there is reason to be skeptical of the recordings of the Brazilian free-tailed bats because of known issues with the acoustic analysis classification algorithms that are discussed below. Similarly, bats were recorded using thermal imaging cameras (Table 3), but identity of species or identification of roosts was not feasible. Most bats were seen as brief thermal profiles flying by the camera.

Discussion

Cliff systems are commonly recognized for the recreational value they provide to the rock climbing community, with regional economies experiencing millions of dollars of income and wages from climbing recreation (Maples et al. 2019). More recently, however, these systems are being recognized for the biodiversity they support (Kraijick 1999). Cliff systems are home to myriad of vegetation, invertebrates, and vertebrates, and many species may flourish because of the inaccessibility of this vertical terrain (Larson et al. 1999). As the sport of rock climbing increases rapidly (Cordell 2012) there is growing concern that activity at cliffs jeopardizes the abundance and biodiversity of plants and animals that exists there (Camp and Knight 1998, Kuntz and Larson 2006, Lorite et al. 2017). The impacts recreational climbing can have on immobile biodiversity, such as plants and lichens, and on wildlife that rely on cliff systems for key habitat requirements, is well studied (Richardson and Miller 1997, Mueller et al. 2004, Adams and Zaniewski 2012). The impacts climbing have on the abundance and diversity of more-mobile or less-restricted organisms is much less clear (Holzschuh 2006, Covy et al. 2019). The desire to balance conservation of cliff biodiversity while maintaining recreational opportunities has created new challenges for resource management professionals tasked with operating under a dual-purpose mandate (Keough and Blahna 2006).

The landscape management challenges rock climbing presents have led biologists and land managers to collaborate with citizen scientists to develop creative management solutions (Keough and Blahna 2006, Emmons 2007, Davis et al. 2017). Although there are concerns regarding climbing’s impacts on cliff systems, there is interest in using climbers to assess such impacts or understand the ecology of cliff-dwelling organisms (McMillan et al. 2003, Vogler and Reisch 2011). The unique skillsets of climbers may help biologists advance conservation. For example, conducting climbing surveys for bats can identify important bat roosts and identify roost-specific features that can improve biologists’ knowledge of roosting requirements (Davis et al. 2017).

Bats’ affinities for cliff systems have long been appreciated (Bogan et al. 2003), and much of what biologists know about bats’ use of cracks and crevices has come from telemetry studies (Chambers et al. 2011, Schorr and Siemers 2013, Johnson et al. 2017). Yet, because of the height of many cliff systems, most telemetry studies fail to observe bats using cliff systems and it is unclear where on the cliff or what specific features bats are selecting. Some biologists have used evening visual surveys or acoustic recordings below cliff walls to assess bat use of cliff areas (Ancillotto et al. 2014, Rolfe and Adams 2015, Lemen et al. 2016). However, like telemetry studies, these efforts rarely give insights into how bats use cliff systems, and usually fail to observe bats using specific cracks or crevices. Drawing habitat use inferences from acoustic studies is particularly challenging because some bats have short vocal ranges and have to be in proximity of detectors to be detected (O’Farrell and Gannon 1999). Additionally, recorders at the base of cliffs may not depict true activity above the surrounding vegetation (Britzke et al. 2013). Evening visual surveys suffer from low detection probability or inaccuracy (Azmy et al. 2012). Thus, tools for better identifying bat use of cliff systems can aid in biologists’ understanding of bat ecology along cliff systems, the impacts recreational climbing may have on cliff-roosting fauna, and identification of healthy bat populations in advance of or after population declines.

A collaboration among bat biologists, rock climbers, and land managers has used recreational climbers’ unique ability to see bats in their natural roosting locations as the basis for a citizen-scientist initiative to understand cliff use by bats (Davis et al. 2017). In this program, called CBC, bat observations have been volunteered by altruistic climbers. Although these records have increased understanding of where bats roost and where large roosts exist, survey-based methods of acquiring roosting observations may be more informative. This study along the Front Range of Colorado employed two research-climbers for approximately eight weeks to climb regions of JCOS and OSMP. They identified two roosts along the approximately 50 climbing routes they visited, and identified cliff systems that may house more bats (Amphitheater, Gregory Canyon). To date, this is the only known climber-based survey study to look for bats in cliff systems.

Acoustic and evening count surveys conducted along several cliff systems on OSMP lands (Rolfe and Adams 2015) indicated that bats used these areas, and there were known maternity colonies at two local caves (Adams 2000). Thus, it was not surprising to eventually document bats roosting along these cliffs. However, it was uncertain if climbing and subjectively searching at periodic intervals along routes would produce any new bat roosting records. This survey project demonstrated that such surveys can document roosting by bats. At JCOS there was no prior knowledge of bats using the cliffs at North Table Mountain or Tiers of Zion, and our surveys failed to locate any bats. The added benefit of having climbing-researchers surveying throughout the summer is that they regularly engaged with the local climbing community. This interaction strengthened local interest in the project, and prompted climbers to submit their observations to CBC. Although researchers did not document bats at Tiers of Zion on JCOS property, one recreational climber saw a bat 3.7 m (12 ft) up on Old Pirates route and reported it to CBC. Additionally, over the summer of 2019, CBC received four bat observations from the northern Front Range, suggesting outreach from having researchers may be another effective technique for acquiring bat roost data.

This study was a pilot program to evaluate what were safe and effective sampling techniques for bat-specific climbing surveys, while discovering new bat roosts in the JCOS and OSMP properties. Surveys were originally designed to be conducted by two people, one climber and one belayer, as the climber ascended the route collecting data. However, researchers found surveying from a top-rope anchor to be easier and less time consuming. When sampling could be done in this fashion, each climber could survey independently, belaying themselves using a device, such as a Petzl Grigri or Micro Traxion. Without the fear of wasting one surveyor's time on belay, the climber could sample regions more thoroughly. This is not always feasible, but in an area with a host of top-rope routes, there may be options to double productivity. Another alteration to the original sampling design was survey direction. We originally intended surveys to start at the base and work to the top, but in many instances it was safer and easier to climb to the top or start at the top and descend using less effort than climbing, stopping, and surveying at each stop. Additionally, we originally segmented a route into four equal lengths to ensure regular sampling of a route. However, not every climb had cracks at each height segment, so sampling at that location would have been fruitless. Instead, researchers used the height segments as a guide, and hunted for cracks near those height intervals. Most equipment worked adequately for the rigors of climbing surveys, but the endoscopic cameras made viewing in cracks challenging because of: 1. Sun glare off of the screen; or 2. Impacts to the camera lens. We first used a Milwaukee M12 handheld camera with a handle that had a protective ring of metal that helped prevent the lens from scratching, but periodically had difficulty transmitting the camera images to the screen. Additionally, this camera, with a big handle, took up a lot of space and was not always easy to climb with. Our second camera was a Teslong NTS 150 that had a much smaller profile, had a longer endoscopic arm, and a bigger screen. Unfortunately, this camera did not have the protective rim of metal around the lens and, thus, the Teslong lens became scratched and made images more difficult to see. Future tests of robust, low-profile cameras with well-protected lenses should be conducted. Alternately, using protective tape around the rim of the lens may prolong its life.

