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Title	Recreational impacts on unmanaged campsites in Daisetsuzan National Park and suitable management strategy to enhance site sustainability [an abstract of entire text]
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Description	この博士論文全文の閲覧方法については、以下のサイトをご参照ください。 https://www.lib.hokudai.ac.jp/dissertations/copy-guides/
Degree Grantor	北海道大学
Degree Name	博士(環境科学)
Dissertation Number	甲第15220号
Issue Date	2022-12-26
Doc URL	https://hdl.handle.net/2115/87923
Type	doctoral thesis
File Information	Wang_Ting_summary.pdf

Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

Recreational impacts on unmanaged campsites in Daisetsuzan National Park and suitable management strategy to enhance site sustainability

(大雪山国立公園の野営指定地におけるレクリエーションの影響と持続可能性を高めるための適切な管理戦略)

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Background

National parks listed as IUCN's category II of protected areas (PAs) are managed for conserving large-scale natural ecosystems while providing recreation use within an acceptable level (no significant geoecological degradation of natural resources).

National parks have been playing a vital role in providing recreation opportunities for visitors chasing outdoor experiences in the natural environment. The popularity of nature-based recreation is increasing worldwide (Newsome et al. 2012; Eagles 2014; Ankre et al. 2016). The increasing recreation use not only disturb the natural environment but also deteriorate the quality of visitor experience (Shelby and Heberlein 1986; Hammitt et al. 2015; Cadoret 2021; Fidelus-Orzechowska et al. 2021). These impacts induced by increasing use make the management of national parks challenging. Deciding clear standards for an acceptable amount of use and resource impacts in different environmental settings is one of the necessary actions to deal with this challenge (Frissell and Stankey 1972; Stankey and McCool 1984; Buckley 1991; Manning 2011).

The management of national parks has been developed unevenly because of the different policies and resources available worldwide. However, the advanced management actions that protect natural resources in one PA can also become a good reference for other places facing the same problem.

Trekking and camping are the main recreation activities provided in most mountain national parks. As altitude ascends, the accessibility, available management, and environment can change considerably, enabling diverse trekking and camping opportunities.

Backcountry campsites are essential accommodation facilities in remote mountain areas with few lodges. Overnight users who conduct long-distance trips in the mountains, either by trekking or other approaches, spend much of their time in campsites. The concentrated transport of campers usually causes locally severe ecological impacts on natural resources (Cole 1981, 1982).

A campsite usually consists of a highly impacted core area, an inter-site area, and a buffer zone where the resources are not disturbed. The majority of the impacts, such as vegetation loss and soil compaction, are contributed by the core area of campsites. The heavily compacted soil causes greater water run-off through the core area, leading to soil erosion in campsites (Eagleston and Marion 2017). In inter-site areas, complicated informal trail networks are the major impacts that usually result from campers' movement between individual sites or between campsites to

toilets/water sources (Cole 1993; McEwen et al. 1996; Smith and Newsome 2002; D'Antonio et al. 2013; Dixon and Hawes 2015; Hammitt et al. 2015).

Bare ground expansion is one of the major camping impacts that increases over time (Cole and Marion 1986; Cole and Hall 1992). Merriam and Smith (1974) identified the site expansion pattern that includes expanding to the contiguous areas of original sites and developing satellite sites in proximity. Daniels and Marion (2006) suggested that extensive bare ground occurs easily in popular campsites surrounded by flat terrain. Marion and Cole (1996) verified the positive relationship between the amount of use and the areal extent of camping impacts.

On the other hand, conflicts and crowding problems are common in popular campsites with high-level use (Aikoh et al. 1994; Aikoh and Asakawa 1998; Daniels and Marion 2006; Cole and Parsons 2013; Wang and Watanabe 2019). Aikoh and Asakawa (1998) demonstrated that uncomfortable camping experiences increased when the use level of a specific campsite exceeded the acceptable level perceived by campers.

In the management of backcountry campsites, great efforts are taken to control site expansion and proliferation of new sites, thus, minimizing the aggregate camping impacts. It is verified that dispersed use in remote areas can lead to a decrease in camping impacts only when campers successfully select a durable place to pitch their tents and conduct low-impact camping based on leave-no-trace guidelines (Hammitt et al. 2015; Marion et al. 2018). On the other hand, concentrating use on designated sites takes a good effect in reducing areal impacts in campsites with moderate-/high-level use (Farrell and Marion 2000; Marion and Farrell 2002; Reid and Marion 2004; Daniels and Marion 2006).

