Site Sustainability of the Unmanaged Campsites in Daisetsuzan National Park, Japan: An Analysis Based on Areal Camping Impacts and Use Level

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Abstract

A higher level of campsite use generally results in a more extensive bare ground. Sustainable campsites must avoid unacceptable levels of bare-ground expansion and social crowding. Both the use level of the site and expansion of the bare ground area are necessary parameters for identifying site sustainability. However, these data are not available for the 12 unmanaged campsites in Daisetsuzan National Park, northern Japan. Therefore, we measured the area of bare ground on each unmanaged campsite and analyzed the site sustainability of the three representative sites based on their use levels. First, we measured the area of bare ground on each of the 12 campsites using georeferenced aerial photographs in ArcMap 10.8.1. The area of bare ground on each campsite ranged from 46 m^2 to 3,603 m^2. Second, the Kuro-dake, Hakuun-dake, and Ura-Asahi campsites were selected to monitor the use level. We set up time-lapse cameras that took photographs of these three selected campsites every hour to record the daily site occupancy from July 12 to September 25, 2019. Among the three selected sites, the bare ground on the Kuro-dake campsite (394 m^2) was the smallest, and that on the Ura-Asahi campsite (1,898 m^2) was the largest. On the busiest day, one tent occupied only 8.8 m^2 on average in the Kuro-dake campsite. However, in the Ura-Asahi campsite, one tent occupied 146.0 m^2 on average. Management actions must be introduced to solve both overcrowding and overexpansion problems on campsites to enhance site sustainability.

Key words: camping impact, use level, sustainable management, national park

I. Introduction

Camping activities on natural surfaces inevitably cause vegetation loss and expansion of bare ground. Higher levels of campsite use generally resulted in more extensive bare ground. In popular campsites, the expansion of the core area, creation of satellite sites, and informal trails induced by inter-site transport can lead to an increase in area of camping impacts (Cole et al., 2008; Eagleston and Marion, 2017; Arredondo et al., 2021). Marion et al. (2018) emphasized that sustainable campsites must avoid unacceptable bare ground expansion and social crowding. Sustainable campsites can provide users with opportunities for high-quality natural experiences. Both the use level and area of bare ground on campsites are necessary parameters for identifying site sustainability.

However, in previous studies, the use level of backcountry campsites in wildlands was usually estimated based on the registered itinerary of users (Cole et al., 2008). It is difficult to check the actual site occupancy using tents when permanent managers are not stationed. The use of lapse cameras can be a new method to monitor campsite use, and it can overcome the limitations of traditional methods.

Daisetsuzan National Park (DNP) in northern Japan has 12 campsites which are unmanaged. Previous studies have detected several problems with unmanaged campsites, including bare ground expansion (Sakamoto, 1991; Aikoh et al., 1995; Wang and Watanabe, 2019), soil erosion (Watanabe, 1998; Wang and Watanabe, 2019, 2022a), crowding problems, and conflicts induced by high use levels (Aikoh et al., 1994; Aikoh and Asakawa, 1998; Aikoh, 2002; Wang and Watanabe, 2019), and informal trails in inter-site areas (Aikoh et al., 1995).

It is believed that visitors tend to explore informal sites when the original campsites are no longer attractive, because of severe resource

degradation or difficult access (Hammitt et al., 2015; Wang and Watanabe, 2019). Site hardening and the use of concentrated campers on side-hill campsites should be considered to avoid extensive bare ground and soil erosion at campsites (Cole, 2013; Hammitt et al., 2015; Marion et al., 2018). Educational efforts and regulation enforcement could be effective in preventing the proliferation of informal visitor-created sites (Reid and Marion, 2004; Daniels and Marion, 2006). These management actions are also necessary to mitigate camping impacts and ensure the sustainable provision of camping opportunities in DNP. Before making any decisions, a comprehensive understanding of current site conditions and use levels is necessary to promote the formal management of unmanaged campsites in DNP.

The variable radial transect method (VRTM) is a traditional method used to accurately measure bare ground at campsites (Marion, 1991). However, on-site implementation typically requires a long period of time. Hockings and Twyford (1997) suggested that aerial photographs enable efficient assessment of campsite impacts in large wilderness settings. However, this method is not applicable for detecting campsites in forests, where visibility from aerial photographs is poor. Meanwhile, in alpine settings, where no forest cover exists, georeferenced aerial photographs show good performance in measuring the area of bare ground induced by recreational activities (Kim, 2010; Monz et al., 2010; Wang and Watanabe, 2019; Fidelus-Orzechowska et al., 2021).

This study aims to measure the areas of bare ground and informal trails in each campsite using aerial photographs and to analyze the site sustainability of three selected campsites based on their use levels. The Kuro-dake, Hakuun-dake, and Ura-Asahi campsites (②, ③, and ⑧ in Fig. 1, respectively) are three representative campsites in the most popular area of DNP. These campsites were selected as target sites to monitor their use level and site occupancy.

Fig. 1

II. Study Area

Daisetsuzan National Park (DNP) in central Hokkaido is a representative mountain national park in Japan (Fig. 1). Camping and trekking are the main recreational activities in summer (from the end of June to the end of September). Unlike other mountain national parks in mainland Japan, no lodges/cabins for commercial purposes are available for accommodation in the alpine zone of DNP. Although there are eight huts in the alpine zone, most are intended for emergency use. Only the Kuro-dake and Hakuun-dake huts provide accommodation for overnight users (Fig. 1). Owing to the limited availability of accommodation huts, most overnight users must camp at 12 designated campsites (before 2022) along trails. Since 2022, the Mae-tengu campsite (43°27′39″ N, 143°2′14″ E, 1,729 m) has been designated the 13th campsite (Fig. 1) after discussions among the members of the Daisetsuzan National Park Council. However, it was not included in this study because the site was designated after the aerial photographs were taken.