Night surveys prior to climbing provided useful data on where bats were active prior to climbing surveys, but were not essential for detecting bats in cracks. For example, thermal camera imagery was not clear enough to identify roosts that bats were exiting from, and acoustic data only provided information about what bats flew and vocalized in the area. In hindsight, acoustic recordings provide enough information to suggest bats may be using features in the climbing area and are easier to implement and use. Thermal cameras may prove more valuable once a large roost is detected. By climbing and establishing such cameras near the roost, biologists may be able to monitor the number of bats that are using a particular roost.

We see the use of climber-based bat surveys as a valuable information resource. Although bats do not roost in high densities along routes we surveyed at JCOS or OSMP, we were able to detect well-hidden bat roosts that may be regularly-used resources. In areas where there is prior knowledge of active bat roosts, the productivity of such climbing surveys may be higher. With that said, such surveys cannot detect all bats that use cliff resources. Our surveys were restricted to those areas where active climbing routes exist. Many bats may choose to roost away from climbers if climbing activity deters their presence and use (Wilson and Adams 2017). Although there is evidence bat use is not altered by climber activity (Loeb and Jodice 2018), a full understanding of the stress bats experience from proximate climbing activity is difficult. Encouragingly, there are numerous accounts from CBC of bats remaining in cracks as climbing occurs in the area, and some bats will reside in a crack after it is used as a handhold during a climb (pers. obs. RAS). As more bat roost are documented by climbers it is essential that pre- and post-climbing surveys be conducted to better assess bat response to climbing activity.

Acknowledgments

We would like to thank Will Keeley of OSMP and Chelsea Beebe of JCOS for their guidance and collaboration. We also thank JCOS Park Ranger Eric Krause, climber Josh Pollock, and the JCOS Fixed Hardware Review Committee for their hospitality, interest, and input. Lastly, we thank Phil Knecht of Devil's Tower National Monument for his advice and guidance. This project was funded by small grants from JCOS and OSMP.

Literature Cited

Adams, M., and K. Zaniewski. 2012. Effects of recreation rock climbing and environmental variation on a sandstone cliff-face lichen community. Canadian Journal of Botany 90:253-259.

Ancillotto, L., J. Rydell, V. Nardone, and D. Russo. 2014. Coastal cliffs on islands as foraging habitat for bats. Acta Chiropterologica 16:103-108.

Arnett, E. B., and E. F. Baerwald. 2013. Impacts of wind energy development on bats: implications for conservation. Pp. 435-456 in Bat evolution, ecology, and conservation (eds. R. A. Adams and S. C. Pederson). Springer Science and Business Media, New York.

Azmy, S. N., S. A. M. Sah, N. J. Shafie, A. Ariffin, Z. Majid, M. N. A. Ismail, and M. S. Shamsir. 2012. Counting in the dark: non-intrusive laser scanning for population counting and identifying roosting bats. Scientific Reports 2:524.

Bogan, M. A., P. M. Cryan, E. W. Valdez, L. E. Ellison, and T. J. O'Shea. 2003. Western crevice and cavity-roosting bats. Pp. 69-77 in Monitoring trends in bat populations of the United States and territories: problems and prospects (eds. T. J. O'Shea and M. A. Bogan). Information and Technical Report USGS-BRD-ITR-2003-0003.

Boyles, J. G., P. M. Cryan, G. F. McCracken, and T. H. Kunz. 2011. Economic importance of bats in agriculture. Science 332:41-42.

Britzke, E. R., E. H. Gillam, and K. L. Murray. 2013. Current state of understanding of ultrasonic detectors for the study of bat ecology. Acta Theriologica 58:109-117.

Burgin, C. J., J. P. Colella, P. L. Kahn, and N. S. Upham. 2018. How many species of mammals are there? Journal of Mammalogy 99:1-14.

Camp, R. J., and R. L. Knight. 1998b. Rock climbing and cliff bird communities at Joshua Tree National Park, California. Wildlife Society Bulletin 26:892-898.

Chambers, C. L., M. J. Herder, K. Yasuda, D. G. Mikesic, S. M. Dewhurst, W. M. Masters, and D. Vleck. 2011. Roosts and home ranges of spotted bats (*Euderma maculatum*) in northern Arizona. Canadian Journal of Zoology 89:1256-1267.

Cordell, H. K. 2012. Outdoor recreational trends and futures: a technical document supporting the forest service 2010 Resources Planning Act assessment. U.S. Forest Service General Technical Report SRS-150. 167 pp.

Covy, N., L. Benedict, and W. Keeley. 2019. Rock climbing activity and physical habitat attributes impact avian community diversity in cliff environments. PLOS One 14:e0209557.

Davis, S. K., R. Schorr, and B. Kuhn. 2017. Climbers for Bat Conservation: methods in forming a novel partnership. Pp. 81-94 in (C. Ward, ed) Wildlife: Perceptions, Threats, and Conservation. Nova Science Publishers, Hauppauge, NY.

Emmons, G. 2007. Catching thermals and sharing cliffs: balancing climbing activities and raptor nesting at Pinnacles National Monument. Joint Meeting of Ecological Society of America and Society of Ecological Restoration, San Jose, California.

Fernandez, A. Z., A. Tablante, S. Beguin, H. C. Hemker, and R. Apitz-Castro. 1999. Draculin, the anticoagulant factor in vampire bat saliva, is a tight-binding, noncompetitive inhibitor of activated factor X. Biochimica et Biophysica Acta 1434:135-142.