Constructing side-hill campsites on sloping terrain was verified to be effective in constraining areal impacts and was practiced widely in backcountry campsites in the USA (Marion and Farrell 2002; Daniels and Marion 2006; Eagleston and Marion 2017). In addition, Marion (2003) suggested that management actions such as placing logs to mark the campsite borders also help to concentrate camping use within core areas.

Managers conduct periodic site maintenance or even site hardening in most developed campsites to avoid serious degradation of campsites (Hammitt et al. 2015). In Australia, hardening campsites by installing tent platforms were practiced to reduce soil erosion (Dixon and Hawes 2015). Meanwhile, the tent platforms on campsites also took a good effect on concentrating use. These active management actions are considered necessary for ensuring the campsites always be attractive to users, therefore, avoiding the creation of new sites (Hammitt et al. 2015).

Monitoring campsite conditions and use levels is necessary for assessing the site sustainability and the effectiveness of existing management actions. Recording site conditions through repeated photography, condition class ratings, and multiple parameter rating systems are typical methods for monitoring campsite conditions (Hammitt et al. 2015). These established methods were widely used in the quantification of changes in vegetation cover and bare ground over time, either through visual estimates or through exact areal measurements (Cole 2013; Arredondo et al.

2021). However, no studies have been conducted to quantify soil erosion that gradually appeared on degraded campsites without the protection of vegetation cover.

Introducing a registration system of overnight users at trailheads and visitor centers, or even through an online reservation system of campsites, is a currently available method used for monitoring camping use. However, an understanding of backcountry camping use is still lacking in national parks without such a registration system.

In Daisetsuzan National Park (DNP), northern Japan, formal management of the backcountry campsites has been lacking. Serious soil erosion and crowding problems were observed on some unmanaged campsites in the alpine zone. Although previous studies have pointed out the necessity of introducing formal management to the campsites in DNP (Sakamoto 1991; Watanabe 1998; Aikoh 2002; Wang and Watanabe 2019), no actions have been conducted until now. It is suggested that managers should select suitable management actions based on the use level and the intensity of impacts on campsites. To develop a suitable and effective management strategy for the unmanaged campsites in DNP, a comprehensive understanding of camping impacts and use levels in the unmanaged campsites is necessary.

Meanwhile, advanced campsite management actions such as reservation of campsites and installation of tent pads/tent platforms were suggested to solve the crowding problems and enhance site sustainability (Dixon and Hawes 2015; Hammitt et al. 2015). However, studies are needed to identify the possibility of introducing these actions to DNP based on the understanding of necessary costs and specific management efforts. Yushan National Park, Shei-Pa National Park, and Taroko National Park in Taiwan are representative mountain national parks where an online reservation system of backcountry campsites has been introduced. Chubusangaku National Park and Yatsugatake-Chushin Kogen Quasi-National Park are two mountain natural parks in Japan where tent pads/tent platforms are actively introduced to the backcountry campsites. These national/quasi-national parks with similar mountain environments are selected as target parks to study the exact effects and challenges of introducing those advanced management actions to backcountry campsites in mountain national parks.

Objectives

This study is designed to monitor the camping impacts and use level comprehensively and explore the possible management approaches to enhance site sustainability. The specific aims of this study are 1) to quantify areal camping impacts at all the unmanaged campsites in DNP, 2) to assess the site sustainability of selected campsites based on the areal impacts and use level, 3) to monitor soil erosion on heavily degraded campsites, 4) to identify the effectiveness and necessary efforts of introducing reservation system and tent pads/platforms to backcountry campsites, and 5) to identify the possibility of introducing reservation system and tent pads/platforms to the unmanaged campsites in DNP. Based on these results, this study would like to develop a sustainable campsite management strategy for DNP and enrich the approaches for monitoring impacts in backcountry campsites.