DNP is located in one city and nine towns (Fig. 1). Most of the land in this national park is owned by the Forestry Agency of Japan, followed by the Hokkaido Government, rather than the responsible authority of DNP that is the Ministry of the Environment (MoE). The Daisetsuzan National Park Council consists of the MoE, and nine local municipalities were launched in 2012 to promote collaborative national park management in DNP. The problems of land ownership and continuous understaffing make it difficult for the responsible authority to manage campsites. These unmanaged campsites (including the Mae-tengu campsite designated in 2022) are still different from visitor-created informal sites as they are officially designated by the MoE.

The Kuro-dake, Hakuun-dake, and Ura-Asahi campsites are directly connected to the trailheads. However, the availability of basic amenities

differs for each site. The Kuro-dake and Hakuun-dake campsites have easy access to drinking water and toilets. There are no toilets at the Ura-Asahi campsite. Drinking water was mainly provided by snowmelt water derived from the slope next to the campsite until mid-August.

III. Methods

1. Measuring areal impacts on the unmanaged campsites

Aerial photographs covering the area of 12 campsites, which were taken in 2017 by the Forestry Agency of Japan, were used in this study. Digital data from aerial photographs with a resolution of 12 cm were utilized to detect the bare ground and informal trails at each campsite. The aerial photograph of each campsite was georeferenced in the projected coordinate system (WGS 1984 UTM 54 N) based on the satellite image provided in ArcMap 10.8.1. More than 13 detectable ground points were selected from each photograph and used as ground-control points. Polygons of bare ground and polylines of informal trails around each campsite were also created in the same coordinate system. We determined the boundaries of the bare ground based on visual observations from aerial photographs. The connected vegetation cover and boulders surrounding the bare ground were recognized as boundaries. Some sparse vegetation mounds spotted on the campsites were excluded when measuring the area of the bare ground.

Bare grounds within 200-m distance of the designated campsites were considered satellite sites (part of the campsite) and were included in the areal measurement of the bare ground. Bare grounds more than 200 m from the designated campsite were considered as informal sites. The area of bare ground at each campsite was measured using the geometry calculation function in ArcMap 10.8.1. The number of bare grounds and informal trails at each campsite was counted and recorded as the characteristics of each campsite. In this study, all trails that were not

included in the official trail networks shown in the Geospatial Information Authority of Japan (GSI) web map were considered informal trails.

2. Identifying the use level and site occupancy on campsites

We set up lapse cameras (Brinno_TLC_200) at the Kuro-dake Hakuun-dake, and Ura-Asahi campsites (Fig. 2) to record the distribution of the tents from July 12 to September 25, 2019. The camera took photographs of the campsite at 1-hour intervals. During the 76-day study period, the number of tents pitched at the Kuro-dake, Hakuun-dake, and Ura-Asahi campsite were successfully recorded for 68 nights (89%), 68 nights (89%), and 63 nights (83%), respectively. Poor visibility on rainy and snowy days was the main cause of the unsuccessful data collection using lapse cameras at the three campsites. In addition, the lapse camera at the Kuro-dake campsite fell to the ground on August 27 and failed to work for five days (August 27–September 1).

Fig. 2

To identify the arrival patterns of users at each campsite, we counted the number of tents pitched in five different time categories (previous day, –10:00, 10:00–14:00, 14:00–18:00, and 18:00–) per day. At the Kuro-dake campsite some surplus tents pitched on the surrounding trails were not captured by the lapse camera. The tents were not summarized based on the arrival time.

The number of tents pitched at each campsite per night was summarized to identify the variability of use at each site and the differences in use among the three campsites. We conducted a t-test to compare the average use levels between the two campsites. In addition, to identify differences in use levels between weekdays and weekends/holidays, the data were divided into two groups for further analysis. To determine the site occupancy of each campsite on the most crowded day, the average area occupied by each tent was calculated by

dividing the area of each campsite by the corresponding number of tents that night.

IV. Results

1. Bare ground and informal trails at campsites

The number and area of the detected bare ground at each campsite varied greatly (Table 1). At all four campsites, only one bare ground was detected within the camping area (Fig. 3). No satellite sites were observed. The bare ground at the Numa-no-hara Oh-numa campsite was divided into three sections because of the existence of waterways. However, these three bare grounds were counted together as one bare ground, because they were not separated by vegetation cover (Fig. 3). A cluster of more than two separate bare grounds was detected at the other eight campsites (Fig. 4). Several vegetation mounds were identified at the Kuro-dake, Chubetsu-dake, Biei-Fuji, and Kami-Horokamettoku campsites (Table 1, Figs. 3 and 4). At the Minami-Numa campsite, eight separate bare grounds were connected by informal trails. Bare ground, less than 200 m from the Kami-Horokamettoku campsite, was also considered a satellite site (Fig. 4). Three bare grounds were found approximately 482 m north of the Futago-ike campsite. These bare grounds were not mapped as part of the Futago-ike campsite. Instead, they were considered as informal sites.

The area of bare ground at each campsite ranged from 46 m^2 to 3603 m^2. The mean area of bare ground at the campsite in DNP was 780 m^2 (Table 1). The largest bare ground was found at the Numa-no-hara Oh-numa campsite, on the exposed bank of the wetland lake. Large bare ground exceeding 1,000 m^2 in size was found at the Ura-Asahi campsite (Table 1). The aggregate area of bare ground at the 12 campsites in DNP was 9,360 m^2.

