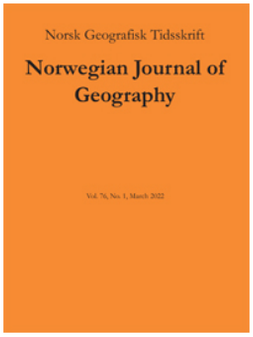

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Short Article

Significant increase in negative impacts on vegetation and soils at informal campsites in a Norwegian national park in the period 1988–2020

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ABSTRACT
The study surveyed changes in vegetation and soil impacts at informal campsites due to visitors in much-visited areas of Femundsmarka National Park, Norway. Data from 1988 were compared with almost similar data in 2020. In general, the number of informal campsites, areas free of vegetation, and the number of damaged trees in 2020 had increased compared with in 1988. The most dramatic change was the increase in damage to trees, which was almost four times as high in 2020 as in 1988, even in cases where the surveyed area around campsites was smaller (campsite + 5 m radius) in 2020 compared to 1988 (campsite + 10 m). The authors conclude there should be systematic monitoring of recreation ecology combined with targeted management actions aimed at curbing and reducing the impacts of recreation on the conservation value of the national park. They also conclude that a regular monitoring programme is needed to control further development of negative ecological impacts from recreation.

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Introduction

National parks and other large protected areas are key areas for nature diversity conservation, and are often considered the most important and, to date, the most successful policy tool for safeguarding biodiversity (Le Saout et al. 2013). Large protected areas, especially national parks, are often also important places for nature-related experiences, tourism, and recreation. The relationship between protected areas and tourism is paradoxical and includes positive and detrimental relations (Buckley et al. 2016). People's experiences in protected areas might be important for a range of potentially positive outcomes such as economic and political support for protected areas, and for educating people about nature by instilling in them empathy for nature through more pro-environmental behaviour as visitors and in everyday life. The other side of the coin is when visits have a negative effect on nature diversity in protected areas and key conservation objectives, especially through disturbance caused to wildlife and negative impacts on vegetation and soils (Cole 2004).

Mainland Norway currently has 40 national parks, which were established between 1962 (Rondane National Park, in Innlandet County) and 2018 (Lofotodden National Park, in Nordland County). During that period, public funding for active management of recreation was limited (Lindberg 2001), and priority was given to costs related to the establishment of parks and

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compensation to private landowners and rights holders (Higham et al. 2016). Due to Norway's strong outdoor life (*friluftsliv*) traditions, which are based on the 'common right of access', there have generally been few restrictions on non-motorized recreation in the country's national parks (Hammitt et al. 1992). This, combined with limited resources and personnel for park management, has been pesented as a paradox to effective management of visitors and conservation objectives (Kaltenborn et al. 2001; Higham et al. 2016).

In 2015, Norwegian authorities proposed a tourism branding programme for national parks, followed by a strategy and framework for visitor management in every national park and in other large protected area (Miljødirektoratet 2015), acknowledging the fact that national parks are among the most important attractions for tourists visiting Norway (Dybedal & Farstad 2013). In accordance with the strategy, tourism and recreation are accepted and supported legitimate and important user and stakeholder interests in protected areas. However, a major premise is that these activities should not harm or reduce conservation values. In a report from 2006, the Auditor General of Norway raised concern about the ecological impacts on biodiversity caused by recreation and tourism through disturbance and negative impacts on vegetation and soils (Riksrevisjonen 2006). More recently in 2018 and 2019, in a qualitative self-evaluation, management authorities identified threats to conservation objectives in 18 of Norway's 40 national parks, primarily from wildlife disturbance and impacts on soils and vegetation (Klima- og miljødepartmentet 2019). Several studies document disturbance of wild reindeer (e.g. Gundersen et al. 2020). However, other threats to conservation values have documented to a lesser extent, and to our knowledge there have not been any studies of changes in the ecological impacts of recreation over time.

This study presents the findings following a comparison of surveys of the impacts of recreation on vegetation and soils in Femundsmarka National Park in 1988 and 2020. The focus of the surveys was on informal campsites, where impacts result from aggregated use and use dynamics over time. Although campsites have ecological impacts, they can also be attractive and be seen as providing amenities for visitors, such flat areas on to pitch tents and existing firepits that are ready for use (Vistad 1995). The ecological impacts in Femundsmarka National Park were mapped in 1988, and the mapping was repeated in 2020. To our knowledge, it was the first study to survey systematically changes over time in the ecological footprint from recreation in protected areas of Norway.