Foley, J., D. Clifford, K. Castle, P. Cryan, and R. S. Ostfeld. 2011. Investigating and managing the rapid emergence of white-nose syndrome, a novel, fatal, infectious disease of hibernating bats. Conservation Biology 25:223-231.

Frick, W. F., J. F Pollock, A. C. Hicks, K. E. Langwig, D. S. Reynolds, G. G. Turner, C. M. Butchkoski, and T. H. Kunz. 2010. An emerging disease causes regional population collapse of a common North American bat species. Science 329:679-682.

Frick, W. F., S. J. Puechmaille, and C. K. R. Willis 2016. White-nose syndrome in bats. Pp. 245-262 in Bats in the Anthropocene: conservation of bats in a changing world (eds. C. C. Voigt and T. Kingston). Springer, Cham, Switzerland.

Furey, N. M., and P. A. Racey. 2016. Conservation ecology of cave bats. Pp. 463-502 in Bats in the Anthropocene: conservation of bats in a changing world (eds. C. C. Voigt and T. Kingston). Springer, Cham, Switzerland.

Hayes, M. 2012. Bats, mines, and citizen science in the Rockies: volunteers make a difference in Colorado. Bats 30:10-11.

Holzschuh, A. 2016. Does rock climbing threaten cliff biodiversity? – A critical review. Biological Conservation 204:153-162.

Ingersoll, T. E., B. J. Sewall, and S. K. Amelon. 2013. Improved analysis of long-term monitoring data demonstrates marked regional declines of bat populations in the eastern United States. PLOS One 8:e65907.

Johnson, J. S., J. J. Treanor, M. J. Lacki, M. D. Baker, G. A. Falxa, L. E. Dodd, A. G. Waag, and E. H. Lee. 2017. Migratory and winter activity of bats in Yellowstone National Park. Journal of Mammalogy 98:211-221.

Keough, H. L., and D. J. Blahna. 2006. Achieving integrative, collaborative ecosystem management. Conservation Biology 20:1373-1382.

Knecht, P., and A. Lyons-Gould. 2016. Bat roost monitoring at Devils Tower National Monument. U.S. Department of the Interior, National Park Service. 14 pp.

Knecht, P., and A. Lyons-Gould. 2018. Bat monitoring & outreach at Devils Tower National Monument. U.S. Department of the Interior, National Park Service. 25 pp.

Knecht, P., and A. Mandanna. 2017. 2017 bat roost monitoring at Devils Tower National Monument. U.S. Department of the Interior, National Park Service. 18 pp.

Kraijick, K. 1999. Scientists – and climbers – discover cliff ecosystems. Science 283:1623-1625.

Kuntz, K. L., and D. W. Larson. 2006. Influences of microhabitat constraints and rock-climbing disturbance on cliff-face vegetation communities. Conservation Biology 20:821-832.

Kunz, T. H., E. Braun de Torrez, D. Bauer, T. Lobova, and T. H. Fleming. 2011. Ecosystem services provided by bats. Annals of the New York Academy of Sciences 1223:1-38.

Larson, D. W., U. Matthes, and P. E. Kelly. Cliffs as natural refuges. American Scientist 87:410-417.

Lemen, C. A., P. W. Freeman, and J. A. White. 2016. Acoustic evidence of bats using rock crevices in winter: a call for more research on winter roosts in North America. Transactions of the Nebraska Academy of Sciences 36:9-13.

Loeb, S. C., and P. G. R. Jodice. 2018. Activity of southeastern bats along sandstone cliffs used for rock climbing. Journal of Fish and Wildlife Management 9:255-265.

Lorch, J. M., J. M. Palmer, D. L. Linder, A. E. Ballmann, K. G. George, K. Griffin, S. Knowles, J. R. Huckabee, K. H. Haman, C. D. Anderson, P. A. Becker, J. B. Buchanan, J. T. Forster, and D. S. Blehert. 2016. First detection of bat white-nose syndrome in western North America. mSphere: 00148-16.

Lorite, J, F. Serrano, A. Lorenzo, E. M. Cañadas, M. Ballesteros, and J. Peñas. 2017. Rock climbing alters plant species composition, cover, and richness in Mediterranean limestone cliffs. PLOS One 12:e0182414.

Maples, J. N., M. J. Bradley S. Giles, R. Leebrick, and B. Clark. 2019. The economic impact of rock climbing in the New River Gorge region. Report submitted to Access Fund and New River Gorge Alliance of Climbers.

McMillan, M. A., J. C. Nekola, and D. W. Larson. 2003. Effects of rock climbing on the land snail community of the Niagara Escarpment in southern Ontario, Canada. Conservation Biology 17:616-621.

Műller, S. W., H. Rusterholz, and B. Baur. 2004. Rock climbing alters the vegetation of limestone cliffs in the northern Swiss Jura Mountains. Canadian Journal of Botany 82:862-870.

O'Farrell, M. J., and W. L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy 80:24-30.

Richardson, C. T., and C. K. Miller. 1997. Recommendations for protecting raptors from human disturbance: a review. Wildlife Society Bulletin 25:634-638.

Rolfe, A., and R. Adams. 2015. Rock climbing vs. Rocky-Mountain bats. Annual Conference of the North American Society for Bat Research, Monterey, California.

Schorr, R. A., and J. L. Siemers. 2013. Characteristics of roosts of male pallid bats (*Antrozous pallidus*) in southeastern Colorado. Southwestern Naturalist 58:470-474.