The number of informal trails at each campsite ranged from 0 to 12, with a mean of 4.8 (Table 1). Figure 4 shows the complicated network of

Table 1

Fig. 3

Fig. 4

211 informal trails at the Minami-numa campsite, which holds the largest
212 number of separated bare grounds (n = 8). Meanwhile, a large number of
213 informal trails were also found at the Biei-Fuji and Chubetsu-dake
214 campsites, and even fewer bare grounds existed (Table 1). No informal
215 trails were found at the Hakuun-dake and Kotengu campsites, as the main
216 trails running through these campsites (Fig. 3).
217
218 2. Use levels and site occupancy at the three selected sites
219 During the study period, the Kuro-dake campsite was occupied with
220 tents for 61 nights. The Hakuun-dake campsite was occupied by tents for
221 59 nights, and the Ura-Asahi campsite for 41 nights. The arrival times of
222 all tents (n = 466) pitched at the Hakuun-dake campsite were successfully
223 identified from the photographs captured by the laser camera (Fig. 5).
224 Among the 120 tents pitched at the Ura-Asahi campsite, 103 tents were
225 identified by arrival time. At the Kuro-dake campsite, except for surplus
226 tents (n = 31) pitched on the trails, a total of 646 tents pitched in the
227 campsites were identified by arrival time.
228 Table 2 shows that the arrival patterns of tents pitched at the three
229 campsites are significantly different ($\chi^2 = 49.003$, $p < 0.001$). The tents
230 that had been recorded since the previous day were more frequently
231 observed at the Kuro-dake campsite. This indicates that campers at the
232 Kuro-dake campsite tend to occupy sites for more than two nights. By
233 contrast, campers at the Ura-Asahi campsite tended to prefer single-night
234 stays. Campers at the Hakuun-dake and the Ura-Asahi campsites tended
235 to arrive at the sites between 14:00 and 18:00. However, campers at the
236 Kuro-dake campsite tended to avoid arrival at that time. Only a small
237 number of campers arrived after 18:00, which was true for all three
238 campsites.

Fig. 5

Table 2

The mean use levels of the three campsites were different. The mean use level of the Kuro-dake campsite was slightly higher than that of the Hakuun-dake campsite (Table 3). During the 2019 camping season, the daily use level of the Ura-Asahi campsite was extremely low. On most nights, there were fewer than three tents pitched at the campsite (Fig. 6). No significant variation was observed in between weekdays and weekends/holidays (Table 4). The daily use levels of the Kuro-dake and Hakuun-dake campsites were more variable.

Table 3

Fig. 6

Table 4

In most cases, the number of tents pitched at the Kuro-dake campsite ranged from 4 to 13 (Fig. 6). An extremely high level of use was observed at the Kuro-dake campsite over three nights. At the Hakuun-dake campsite, the number of tents per night varied between 2 and 10 (Fig. 6). An extremely high level of use was observed thrice. At both the Kuro-dake and Hakuun-dake campsites, higher mean use levels were observed on weekends and holidays than on weekdays (Table 4).

On the most crowded night (August 14), 56 tents were counted for the Kuro-dake campsite. Among these, 45 tents were pitched at the designated campsite, whereas the other 11 tents were pitched on nearby trails. The largest numbers of tents pitched at the Hakuun-dake campsite (August 13) and the Ura-Asahi campsite (August 14) were 31 and 13, respectively. On the most crowded night, the mean area occupied by one tent at the Kuro-dake campsite was only 8.8 m^2/tent. It is much smaller than that at the Hakuun-dake campsite (24.7 m^2/tent) and the Ura-Asahi campsite (146.0 m^2/tent).

V. Discussion

1. The proliferation of satellite sites and visitor-created informal sites

Long-term monitoring studies on the trend of camping impacts in backcountry settings have suggested that site proliferation has caused a

drastic increase in the aggregate amount of camping impacts (Cole et al., 2008; Cole, 2013). Although camping outside the 12 designated campsites in DNP is not allowed, no strict regulations or laws are applicable to regulate camping activities. At some campsites in DNP, ropes were used to circle the range of the designated camping area (Fig. 7), which aimed to indirectly control the footprints of the campers. However, this information is not clearly conveyed to campers. At campsites where no permanent managers were stationed, campers easily expanded their footprints outside the designated camping area by mistake or deliberately creating a cluster of satellite sites (Fig. 4). The repeated use of satellite sites completely removed the vegetation cover. It was found that bare ground usually attracts repeated use by campers (Hammitt et al., 2015) because these places are usually considered ideal for camping. The repeated use of informal sites results in lasting impacts on the environment (e.g., soil erosion).

Fig. 7

Meanwhile, at campsites with several separate bare grounds, the creation of informal trails (e.g., the Minani-numa campsite, the Biei-Fuji campsite, and the Futago-ike campsite) is inevitable because of the campers' inter-site movement and other transport towards the water source and toilets. Complicated informal trails have led to serious fragmentation of vegetation cover. In alpine settings, these informal trails damage the landscape and threaten the integrity of alpine plant communities, which are typically fragile and rare (Monz et al., 2010). The recovery of vegetation cover in alpine areas usually requires a long time. Although rehabilitation efforts can help increase speed, the cost is usually high.

At campsites where the nearby terrain is not ideal, campers even explore a larger range and create informal sites along trails. Wang and Watanabe (2022b) reported the existence of informal sites in the long-distance trail section between the Minami-numa and Futago-ike campsites.

Fig. 8

The results of our study corroborate this finding. Figure 8 shows 15 informal sites in the trail section between the Minami-numa and Biei-Fuji campsites. Campers who have camped or who have seen other camps at informal sites may continue to use them or explore more in the future.

2. Necessary management efforts for regulating the camping activities in DNP

To avoid further increases in aggregate areal impacts, managers need to make more efforts to address the main causes of the creation of informal sites/satellite sites in DNP.

Amending the current laws to enforce regulations on informal camping activities is difficult. Instead, some educational interactions can help solve this problem. In 2020, national park rangers reported two cases of camping activities at informal sites on the official website of the Daisetsuzan National Park Council (http://www.daisetsuzan.or.jp/manner/). Reporting cases of such an inappropriate camping manner and conveying correct regulations on camping in DNP through multiple platforms (e.g., YAMAP, trekkers' community group on Facebook) are suggested.