Study areas and methodology

Daisetsuzan National Park

Daisetsuzan National Park (DNP) is the largest national park in Japan. It covers an area of approximately 2267.64 km^2 in central Hokkaido. There are 38 peaks above 1500 m. Alpine landforms, flora, and fauna are widely distributed. The highest peak, Mt. Aasahi-dake (2291 m), is often called the roof of Hokkaido. Trekking and camping are limited to three months, from the end of June until the end of September. There are eight huts for emergency use in the alpine zone. Two huts (Ishimuro hut and Hakuun-dake hut) provide accommodation during the camping season. Long-distance overnight trekkers use 12 campsites at most when staying in the area

Most of the 12 campsites are situated in a fragile alpine setting. Different from the nine campgrounds located in the subalpine zone, these 12 campsites are unmanaged. During the off-season period, these campsites are covered by thick snow for three-quarters of a year. Heavy precipitation and the continuous supply of snowmelt water in summer cause serious soil erosion in campsites and trails.

The most popular campsite is the Kuro-dake campsite. It is located approximately 0.8 km southwest of the peak of Mt. Kuro-dake. Most visitors use ropeways and chairlifts to reach the peak of Mt. Kuro-dake. Easy access has made it one of the most frequently visited peaks in DNP. The current and former Kuro-dake campsites are representative campsites that suffer serious soil erosion.

Chubusangaku National Park

The Chubusangaku National Park covers an area of 1743.23 km^2 among four prefectures named Niigata, Toyama, Nagano, and Gifu. The main parts of the Northern Japanese Alps (Hida Mountain Range) consist of representative high peaks that rise around 3000 m a.s.l. lying in the national park.

In Chubusangaku National Park, most cabins are owned and managed by private families and companies. There are some campsites next to the cabins, which are designated by the Ministry of the Environment based on the park plan. In most cases, these campsites are also managed and maintained by the owner of the corresponding cabins. Camping season is from April to November. The management and maintenance of the campsites vary from each other. Proactive management actions such as installing tent pads are only implemented in the Enzanso campsite and the Yarigatake-sansou campsite.

Yatsugatake-Chushin Kogen Quasi-National Park

The Yatsugatake-Chushin Kogen Quasi-National Park lies between Nagano and Yamanashi prefectures. It covers an area of 398.57 km^2. Peaks rising 2500 m a.s.l. are widely distributed in the southern part of this park. The highest peak is Mt. Aka-dake (2899 m). Several campsites and cabins are provided for overnight users on the way to Mt. Aka-dake.

The Seitaiso cabin, together with the Shirakoma-no-ike campsite, is the main accommodation facility located on the north bank of Shirakoma-no-ike lake. Camping use is provided all year round. The location of each tent is not designated. Campers can pitch their tents on flat ground or on wooden tent platforms.

Three mountain national parks in Taiwan

In Taiwan, there are nine national parks. Yushan (1031 km^2), Shei-Pa (769 km^2), and Taroko (920 km^2) are the three representative mountain national parks with alpine zones in Taiwan. These three national parks are open for camping all year round, even though the alpine zones are covered with snow in winter.

All campsites in the alpine zone of these three national parks belong to ecological-protected areas. Here, users are required to apply for a park entry permit and a mountain entry permit based on the National Park Act. Users should apply for park entry permits, and mountain entry permits online in advance. Moreover, they should make reservations for campsites and cabins if they wish to conduct overnight trekking trips. Most cabins and all the campsites in the ecological-protected areas are free of charge.

Methodology

The map of campsites in DNP was created based on the online georeferenced aerial photographs provided by the Geospatial Information Authority of Japan (GSI). I measured the distance between the nearest campsites and between a campsite and a major trailhead using the geometry calculation function to identify the distribution of campsites in DNP. Each campsite's altitude was confirmed based on a Digital Elevation Model (DEM) of 10-m resolution provided by GSI to identify the vertical distribution of campsites in the mountains.

This study used georeferenced aerial photographs taken in 2017 to characterize and quantify the severity of bare grounds and informal trails in 12 unmanaged campsites in DNP.

Photographs of campsites taken by lapse cameras (Brinno_TLC_200) at 1-hour interval were used to monitor the use levels and site occupancies of three representative campsites (the Kuro-dake, Hakuun-dake, and Ura-Asahi campsites) in DNP during the camping season of 2019 (July 12–September 25).