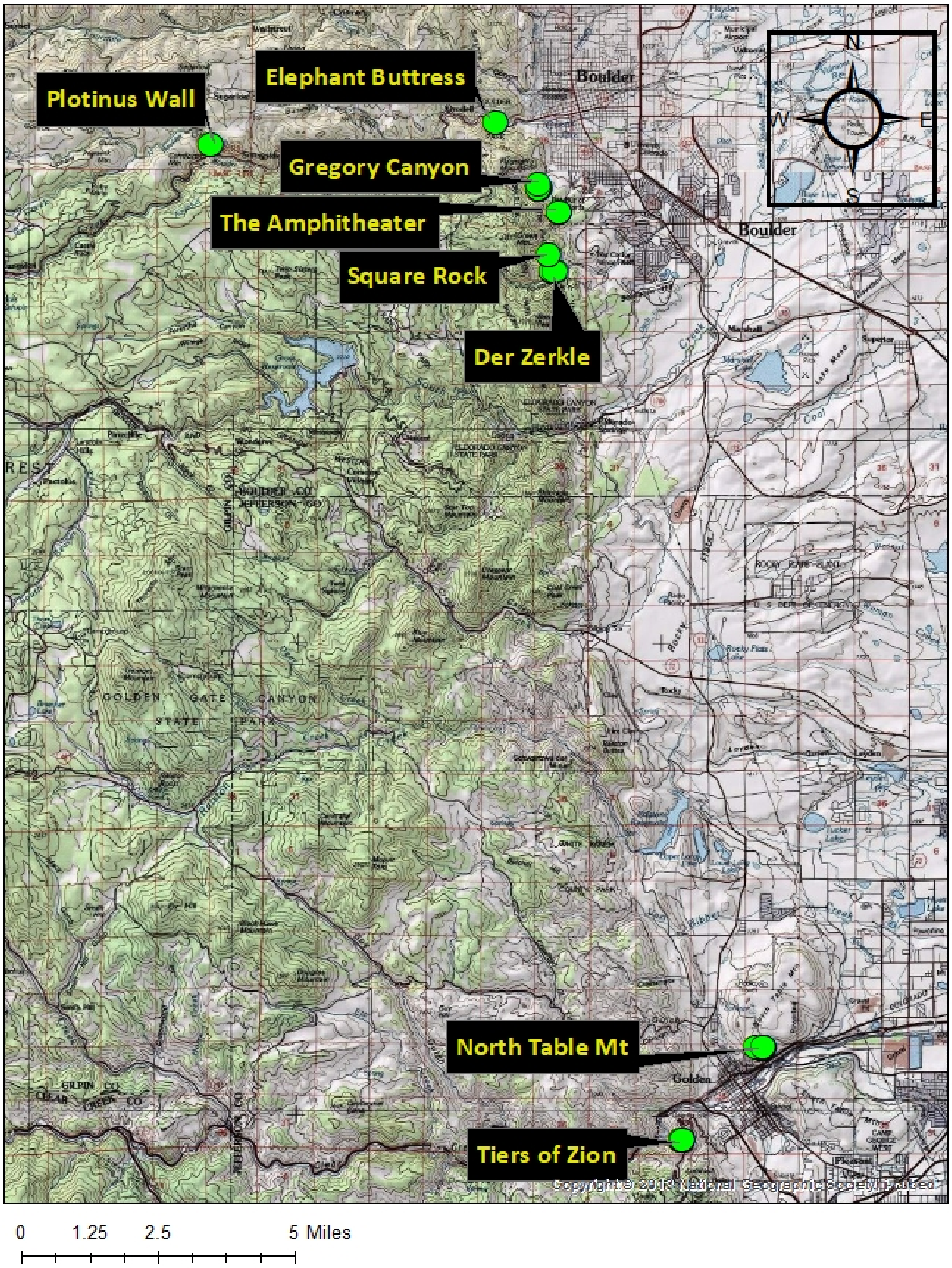
Vogler, F., and C. Reisch. 2011. Genetic variation on the rocks – the impact of climbing on the population ecology of a typical cliff plant. Journal of Applied Ecology 48:899-905.

Voigt, C. C., K. L. Phelps, L. F. Aguirre, M. Corrie Schoeman, J. Vanitharani, and A. Zubaid. 2016. Bats and buildings: the conservation of synanthropic bats. Pp. 427-462 in Bats in the Anthropocene: conservation of bats in a changing world (eds. C. C. Voigt and T. Kingston). Springer, Cham, Switzerland.

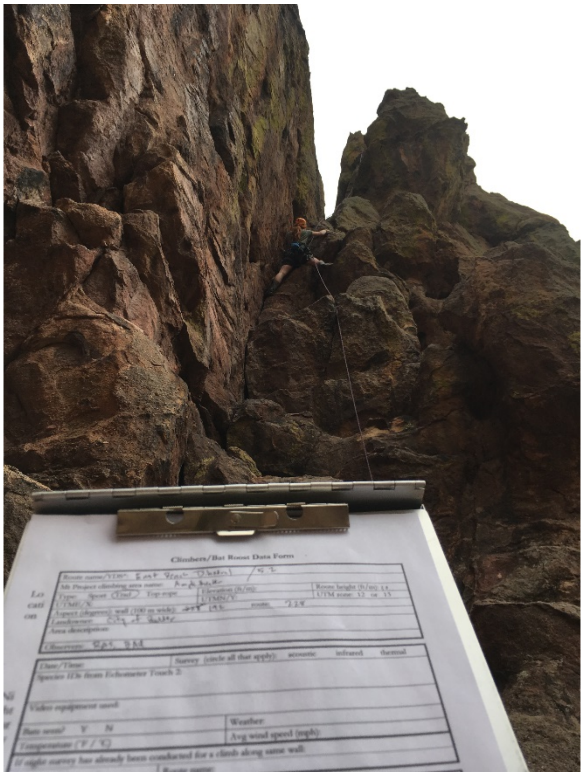
Weller, T. J., T. J. Roadhouse, D. J. Neubaum, P. C. Ormsbee, R. D. Dixon, D. L. Popp, J. A. Williams, S. D. Osborn, B. W. Rogers, L. O. Beard, A. M. McIntire, K. A. Hersey, A. Tobin, N. J. Bjornlie, J. Foote, D. A. Bachen, B. A. Maxwell, M. L. Morrison, S. C. Thomas, G. V. Oliver, and K. W. Navo. 2018. A review of bat hibernacula across the western United States: implications for white-nose syndrome surveillance and management. PLOS One 13:e0205647.

Wilson, A. K., and R. A. Adams. 2017. Bats, boulders, and biodiversity: the influence of rock climbing on cliff face ecosystems. Annual Conference of the North American Society for Bat Research. Knoxville, Tennessee.

Figure 1. Climbing areas where climbers searched for bats on Jefferson County Open Space and City of Boulder Open Space and Mountain Park lands, 2019.