Unlike informal sites, national park managers do not strictly prohibit the use of satellite sites. However, unnecessarily expanded bare ground at the satellite sites should be avoided. At campsites where several bare grounds exist, closing unnecessary satellite sites and concentrating their use on one or two main sites can also help reduce the aggregate amount of camping impacts. At the Ura-Asahi campsite, the bare ground was too large for current use (Fig. 6). Even on the most crowded days, a large space remained unused at the main site (Fig. 9). Therefore, it was possible to maintain only the main site close to the other two satellite sites. There were some gullies at the main site that campers might have avoided for use (Fig. 9). To effectively concentrate on the main site, maintenance

Fig. 9

329 efforts are needed to improve the site condition and keep it always
330 attractive. In addition, rehabilitation of closed sites is important to
331 successfully reduce the impact of camping. Without any rehabilitation
332 efforts, little evidence of recovery was found at the former Kuro-dake
333 campsite, even 25 years after its closure (Wang and Watanabe, 2022a). To
334 identify unnecessary satellite sites in the other campsites in DNP, the
335 lapse camera used in this study can be utilized to monitor campsite use.
336 On the other hand, in the long-distance trail section, such as the
337 section between Minami-numa campsite and Futago-ike campsite,
338 managers may consider recognizing the use of a few visitor-created
339 informal sites to reduce walking distance. For instance, recognizing site
340 3 in Fig. 8 as a new campsite would help reduce walking distance. In
341 contrast, other informal sites along the trail should be closed. Setting up
342 signboards at officially recognized sites can also help to concentrate use
343 on them, thus avoiding the further proliferation of new informal sites.
344
345 3. Imbalance between the use level and the available camping
346 space
347 Among the Kuro-dake, Hakuun-dake, and Ura-Asahi campsites, the
348 use level at the Kuro-dake campsite is the highest. However, the available
349 camping space was the smallest. During the 2019 camping season, surplus
350 tents pitched outside of the campsite were observed four times. On
351 crowded days, the mean area occupied per tent was no more than 15.8 m^2
352 (Table 5). On the most crowded day, one tent occupied only an area of
353 8.8 m^2 on average. Such a crowding situation usually damages the quality
354 of campers' experience (Kobayashi and Aikoh, 1994; Aikoh and Asakawa,
355 1998; Wang and Watanabe, 2019). Wang and Watanabe (2019) found that
356 most campers could not find a satisfactory place to pitch their tents in
357 the Kuro-dake campsite on crowded days. Late arrivals had to pitch their
358 tents on the undulating surface around the gully. This may explain why

Table 5

the campers in Kuro-dake tended to avoid arriving later than 14:00 compared to the users of the other two campsites (Table 2).

Figure 10 shows the situation of the three campsites on the most crowded days. The Kuro-dake campsite was overused compared with the other two campsites. In addition, surplus tents further expand the disturbance to the surrounding environment. During the COVID-19 period, people tended to stay far away from the other groups. Thus, more tents may have overflowed outside the campsite, even under the same use level.

Fig. 10

In contrast, the bare ground at the Ura-Asahi campsite was too large for its low use level. Several gullies are observed at the main site (Fig. 9). The limited ideal space for camping might be one of the causes of the excessive expansion of bare ground. The existence of gullies reduced the ideal camping space at the main site, which pushed campers to create satellite sites. Therefore, the development of gully erosion caused additional bare ground expansion at the Ura-Asahi campsite. As gully development continues, the ideal camping space at the main site continuously decreases, which may lead to further site expansion.

An imbalance between the use level and size of the campsites was identified in the three campsites. The overuse problem in the Kuro-dake campsite and the over-expanded bare ground in the Ura-Asahi campsite have deteriorated the sustainability of the campsites. Such imbalanced problems may also exist in other campsites in DNP, which requires further study.

VI. Conclusions

This study identified various problems at 12 unmanaged campsites in DNP. The camping activities in unmanaged campsites resulted in a total area of 9,360 m^2 of bare ground. Proliferation of visitor-created informal sites and satellite sites was detected in DNP, which caused unnecessarily

expanded bare grounds around the designated campsite (e.g., Ura-Asahi campsite) or along the trails. The complicated informal trails around the campsite, over-expanded bare ground, and overuse problems detected in this study may harm site sustainability.

At the Kuro-dake campsite, much higher use levels were identified on weekends and holidays than on weekdays. During the prominent use peaks in August, a total of 31 surplus tents were pitched on the trails near the Kuro-dake campsite. The expansion of resource degradation induced by surplus tents and the overcrowding conditions in the campsite make the Kuro-dake campsite less sustainable. It was verified that the Hakuun-dake campsite has sufficient capability to support the current use level without worries about unnecessary bare ground expansion, indicating high sustainability. At the Ura-Asahi campsite, the poorly degraded ground surface at the main site enlarged as gully erosion continues. There is a high risk of further expansion and proliferation of satellite sites under the current conditions, indicating low sustainability.