Methods

Study area

Femundsmarka National Park (Femundsmarka nasjonalpark) is located in south-eastern Norway, between the lake Femund (Femunden) and the border with Sweden (Fig. 1). It includes forests and mountains, and ranges from 662 m a.s.l. (Femund lake) to 1561 m a.s.l. (Storviglen peak). The park was established in 1971, expanded in 2003, and today covers 573 km^2. Femundsmarka National Park borders protected areas in Sweden. Key conservation objectives are to protect a large, mainly intact, forest and mountain ecosystem, including the unique Quaternary geological landscape elements, and plant and wildlife biodiversity. In addition, all dead standing trees are protected (Lovdata.no 1971). Besides being a popular area for outdoor recreation activities (angling, hiking, canoeing), the park is also used extensively by the Sami people as grazing land for their reindeer (*Rangifer tarandus*).

Studies of informal campsite related impacts on vegetation and soil were undertaken in core areas of the park along the Røa watershed, more specifically along a 2.4 km stretch of the shore of Femund (north and south of where the Røa river enters the lake), and along the southern side of the Røa river from the headland Røsanden and farther north to the lake Roasten (c.6.2 km. Røsanden is mostly flat, dominated by rocks, gravel, and sandy sediments, with pine forests dominated by blueberry shrubs and lichens in the field (herb) layers and bottom layers. Along the Røa, the landscape is hilly, with some boulders and exposed bedrock. The dominating vegetation types are similar to those on Røsanden, but also include grasses and heather,which are the dominant species on small mires.

On Røsanden, there is a small harbour used by the passenger vessel *Femund II* that sails a daily southern and northern route on Femund from early June to mid-August, and at weekends in September. There is also an open rustic log cabin near the harbour. Other recreation infrastructure includes the T-marked trail from Røsanden to the self-serviced cabin owned and managed by the Norwegian Trekking Association (DNT) at Røvollen (Fig. 1). The trail currently crosses the Røa river via a footbridge c.800 m above Røsanden. Until 2002, the bridge was located close to Femund, which made it easier for hikers to use Røsanden north of the estuary for camping. Due to damage caused by broken up ice flowing in the river, the bridge was relocated farther upstream. Røsanden is, together with the