Figures 2 – 5: Clockwise from top left:
Figure 2: Researcher (RAS) transcribing while climber-biologist (BAH) communicates data
Figure 3. Climber-biologist (MDM) transcribing data in the field
Figure 4. Climber-biologist (BAH) climbing a route
Figure 5. *Myotis* found along Trident route



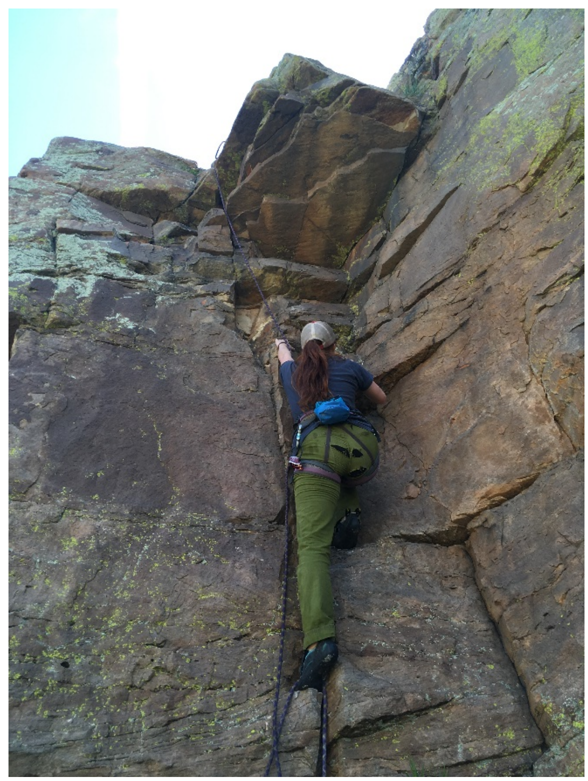


Figure 6. Climbing and bat roost survey data form example (from Standard Inside East Face)

Climbers/Bat Roost Data Form

Location

Route name/YDS*: Standard Inside East Face 5.1		Pics taken? (Y)/N
Mt Project climbing area name: Gregory Canyon		
Type: Sport (Trad) (Top-rope)	Elevation (ft/m): 6134	Route height (ft/m): 55
UTME/X: 75523	UTMN/Y: 26620	UTM zone: ~~12~~ or (13)
Aspect (degrees): wall (100 m wide): 70	route: 70	
Landowner: OSMP		
Area description: Amphitheater. Hot during the day. View of talus slope. No large trees → small shrubs		
Observers: Michael Bailey		

Night Survey

Date/Time:	Survey (circle all that apply): acoustic infrared thermal	
Species IDs from Echometer Touch 2:		
Video equipment used:		
Bats seen? Y N	Weather:	
Temperature (°F / °C)	Avg wind speed (mph):	Night-sky reading:
If night survey has already been conducted for a climb along same wall:		
Date:	Route name:	

Climbing Survey

Date/Time: 5:30pm 8/6	Climber: Michael		Belayer: —	
Total height/5 = [ ]	Stop 1 40'	Stop 2 30'	Stop 3 20'	Stop 4 5'
Crack? If "yes", width (cm/in) If "no" = NA	(3piece) .3"	.5"	1"	3'
Bats (Y/N)	!!! Y !!!	N	N	N
Crack orientation? Vert/Horiz/Diag	Vert	Diag	Diag	Diag
Guano (Y/N)	N	N	N	N

Bat Obs

Height of bat roost (m/(ft)): 42	Width of crack at bat (cm/in): .3 piece
Depth of bat in crack (cm/m/(in)/ft): 4"	Crack orientation: (vertical) horizontal diagonal
Depth of crack at roost (cm/m/(in)/ft): 15	Distance to top of climb (m/(ft)): 13
Is there an overhang at roost? (Y) N	Sign: Guano Staining Mouse Rat Bird N/A
roost temperature (°F)/ °C): 93.4	
comments: CUTE! roof at top of crack	small ears dime face size quarter gold face black wings

*Yosemite Decimal System

Table 1. Climbing routes that were climbed to survey for bats in Jefferson County Open Space and City of Boulder Open Space and Mountain Park lands, 2019. YDS = Yosemite Decimal Scale.

Land Owner	Climbing Area	Route Name	YDS	YDS simple	Type of Climb	Elevation (ft)	UTME	UTMN
City of Boulder Open Space and Mountain Parks	Amphitheater/Gregory Canyon	Direct West Bench	5.6	5.6	Trad/Top-rope	6,134	475533	4426630
City of Boulder Open Space and Mountain Parks	Amphitheater/Gregory Canyon	East Bench Dihedral	5.2	5.2	Trad	6,136	474993	4427334
City of Boulder Open Space and Mountain Parks	Amphitheater/Gregory Canyon	Inset	5.5	5.5	Trad/Top-rope	6,134	475533	4426630
City of Boulder Open Space and Mountain Parks	amphitheater/Gregory Canyon	Red Gully	5.10a	5.10	Trad	6,134	475446	4424890
City of Boulder Open Space and Mountain Parks	Amphitheater/Gregory Canyon	Red Wall (Raptors in Cellophane	5.10	5.10	Sport	6,165	474967	4427323
City of Boulder Open Space and Mountain Parks	Amphitheater/Gregory Canyon	Standard Inside East Face	5.7	5.7	Trad/Top-rope	6,134	475533	4426630
City of Boulder Open Space and Mountain Parks	Amphitheater/Gregory Canyon	Standard Inside East Face	5.7	5.7	Trad/Top-rope	6,134	475533	4426630
City of Boulder Open Space and Mountain Parks	Amphitheater/Gregory Canyon	West Bench Dihedral	5.4	5.4	Trad/Top-rope	6,134	475533	4426630
City of Boulder Open Space and Mountain Parks	Der Zerkle	Feeling Lucky	5.10a	5.10	sport/toprope	6,690	475336	4424899
City of Boulder Open Space and Mountain Parks	Der Zerkle	Final Solution	5.8	5.8	Trad	6,680	475343	4424891
City of Boulder Open Space and Mountain Parks	Der Zerkle	What if you're not?	5.7	5.7	sport/toprope	6,690	475336	4424899
City of Boulder Open Space and Mountain Parks	Dinosaur Rock	crack splitting Dinosaur Rock	4th class	NA	Trad	6,383	475433	4424876
City of Boulder Open Space and Mountain Parks	Elephant Buttresses	Chimney	5.6	5.6	Trad/Top-rope	6,339	473671	4429234
City of Boulder Open Space and Mountain Parks	Elephant Buttresses	Pine Tree Route	5.7	5.7	Trad	5,578	473671	4429234
City of Boulder Open Space and Mountain Parks	Plotinus Wall	Golden Slumber	5.10d	5.10	Sport/Trad	7,070	465287	4428591
City of Boulder Open Space and Mountain Parks	Plotinus Wall	Mr.Sandman	5.10a	5.10	Sport	7,078	465300	4428590
City of Boulder Open Space and Mountain Parks	Square Rock	Crack	5.11c	5.11	Toprope	6,268	475237	4425355
City of Boulder Open Space and Mountain Parks	Square Rock	Yellow Christ	5.12Bb	5.12	Toprope	6,268	475237	4425355
City of Boulder Open Space and Mountain Parks	Third Pinnacle/Gregory Canyon	Halls Of Ivy	5.3	5.3	Trad/Top-rope	6,205	474964	4427299
City of Boulder Open Space and Mountain Parks	Third Pinnacle/Gregory Canyon	Thin Crack	5.4	5.4	Trad/Top-rope	6,210	474949	4427317
City of Boulder Open Space and Mountain Parks	Third Pinnacle/Gregory Canyon	Trident	5.7	5.7	Trad/Top-rope	6,194	474954	4427312
City of Boulder Open Space and Mountain Parks	Third Pinnacle/Gregory Canyon	Trident	5.7	5.7	Trad/Top-rope	6,194	474954	4427312
City of Boulder Open Space and Mountain Parks	Third Pinnacle/Gregory Canyon	Wide Crack	5.4	5.4	Trad/Top-rope	6,210	474966	4427425