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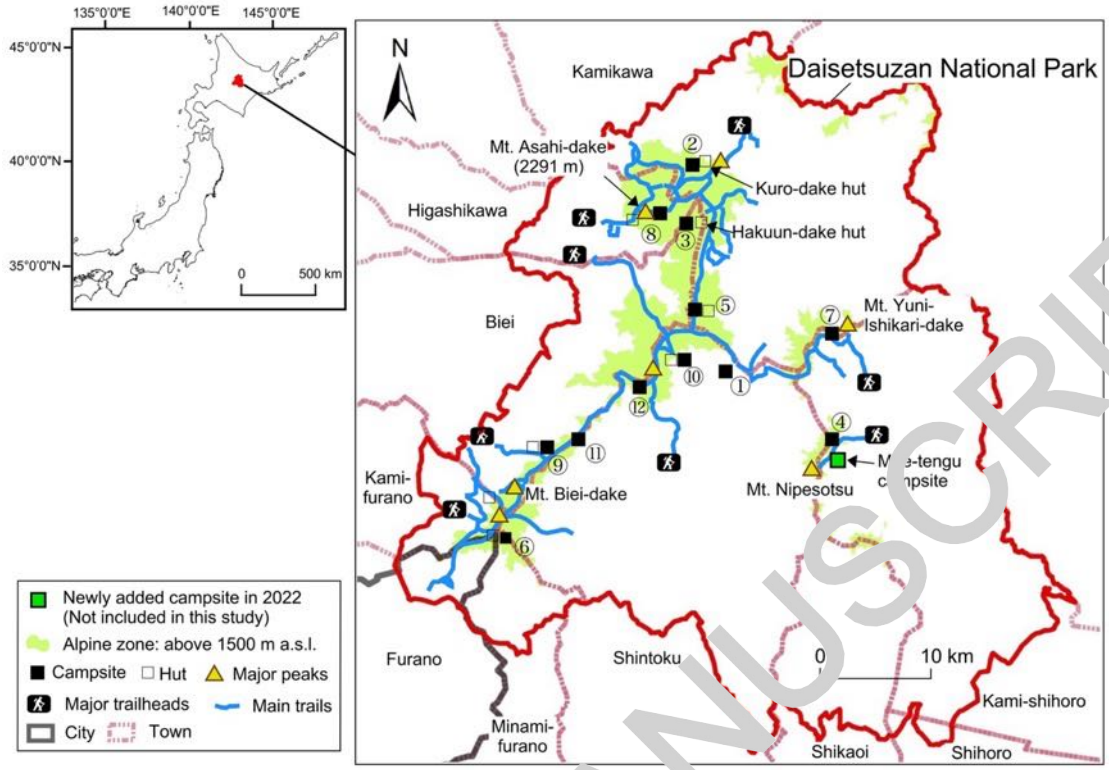

Fig. 1 Map of Daisetsuzan National Park (see Table 1 for the names of campsites ①–⑫)

516

517

518

519 Fig. 1 Caps cameras in the three campsites and a photograph of each campsite captured by

520 the la se cameras

521 (a) Kuro-dake campsite (taken by T. Wang on August 13, 2019), (b) Hakuun-dake campsite

522 (taken by T. Wang on July 14, 2020), and (c) Ura-Asahi campsite (taken by T. Watanabe on

523 September 9, 2020).

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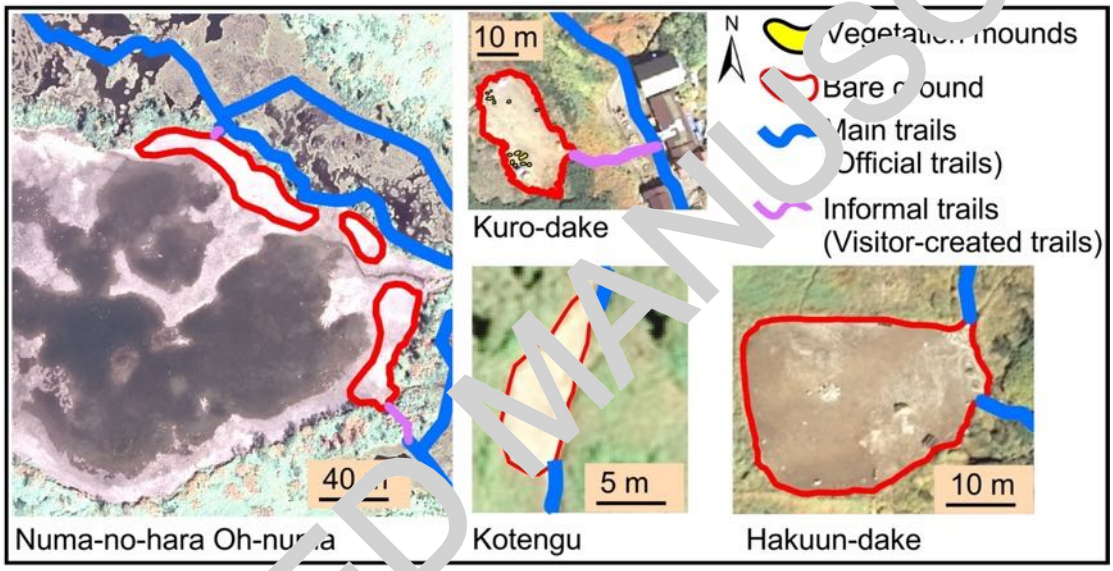


Fig. 3 Ortho images of four campsites with individual bare ground in Daisetsuzan National Park

Three bare grounds on the bank of the Oh-numa wetland lake were considered as single bare-ground patch because they were not separated by vegetation cover (Note: the scales are different).