The former and current Kuro-dake campsites in DNP were selected as target sites for monitoring campsite soil erosion. For this purpose, high-resolution (<3 cm) digital elevation models (DEMs) of the campsites were created through structure-from-motion (SfM) photogrammetry surveys with ground control points (GCPs) by using photographs taken by pole-mounted cameras/UAVs from 2017 to 2020. In this study, I produced two sets of DEMs of difference (DoD) maps for each campsite over the corresponding study periods by subtracting the early DEM from the latter using the raster calculator in ArcMap 10.8.1.

Volumetric changes were calculated by multiplying the average of certain negative/positive changes in elevations by the corresponding area, where negative

values indicate erosion and positive values indicate deposition. Cells with elevation changes within minimum level of detection were excluded from the calculation.

The structured interview surveys with the managers of three Taiwan's national parks and the managers of three campsites in two Japanese national parks were conducted to assess the effectiveness of the campsite management actions they introduced.

I conducted a literature review and an internet survey to collect information about the availability of campsites and cabins in Yushan, Shei-Pa, and Taroko National Parks. Based on the location data of campsites and cabins collected from official maps of the three national parks and an official document of informal campsites in Taroko National Park, I created maps of the distribution of accommodation facilities in each national park's alpine zone (including some subalpine-zone areas).

In March and June to September 2018, I interviewed the three national park managers to learn about the online application system for park and mountain entry permit, the campsites' reservation systems, and their effectiveness. Structured qualitative interview surveys containing questions regarding the contents mentioned above were conducted separately. Each national park's number of issued permits in recent years was collected from the data available on each national park headquarters' website.

The target campsites in two Japanese national parks are the Enzanso campsite (tent pads) and Yarigatake-sansou campsite (tent pads) in Chubusangaku National Park and the Shirakoma-no-ike campsite (tent platforms) in Yatsugatake-Chushin Kogen Quasi-National Park. Structured qualitative interview surveys were conducted in 2020 with the managers of the three campsites face-to-face or through e-mail. The main questions designed for inquiring about tent pads/tent platforms include three parts: 1) the history of introducing tent pads/tent platforms and the reasons, 2) the necessary cost and efforts for ordinary maintenance, and 3) the effectiveness and challenges. In addition, the existence of the crowding problem during the peak use period and the management actions used to deal with the crowding problem were also asked.

Then, the necessity and possibility of introducing management actions to the campsites in DNP were assessed through social surveys, including questionnaire surveys with users and focused group discussions among the stakeholders.

A questionnaire survey was conducted in 2019 and 2021 to identify users' opinions on the current camping environment in DNP and their attitudes towards introducing specific management actions to the campsites in DNP. In 2019, 56 effective responses were collected at the Kuro-dake campsite through face-to-face surveys. In 2021, 133 effective responses were collected through an online survey. The Pearson Chi-Square test was used to detect the differences between the results of 2019 and 2021. When no differences were detected, the results for 2019 and 2021 were analyzed together.

Focused group discussions among the main stakeholders of DNP were conducted online two times on May 5, 2021, using Cisco Webex Meetings. The main topics were the potential management actions to solve the problems observed in the Kuro-dake campsite, the Ura-Aasahi campsite, and the trail section between the

Minami-numa campsite and the Biei-Fuji campsite. Stakeholders' opinions on introducing each specific management action to the corresponding campsite in DNP were asked during the discussions. The answers were collected by using the vote function in Cisco Webex Meetings. Then, during the following discussion, participants were organized to describe the reasons for their choices and other concerns in more detail. The results were recorded by text.

Results

This study identified various problems existing in the 12 unmanaged campsites in DNP. The spatial distribution of campsites in long-distance sections needs to be reconsidered. Meanwhile, the campsite (e.g., Ura-Asahi campsite) located in short-distance sections that are less visited could be closed as it is of little necessity. The camping activities in unmanaged campsites had caused a total area of 9460 m^2 bare grounds. The complicated informal trails around the campsite, the over-expanded bare ground, and the overuse problem detected in this study might harm the site's sustainability.

In the current Kuro-dake campsite, the total erosion volume from 2017 to 2018 was approximately 2.52 m^3. The gully remained stable during the second study period (September 2018 to September 2019) without any significant elevational changes. The annual erosion rate for each study period was 0.01 m/year and 0.00 m/year, respectively. In the former Kuro-dake campsite, erosion and deposition were assessed between September 2018 and September 2019. The net volumetric change was −1.55 m^3, showing a small amount of soil loss. From September 2019 to September 2020, large-scale erosion became dominant, especially in the central area. The total volume of erosion was 22.67 m^3. The annual erosion rate for each study period was 0.00 m/year and 0.02 m/year, respectively.