Table 1 (cont.). Climbing routes that were climbed to survey for bats in Jefferson County Open Space and City of Boulder Open Space and Mountain Park lands, 2019. YDS = Yosemite Decimal Scale.

Land Owner	Climbing Area	Route Name	YDS	YDS simple	Type of Climb	Elevation (ft)	UTME	UTMN
Jefferson County Open Space	Brown Cloud Rocks/North Table	Big Dihedral	5.8	5.8	Trad/Top-Rope	6,330	481566	4402071
Jefferson County Open Space	Brown Cloud Rocks/North Table	Christmas Night	5.5	5.5	Trad/Top-Rope	6,360	481578	4402091
Jefferson County Open Space	Brown Cloud Rocks/North Table	Crack	5.6	5.6	Trad/Top-Rope	6,330	481578	4402074
Jefferson County Open Space	Brown Cloud Rocks/North Table	Crack (2 cracks left of Interface)	5.7+	5.7	Trad/Top-Rope	6,330	481552	4402063
Jefferson County Open Space	Brown Cloud Rocks/North Table	Chimney	5.6	5.6	Trad/Top-Rope	6,330	481578	4402074
Jefferson County Open Space	Brown Cloud Rocks/North Table	John Adam's Adams Apple	5.7	5.7	Trad/Top-Rope	6,330	481537	4402040
Jefferson County Open Space	Brown Cloud Rocks/North Table	Killians Dead	5.6	5.6	Trad/Top-Rope	6,330	481537	4402040
Jefferson County Open Space	Brown Cloud Rocks/North Table	The Ark	5.6	5.6	Trad/Top-Rope	6,330	481537	4402040
Jefferson County Open Space	Brown Cloud Rocks/North Table	Thick Crust	5.7	5.7	Trad/Top-Rope	6,330	481566	4402074
Jefferson County Open Space	Brown Cloud Rocks/North Table	Unknown Crack	5.10a	5.10	Trad/Top-Rope	6,317	481566	4402071
Jefferson County Open Space	Brown Cloud Rocks/North Table	Unknown Crack	5.10c/d	5.10	Trad/Top-Rope	6,330	481537	4402071
Jefferson County Open Space	Brown Cloud Rocks/North Table	Unknown left of Left Slab	5.7	5.7	Trad/Top-Rope	6,400	481552	4402063
Jefferson County Open Space	Brown Cloud Rocks/North Table	Variation to the Virus	5.9	5.9	Sport	6,330	481566	4402074
Jefferson County Open Space	Brown Cloud Rocks/North Table	Wide Crack	5.7	5.7	Trad/Top-Rope	6,330	481537	4402071
Jefferson County Open Space	Brown Cloud Rocks/North Table	Ypsilon	5.4	5.4	Trad/Top-Rope	6,330	481537	4402071
Jefferson County Open Space	MBA Buttress	Shadow of a Hangdog (Fat Fingers)	5.10b	5.10	Trad	6,320	481347	4402070
Jefferson County Open Space	Overhang Area/North Table	In Between The Lines	5.9	5.9	Sport/Toprope	6,330	481565	4402074
Jefferson County Open Space	Tiers of Zion- Lower Tier	Irie	5.7	5.7	Sport	6,752	479172	4399381
Jefferson County Open Space	Tiers of Zion- Lower Tier	Old Pirates	5.11	5.11	Sport	6,697	479135	4399354
Jefferson County Open Space	Tiers of Zion- Lower Tier	Three Little Birds	5.9	5.9	Sport	6,697	479135	4399354
Jefferson County Open Space	Tiers of Zion- Lower Tier	Unknown Chimney	5.3	5.3	Trad	6,767	479137	4399386
Jefferson County Open Space	Tiers of Zion- Lower Tier- Middle and West walls	Buffalo Soldier	5.10c	5.10	sport	6,280	514015	4316975
Jefferson County Open Space	Tiers of Zion- Lower Tier- Middle and West walls	Lyin' like a Lion	5.10+	5.10	Sport	6,280	514015	4316975
Jefferson County Open Space	Tiers of Zion- Recessed Slab	Beauty for ashes	5.8	5.8	Sport	6,552	490158	4491512
Jefferson County Open Space	Tiers of Zion- Recessed Slab	Cornmeal Porridge	5.7+	5.7	Sport	6,552	490158	4491512
Jefferson County Open Space	Tiers of Zion- Recessed Slab	Don't Rock My Boat Pitch 1	5.7+	5.7	Sport	6,800	479168	4399374
Jefferson County Open Space	Tiers of Zion- Recessed Slab	Don't Rock My Boat Pitch 2	5.7+	5.7	Sport	6,720	479168	4399374

Table 2. Climbing survey data along routes at Jefferson County Open Space and City of Boulder Open Space and Mountain Park lands, 2019