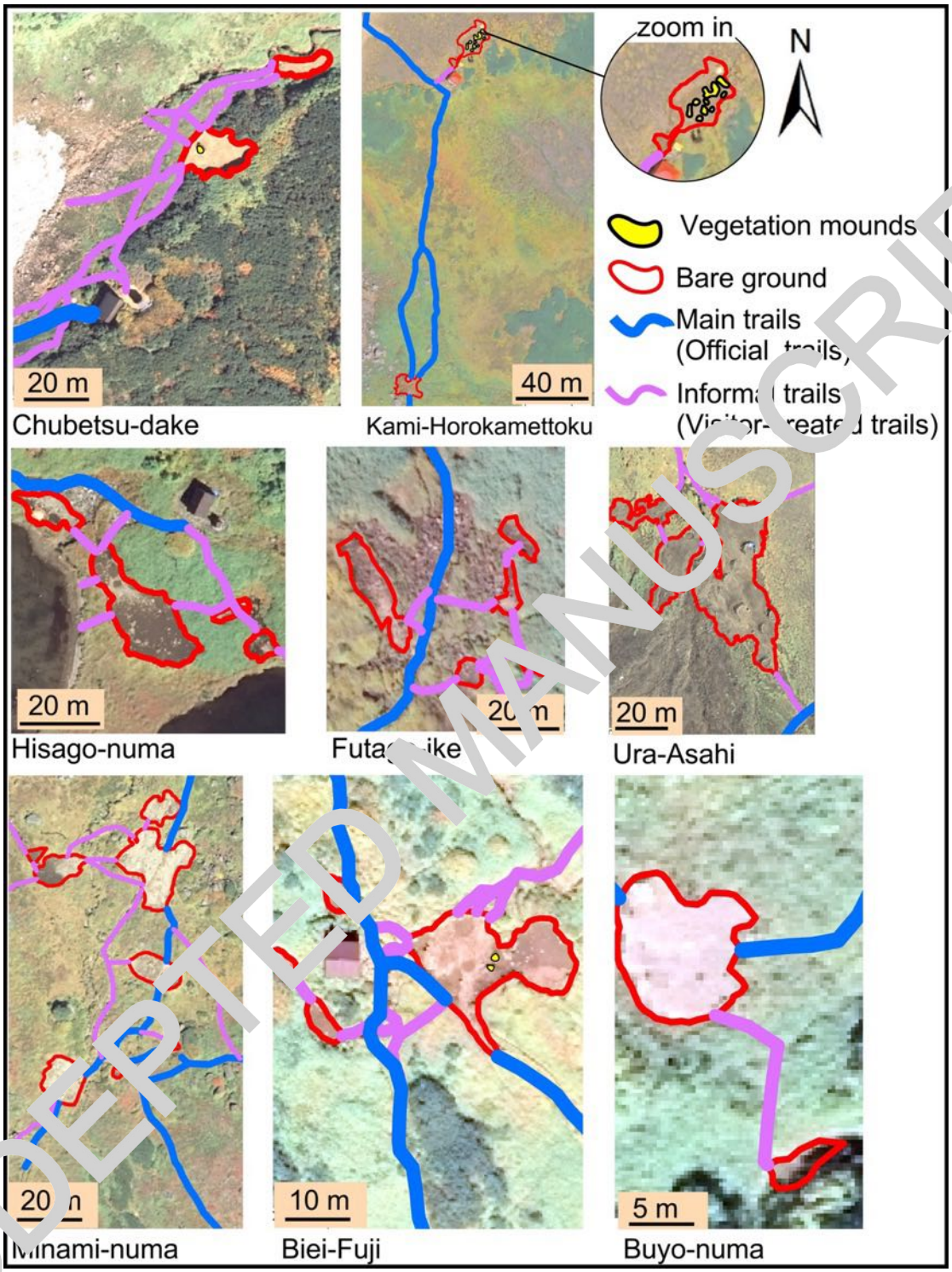
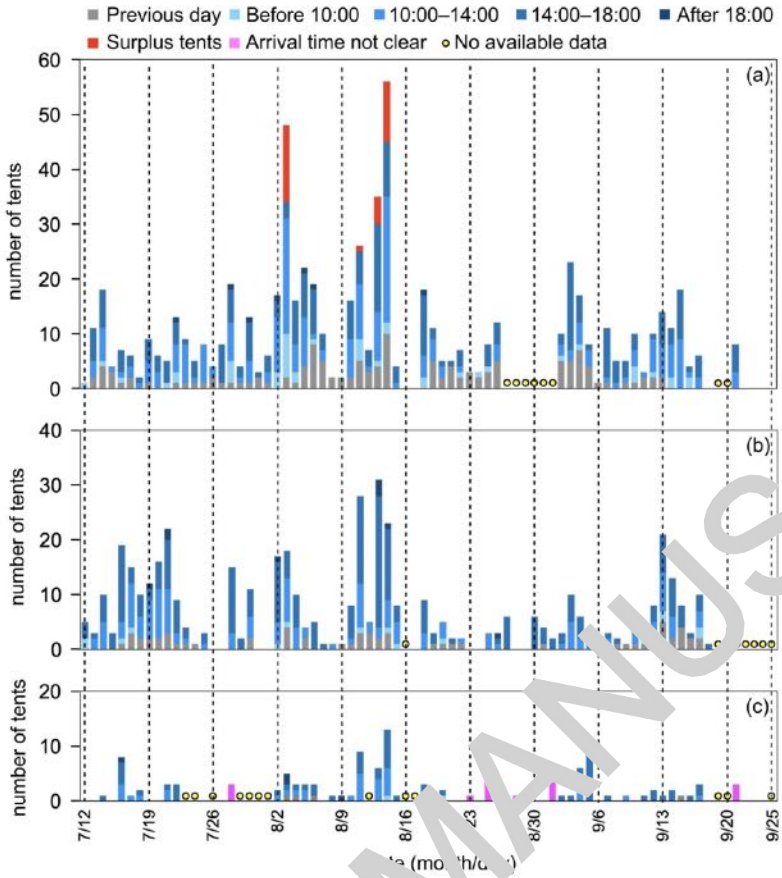


Fig. 4 Ortho images of eight campsites with a cluster of separated bare grounds in Daisetsuzan National Park (Note: the scales are different)