Efforts should be made to stop or mitigate further soil erosion in both current and former Kuro-dake campsites. Burying the gullies with boulders and setting up boulders or wooden fences at the termini of the gullies can be a potential solution to stop or mitigate further erosion. Rehabilitation efforts need to be taken into consideration to avoid the development of new gullies in closed sites.

This study first investigated the reservation systems of campsites in three mountain national parks in Taiwan. National-park managers recognized that the introduction of reservation-based campsite management would effectively reduce crowding problems and improve the camping experience. However, it was also found that there is still room for improvement. Particularly, some campsites still have a crowding problem caused by unauthorized camping that needs to be addressed. The potential use of tent pads/tent platforms for enlarging camping space on unideal terrains was identified by this study. The step-type tent pads in Enzanso campsite can take a good effect in reducing soil loss from the campsite. However, the following constant maintenance efforts in mitigating soil erosion are still necessary. In the Yarigatake-sansou campsite, where camping is only allowed on the separated tent pads, conflicts and crowding problems are effectively avoided.

In the survey of 2019, most of the respondents were experienced campers. Approximately 48% of the respondents have experienced camping in the mountains more than seven times. In contrast, among the respondents surveyed in 2021, 41% of them had no experience camping in the mountains. In DNP, many campers showed their preferences for campsites due to more freedom and the enjoyment of the natural environment. The result of the questionnaire survey indicated that there are gaps between the current camping environment and the campers' expectations. Problems related to environmental, social, and management conditions were all confirmed for the campsites in DNP. Management efforts need to be taken to solve the problems.

Many improvements need to be completed by the managers, such as limiting use in crowded campsites and increasing the number of toilets and campsites. Introducing a reservation system and tent pads/platforms to improve the environment of the crowded Kuro-dake campsite is suggested. Repairing the degraded ground surface in some campsites (e.g., the Ura-Asahi campsite and the Hisago-numa campsite) was agreed upon by around 84% of stakeholders (n = 18). More than half of the respondents supported the introduction of tent pads/platforms (n = 189). It could be considered a potential option to improve the camping environment for those degraded campsites

Discussion

Using a lapse camera was verified to be a good option for monitoring use and site occupancy in most campsites in DNP where no permanent managers are assigned. The georeferenced aerial photographs showed that all campsites in DNP have lost all the vegetation on site. Such bare ground induced by human activities is vulnerable to soil erosion, especially in the fragile alpine environment in DNP. This study indicated that simple site closure could not stop further soil loss where gullies exist. Rehabilitation and hardening efforts are necessary to mitigate soil loss caused by gully erosion. Detecting the evidence of soil erosion in campsites from an early stage is essential for providing sustainable camping use while reducing management costs. The SfM photogrammetry surveys used in this study will provide high-resolution 3D models of the campsites, which enables the detection of newly formed gullies. Such approaches can achieve comprehensive monitoring of soil erosion in all 12 campsites in DNP.

Unlike Taiwan's three mountain national parks, no reservation system has been introduced for campsites in DNP's alpine zone. When the campsite is crowded, tents are often pitched in front of the hut or on the trail (e.g., the Kuro-dake campsite).

In the case of DNP, introducing a reservation system mainly for campsites where tents are likely to overflow on crowded days can be a good option. In the popular Kuro-dake campsite, tent overflow repeatedly occurs on certain weekends and holidays around the same dates every year (Wang and Watanabe 2019). In this regard, it is suggested that the reservation system can be introduced only on crowded days. The main obstacle is that there is currently no assignment of a formal manager for the campsite, so the introduction of an immediate reservation system may not be realized.

The Daisetsuzan National Park Council could become the management body responsible for constructing a reservation system and arranging necessary managers to accept reservations and check reservation proofs at campsites. The cost of conducting all the management work mentioned above must be ensured. For example, a 500-yen donation fee/person/night was paid by the campers who camp at the Kuro-dake campsite. Setting up another donation fee item or increasing the current donation fee could be a possible option to cover the cost of introducing a reservation system.