								1st stop along route			2nd stop along route			3rd stop along route			4th stop along route		
Climbing Area	Route Name	Bats seen?	Guano seen?	Date	Height of climb (ft)	Aspect (˚) of wall	Aspect (˚) of route	Height (ft)	Crack width (in)	Orientation of crack	Height (ft)	Crack width (in)	Orientation of crack	Height (ft)	Crack width (in)	Orientation of crack	Height (ft)	Crack width (in)	Orientation of crack
Amphitheater/Gregory Canyon	Direct West Bench	No	No	6-Aug-19	55	20	20	45	1.5	vertical	UNK	5	horizontal	UNK	4	diagonal	UNK	10	horizontal
Amphitheater/Gregory Canyon	East Bench Dihedral	No	No	23-Aug-19	30	192	228	30	1	horizontal	25	1.5	vertical	20	0.5	vertical	15	0.75	vertical
Amphitheater/Gregory Canyon	Inset	No	No	6-Aug-19	60	20	20	35	4	horizontal	30	1	horizontal	20	1	vertical	15	2	vertical
Amphitheater/Gregory Canyon	Red Gully	No	No	8-Aug-19	130	20	20	100	1	vertical	80	2	horizontal	60	1.5	vertical	35	1.5	horizontal
Amphitheater/Gregory Canyon	Red Wall (Raptors in Cellophane)	No	No	6-Aug-19	50	300	300	40	0.5	vertical	35	6	diagonal	20	1	vertical	10	0.75	vertical
Amphitheater/Gregory Canyon	Standard Inside East Face	**Yes**	No	6-Aug-19	55	70	70	40	0.3	vertical	30	0.5	diagonal	20	1	diagonal	5	3	diagonal
Amphitheater/Gregory Canyon	Standard Inside East Face	No	No	6-Oct-19	55	70	70	40	0.4	vertical	35	0.5	diagonal	20	0.4	horizontal	8	2	vertical
Amphitheater/Gregory Canyon	West Bench Dihedral	No	No	6-Aug-19	55	20	20	25	0.4	vertical	20	0.4	vertical	15	4	diagonal	7	0.4	vertical
Brown Cloud Rocks/North Table	Big Dihedral	No	No	2-Aug-19	40	200	300	40	4	vertical	30	1.5	vertical	20	0.5	vertical	10	0.75	vertical
Brown Cloud Rocks/North Table	Christmas Night	No	No	13-Aug-19	30	180	40	25	0.2	vertical	20	0.4	vertical	15	5	vertical	10	8	vertical
Brown Cloud Rocks/North Table	Crack	No	No	13-Aug-19	35	180	120	30	0.5	horizontal	25	3	vertical	NS	0.75	vertical	NS	0.5	vertical
Brown Cloud Rocks/North Table	Crack (2 left of Interface)	No	No	13-Oct-19	30	180	180	30	0.5	vertical	25	0.4	vertical	15	3	vertical	5	0.5	vertical
Brown Cloud Rocks/North Table	Crack/Chimney	No	No	12-Aug-19	35	180	120	35	0.5	horizontal	NS	0.4	vertical	NS	3.5	vertical	NS	2	vertical
Brown Cloud Rocks/North Table	John Adam's Adams Apple	No	No	2-Aug-19	35	168	168	35	8	vertical	25	4	vertical	20	2	vertical	15	0.5	vertical
Brown Cloud Rocks/North Table	Killians Dead	No	No	2-Aug-19	40	168	168	30	4	vertical	20	0.75	vertical	10	3	vertical	5	4	vertical
Brown Cloud Rocks/North Table	The Ark	No	No	2-Aug-19	35	168	168	35	10	vertical	25	8	vertical	15	8	vertical	5	4	diagonal
Brown Cloud Rocks/North Table	Thick Crust	No	No	2-Aug-19	40	200	200	30	20	vertical	30	20	vertical	15	20	vertical	10	1	diagonal
Brown Cloud Rocks/North Table	Unknown Crack	No	No	13-Aug-19	35	180	140	25	0.75	vertical	NS	1	vertical	NS	4	vertical	NS	0.5	vertical
Brown Cloud Rocks/North Table	Unknown Crack	No	No	2-Aug-19	40	210	210	40	N/A	N/A	35	1.5	vertical	20	0.5	vertical	15	4	vertical
Brown Cloud Rocks/North Table	Unknown left of Left Slab	No	No	13-Aug-19	30	180	180	30	3	vertical	NS	2	vertical	NS	1	vertical	NS	0.4	vertical
Brown Cloud Rocks/North Table	Variation to the Virus	No	No	2-Aug-19	35	200	300	35	1	vertical	25	0.75	vertical	20	6	vertical	10	0.75	horizontal
Brown Cloud Rocks/North Table	Wide Crack	No	No	2-Aug-19	40	210	210	40	5	vertical	30	4	vertical	25	5	vertical	10	6	vertical
Brown Cloud Rocks/North Table	Ypsilon	No	No	2-Aug-19	40	210	210	40	1.5	vertical	30	2	horizontal	15	0.4	vertical	3	3	vertical

Table 2 (cont.). Climbing survey data along routes at Jefferson County Open Space and City of Boulder Open Space and Mountain Park lands, 2019