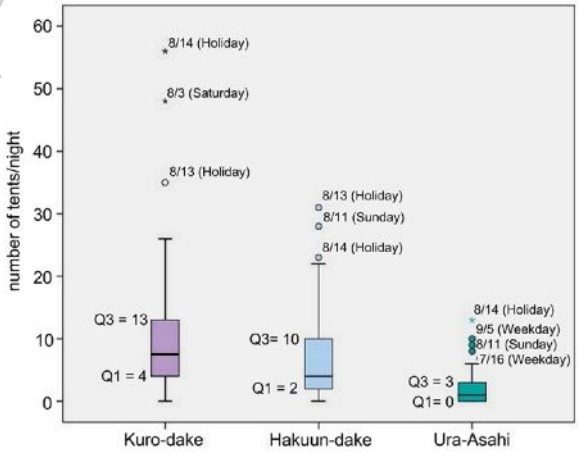
544

545 Fig. 5 The number of tents pitched in the Kuro-dake campsite (a), Hakuun-dake campsite (b),

546 and Ura-Asahi campsite (c) at different time of day from July 12 to September 25, 2019 (the

547 number of tents was counted using photographs captured by lapse cameras).

548



549

550 Fig. 6 Variation in daily use levels in the three campsites in Daisetsuzan National Park during

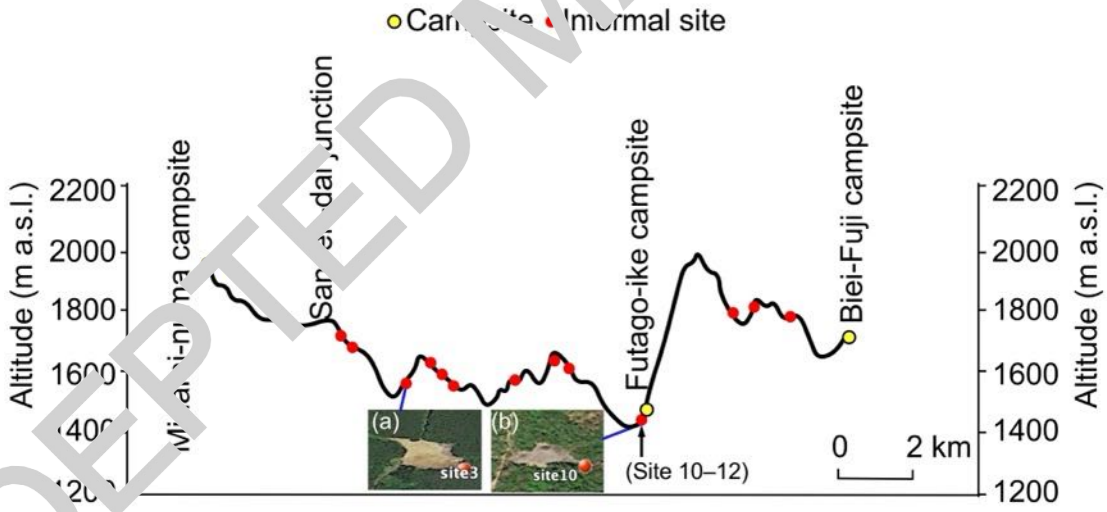
551 the study period (July 12–September 25, 2019)

552

553 Fig. 7 Photograph of the designated range of the Kuro-dake campsite circled by rope tied to

554 the steel bars (taken by T. Wang on July 27, 2022)

555



556

557 Fig. 8 Informal sites in the trail section: Minami-numa campsite–Biei-Fuji campsite (the

558 profile was created using a 10-m DEM provided by the Geospatial Information Authority of

559 Japan)

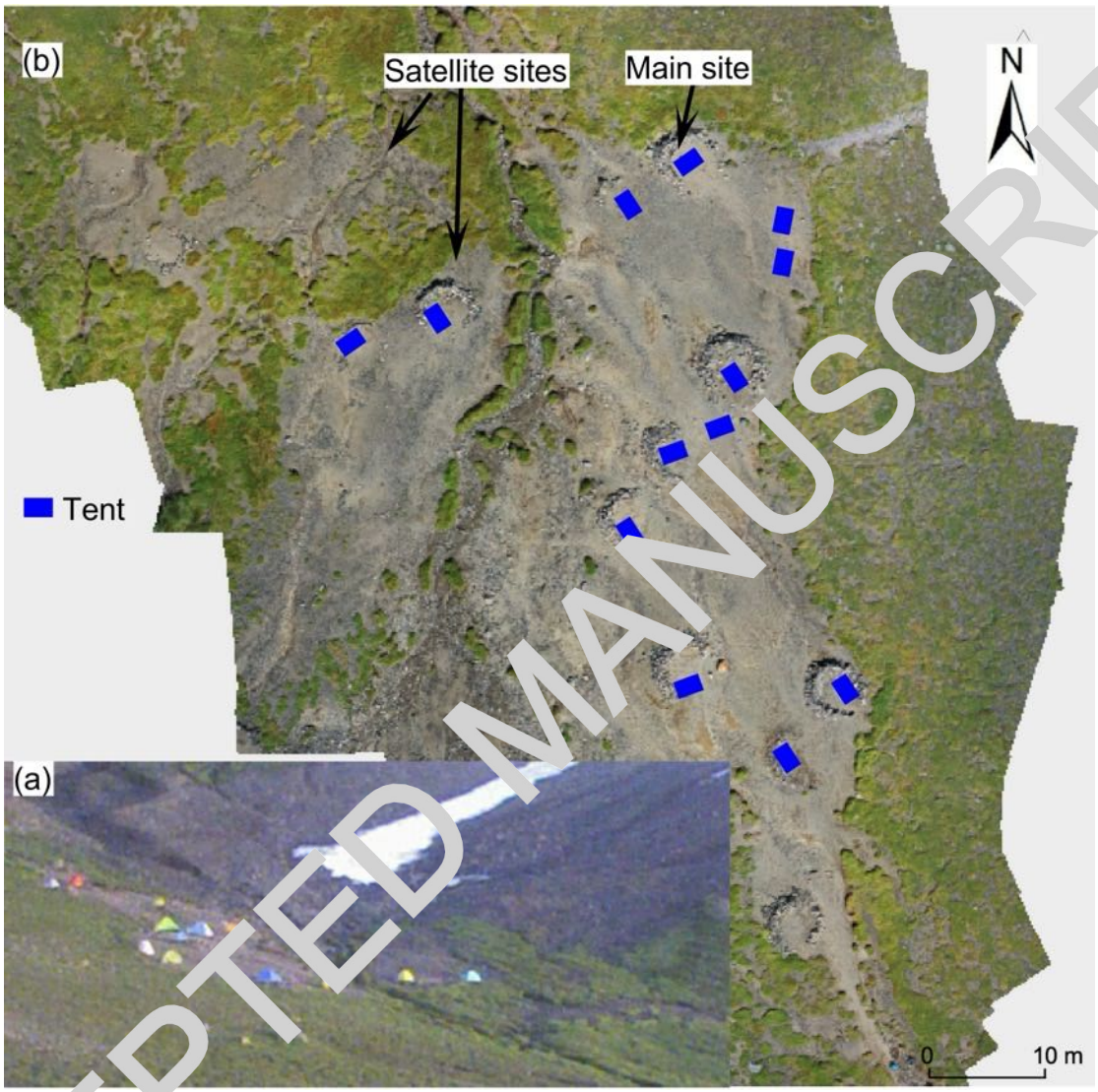
560 (a) and (b) show two examples of informal sites (satellite images exported from Google Earth