When introducing a reservation system, the number of available quotas needs to be decided based on the size of the Kuro-dake campsite. The installation of platforms and tent pads provides an advantage insofar as the maximum number of tents per day at a given site can be determined. The capacity of the Kuro-dake campsite could be estimated as 96 persons at maximum after constructing tent pads inside.

In the proposed campsite management framework by this study, monitoring the use levels of campsites by lapse cameras comes first. In the case of the highly degraded Ura-Asahi campsite in DNP, where the use level is low, even a complete site closure is recommended.

In completely closed campsites (e.g., unnecessary campsites) or partially closed campsites (e.g., over-expanded campsites), an inventory of site conditions by collecting 3D data should be conducted before its closure. If any evidence of soil erosion is detected, a site closure accompanied by rehabilitation must be undertaken to promote effective recovery.

All the necessary campsites should be maintained periodically to keep them attractive for campers. To prevent serious soil erosion in campsites, an erosion evidence inventory should be conducted by collecting 3D data of campsites. In the campsites where evidence of soil erosion was identified, continuous monitoring efforts should be planned to track the topographic changes. Once the potential of gully formation is confirmed, actively filling the gullies by boulders to terminate further development would be necessary. The repeated SfM surveys with GCPs can help managers to achieve this goal.

This proposed framework emphasizes the importance of conducting science-directed campsite management by managers. In DNP, the stakeholders who manage different trail sections could be assigned as the managers of the campsites.

The Ministry of the Environment (MoE) should organize training workshops to promote the utilization of consistent monitoring methods among the stakeholders who are going to manage the campsites. It requires the MoE to hire elites with professional knowledge. Another option is collaborating with research institutes or universities (e.g., Hokkaido University) that could provide training workshops for the stakeholders of Daisetsuzan National Park Council.

The insights for conducting effective campsite management in backcountry areas, thus, enhancing the site sustainability, would be spread to the managers of both DNP and other national parks by this study. By promoting the introduction of this proposed framework in national parks, the essential data for sustaining the campsite management could be collected extensively and continuously by managers, which will highly exceed the limited power of researchers.

Conclusions

This study aims to gain a comprehensive understanding of the recreational impacts on unmanaged campsites and to explore potential solutions for reducing unsustainable factors in backcountry campsites in DNP. To achieve these goals, studies addressing the distribution and severity of bare grounds and informal trails, the current use level, site occupancy, and the development of soil erosion were conducted in the unmanaged campsites in DNP. The current bare grounds in 12 campsites and the informal trails radiating from each site were mapped and measured using georeferenced aerial photographs of 2017. The use of lapse cameras in this study enabled the identification of different use levels in the campsites where no managers were stationed. This study successfully quantified the volume of annual soil loss in campsites by conducting repeated SfM surveys with GCPs. High-resolution orthomosaic images produced in SfM surveys were verified as usable for detecting newly formed small gullies in the campsite. An array of interview surveys with the managers of other national parks were conducted to explore the effectiveness of the advanced management actions introduced to their campsites, i.e., reservation system and tent pads/platforms. Then, the necessity and possibility of introducing formal management involving these advanced management actions to the campsites in DNP were analyzed based on the opinions of both users and related stakeholders. Finally, this study proposed a management framework for reducing and preventing the problems that deteriorate the sustainability of campsites in DNP.

This study indicated that the sustainability of the campsites in DNP was damaged by the over-expansion of bare ground, soil erosion, and crowding problem. A good match between the use level and available camping space was considered the key point to avoiding these problems. It requires the inventory of the site occupancy and site condition in each campsite. This study proposed a campsite management framework involving an inventory survey and the corresponding management responses for the campsites under different conditions. This study found that either controlling use within the capacity or increasing capacity by introducing tent pads/platforms could help accommodate the intended use. Periodical site maintenance was essential for providing ideal camping space sustainably. These management actions have played important roles in ensuring the sustainable use of the campsites in three Taiwan's national parks and two Japanese national parks. This study verified that a lapse camera could become a powerful tool for monitoring use levels and site occupancy of backcountry campsites. In addition, the repeated SfM surveys conducted in this study provide novel methods to monitor site degradation and prevent soil erosion at an early stage. The results of this study will promote sustainable campsite management in backcountry settings in DNP and other national parks/PAs.