								1st stop along route			2nd stop along route			3rd stop along route			4th stop along route		
Climbing Area	Route Name	Bats seen?	Guano seen?	Date	Height of climb (ft)	Aspect (˚) of wall	Aspect (˚) of route	Height (ft)	Crack width (in)	Orientation of crack	Height (ft)	Crack width (in)	Orientation of crack	Height (ft)	Crack width (in)	Orientation of crack	Height (ft)	Crack width (in)	Orientation of crack
Der Zerkle	Feeling Lucky	No	No	21-Sep-19	50	237	210	45	2	diagonal	35	0.3	diagonal	25	4	d	15	0.3	diagonal
Der Zerkle	Final Solution	No	No	21-Sep-19	45	237	237	40	0.4	vertical	35	0.75	vertical	25	0.75	vertical	15	0.5	vertical
Der Zerkle	What if You're Not?	No	No	21-Sep-19	50	237	210	35	5	pocket	30	0.3	diagonal	25	0.3	diagonal	20	0.3	diagonal
Dinosaur Rock	crack Splitting Dinosaur Rock	No	No	30-Jul-19	115	340	340	100	6	diagonal	80	8	diagonal	60	8	diagonal	40	8	diagonal
Elephant Buttresses	Chimney	No	No	29-Jul-19	90	270	320	100	4	vertical	80	20	vertical	60	2	diagonal	45	1	diagonal
Elephant Buttresses	Pine Tree Route	No	No	29-Jul-19	100	50	270	UNK	UNK	vertical	UNK	UNK	diagonal	UNK	UNK	diagonal	UNK	UNK	diagonal
MBA Buttress	Shadow of a Hangdog	No	No		50	180	100	45	0.3	vertical	35	0.75	vertical	25	0.4	vertical	10	0.4	vertical
Overhang Area/North Table	In Between The Lines	No	No	14-Aug-19	35	200	300	UNK	2	vertical	UNK	1	vertical	UNK	4	vertical	UNK	4.5	vertical
Plotinus Wall	Golden Slumber	No	No	5-Oct-19	75	130	162	70	1	vertical	60	2	vertical	40	1	vertical	15	0.5	vertical
Plotinus Wall	Mr.Sandman	No	No	5-Oct-19	65	130	145	45	0.75	vertical	45	1	vertical	30	2	vertical	25	0.5	vertical
Square Rock	Crack	No	No	13-Jul-19	25	90	90	UNK	0.5 - 1.5	diagonal	UNK	1	vertical	UNK	0.75	vertical	UNK	1	diagonal
Square Rock	Yellow Christ	No	No	13-Jul-19	25	90	90	-	-	-	UNK	0.5	vertical	UNK	0.5	vertical	10	0.5	diagonal
Third Pinnacle/Gregory Canyon	Halls Of Ivy	No	No	22-Aug-19	65	70	150	60	0.5	vertical	50	0.75	vertical	40	0.3	vertical	30	7	diagonal
Third Pinnacle/Gregory Canyon	Thin Crack	No	**Yes**	23-Aug-19	55	70	70	50	0.5	diagonal	40	0.3	diagonal	35	2	horizontal	20	0.3	diagonal
Third Pinnacle/Gregory Canyon	Trident	**Yes**	**Yes**	23-Aug-19	55	70	70	50	1	vertical	40	2	horizontal	35	0.4	vertical	20	7	horizontal
Third Pinnacle/Gregory Canyon	Trident	No	No	6-Oct-19	55	70	70	35	0.3	vertical	30	2	vertical	25	2	diagonal	20	1	diagonal
Third Pinnacle/Gregory Canyon	Wide Crack	No	No	23-Aug-19	55	70	70	50	1	vertical	40	0.4	horizontal	25	1	vertical	10	0.3	diagonal
Tiers of Zion- Lower Tier	Irie	No	No	11-Jul-19	30	330	330	30	2.5	horizontal	25	1.5	vertical	20	1.5	horizontal	8	2	vertical
Tiers of Zion- Lower Tier	Old Pirates	No	No	18-Jul-19	65	west NS	350	65	1.0-3.0	horizontal	60	1.0-3.0	horizontal	30	0.5	vertical	15	2	horizontal
Tiers of Zion- Lower Tier	Three Little Birds	No	No	18-Jul-19	55	350	350	52	6	horizontal	40	0.5	vertical	25	1	vertical	15	0.75	vertical
Tiers of Zion- Lower Tier	Unknown Chimney	No	No	18-Jul-19	60	340	(corner)	50	1.5	(under roof)	45	1	(under roof)	20	2	vertical	15	3.5	vertical
and West walls	Buffalo Soldier	No	No	11-Jul-19	75	80	20	45	4	vertical	35	3	vertical	25	2	vertical	10	2	vertical
and West walls	Lyin' like a Lion	No	No	11-Jul-19	65	20	20	60	N/A	No	40	N/A	No	25	2	horiz	N/A	No	N/A
Tiers of Zion- Recessed Slab	Beauty for ashes	No	No	11-Jul-19	30	300	300	24	0.5	horizontal	18	N/A	N/A	12	4	diagonal	4	N/A	N/A
Tiers of Zion- Recessed Slab	Cornmeal Porridge	No	No	18-Jul-19	50	300	300	45	7	diagonal	40	2	flake	35	3	vertical	20	1	vertical
Tiers of Zion- Recessed Slab	Don't Rock My Boat Pitch 1	No	No	6-Aug-19	100	325	325	100	0.3	vertical	85	1.75	diagonal	50	0.3	diagonal	NS	N/A	None
Tiers of Zion- Recessed Slab	Don't Rock My Boat Pitch 2	No	No	6-Aug-19	110	325	325	65	1	vertical	55	2	diagonal	45	4	horizontal	35	3	vertical

Table 3. Bat observations along climbing routes and night survey data at those climbing routes in City of Boulder Open Space and Mountain Parks lands, 2019. Note: no bats were found along climbing routes in Jefferson County. Note: only 1 bat was found at each location.

Route Name	**Land Owner**	**Date**	**Height of climb (ft)**	**Elevation (ft)**	**Aspect (˚) of wall**	**Aspect (˚) of route**	**Height of bat (ft)**	**Width of crack at bat (in)**	**Depth of bat in crack (in)**	**Depth of crack at roost (in)**	**Distance to top of climb (ft)**	**Overhang present?**	**Other sign?**	**Temperature of roost (˚F)**
Standard Inside East Face	City of Boulder Open Space and Mountain Parks	6-Aug-19	55	6,134	70	70	42	0.3	4	15	13	Yes	None	93.4
Trident	City of Boulder Open Space and Mountain Parks	23-Aug-19	55	6,194	70	70	35	0.4	16	16	20	Yes	Guano	82.5

										Number of bat calls by species detected using EchoTouch 2 ultrasonic recorder					
	Night Survey conducted?	**Date of Night Survey**	**Time of Night Survey**	**Type of Survey**	**Bats seen?**	**Weather**	**Temperature during Night Survey (˚F)**	**Average Windspeed during Night Survey (mph)**	**Night Sky reading**	***Lasiurus borealis***	***Lasiurus cinereus***	***Lasionycteris noctivagans***	***Eptesicus fuscus***	***Myotis ciliolabrum***	***Myotis lucifugus***
Standard Inside East Face	Yes	8-Aug-19	20:45-21:45	Acoustic, Thermal	Yes	Overcast/ light rain	74.5	0	18	0	16	3	1	0	0
Trident	Yes	22-Aug-19	20:30-21:30	Acoustic, Thermal	Yes	Scattered storms	75.6	0	18.8	1	0	1	2	4	2