561 Pro).

562

563

564



565

566 Fig. 9 Distribution of tents in the Ura-Aasahi campsite on the most crowded day in 2019

567 (a) Photograph of the Ura-Asahi campsite captured by lapse camera on August 14, 2019, and

568 (b) Ortho image of the Ura-Asahi campsite with tents set up (created through UAV mapping

569 using photographs taken on September 4, 2019).

570

Fig. 10 Photographs of the Kuro-dake campsite (a), Hakuun-dake campsite (b), and Ura-Asahi campsite (c) on the most crowded days in 2019 (captured by lapse cameras).

586 Table 1 Characteristics of bare ground and informal trails in 12 campsites in Daisetsuzan

587 National Park

Name of campsite	Area of bare ground (m^2)	Number of bare grounds	Number of informal trails
① Numa-no-hara Oh-numa	3603	1*	2
② Kuro-dake[a]	394	1	1
③ Hakuun-dake	776	1	0
④ Kotengu	46	1	0
⑤ Chubetsu-dake[a]	323	2	8
⑥ Kami-Horokamettoku[a]	291	2	1
⑦ Buyo-numa	98	2	1
⑧ Ura-Asahi	1898	3	7
⑨ Biei-Fuji[a]	289	4	10
⑩ Hisago-numa	536	5	7
⑪ Futago-ike	307	5	8
⑫ Minami-numa	799	8	12
Total	9360	35	57
Mean	780	2.9	4.8

588

589 [a] Vegetation mounds were detected within the boundary of the bare ground (see Figures 3 and 4). Vegetation mounds

590 were excluded from the measurements of the bare ground.

591 * Three bare grounds on the bank of the Oh-numa wetland lake were considered as single bare ground because

592 they were not separated by vegetation cover.

593

594

595

596 Table 2 Different arrival patterns of tents in the three campsites in Daisetsuzan National Park

Name of campsite	Arrival time					Total
	Previous day	Before 10:00	10:00 – 14:00	14:00 – 18:00	After 18:00	
Kuro-dake	131[a] (4.3[b]*)	36 (1.6)	221 (1.7)	241 (-5.1*)	7 (-1.6)	646 (NA)
Hakuun-dake	64 (-1.9)	16 (-1.7)	139 (-1.6)	238 (3.5*)	9 (0.6)	466 (NA)
Ura-Asahi	1 (-4.4*)	5 (0.1)	32 (-0.3)	61 (3.1*)	4 (1.8)	103 (NA)

597

598 Pearson Chi-Square ($p < 0.001$)

599 The arrival time of the tents was confirmed using photographs captured by lapse

600 cameras.

601 [a] Number of tents

602 [b] Adjusted residuals; * $p < 0.05$

603

Table 3 Differences in the mean use levels of the three campsites in Daisetsuzan National Park

Item	Name of campite			Differences		
	Kuro-dake (K)	Hakuun-dake (H)	Ura-Asahi (U)	K-H[a]	K-U	H-U
Mean use level (tents/night)	10.0	6.9	2.0	3.1*	7.9**	4.8**

[a] Subtracted mean use level of the Kuro-dake campsite by that of the Hakuun-dake campsite.

* t-test ($p < 0.05$); ** t-test ($p < 0.001$)

Table 4 Differences in the mean use level between weekdays and weekends/holidays in each selected campsite

Name of campsite	Mean use level		
	Weekdays	Weekends/Holidays	Differences[a] (Weekdays-Weekends/Holidays)
Kuro-dake	7.8	13.0	-5.2*
Hakuun-dake	5.2	9.5	-4.3*
Ura-Asahi	1.7	2.5	-0.8

[a] Subtracted mean use level on weekdays by that on weekends/holidays.

* t-test ($p < 0.05$)

627 Table 5 Site occupancy of the Kuro-dake campsite on the four most crowded days with surplus

628 tents

Date	Number of tents in site	Number of surplus tents	Mean occupancy level (m^2/tent)
8/3/2019	34	14	11.6[a]
8/11/2019	25	1	15.8
8/13/2019	30	5	13.1
8/14/2019	45	11	8.8

629

630 [a] Divided area of bare ground in the Kuro-dake campsite (394 m^2) by the number of tents in

631 the site.