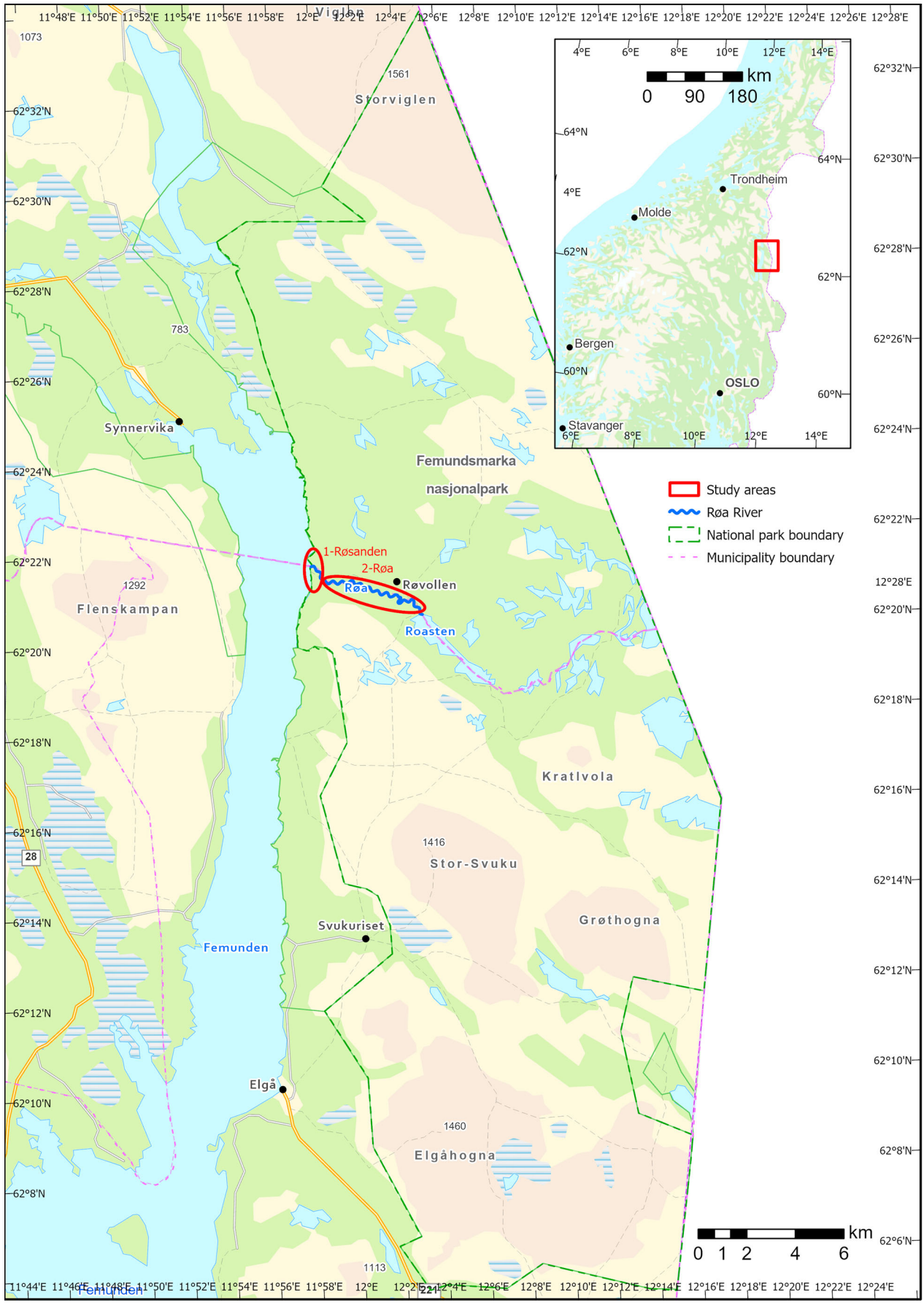

Fig. 1. Location of study areas in Femundsmarka National Park, Norway (Data source: 2022, kartverket/norgeskart.no©, ArcGIS® software by Esri)

small settlements of Synnervika and Elgå, and a farm named Haugen, the key entrance points for visitors to the park. Since many visitors travel on the *Femund II* to access the park, they often camp at Røsanden on arrival or departure. The shores of the Røa river are used by anglers, canoeists, rafters, and hikers: in the case of anglers, it is used those on their way eastwards to the more attractive parts of the watershed. Typically, visitors to Femundsmarka National Park stay overnight in tents, using informal campsites, which usually are near water. Informal campsites created by visitors influenced the selection of study sites in 1988 (Vistad 1995). More recent studies have clarified that recreation in the national park is characterized by a higher number of anglers, canoeists, and people on multiday hikes (average 5.1 nights per visit), who camp in private tents on informal campsites (Vorkinn 2016). Reindeer herders generally make little use of the two areas covered by the study.

Recording impacts on soil and vegetation

Impacts on vegetation and soil were recorded in year 1988 and in 2020. Two different researchers conducted the field surveys (Odd Inge Vistad in 1988, Sindre Kolstad Valan in 2020). Before the 2020 survey, Valan and Vistad communicated to ensure that the inventories would be as similar as possible. For both years, recordings were done during the main summer holiday weeks between mid-July and mid-August. An informal campsite was defined as a place suitable for putting up a tent and preparing a meal, as having signs of use such as a man-made informal campfire, and where there were impacts on vegetation (understorey vegetation or trees) and in some cases even on the soils. None of the campsites were formally established, and they had not been made or managed by the park authorities, although starting in 2016 the park managers limited the number of campfires to a specified minimum on each campsite, and they tidied and/or improved those campfires.

The two surveyed areas were defined as being in 'the natural riparian zone', in which it was judged 'natural' for visitors to stay or move around for fishing, canoeing, camping, or hiking along the shore of the lake (cf. Vistad 1995). Four types of data were registered for all identified campsites in 1988 and 2020: area free of any field and bottom layer vegetation, condition class, number of campfires, and damage to trees. The data types are described in detail as follows.

Area free of any field and bottom layer vegetation was defined as the part of the informal campsite that had a dominance of visible humus or mineral soil as its top layer. Area was measured in square metres by applying known geometric figures to cover the area (circle, ellipse, triangle, square or rectangle) and then calculating the total area free of vegetation.

Condition class was assessed for each informal campsite by applying Per Wallsten's index (Wallsten 1988),[1] which has four categories:

1. Field and bottom layer vegetation subject to trampling and/or changed species composition, no direct loss of vegetation, with the possible exception of loss due to one campfire.
2. Vegetation lost on smaller pieces of land (up to 3 m^2), no visible tree roots
3. Vegetation lost on larger pieces of land (up to 30 m^2), soil layer intact with minor exceptions, some visible tree roots
4. Either vegetation lost across larger areas (above 30 m^2), combined with smaller areas with exposed soil, or vegetation lost on areas up to 10 m^2, combined with larger areas of exposed soil, and visible tree roots.

The *number of campfires* was counted and mapped for each area. A campfire was defined as a man-made circle of stones with signs of a campfire inside the ring. Smaller pits without a prepared circle of stones were not registered. There were no formally established campfires in the area (e.g. established by park management or landowners).

With regard to *tree damage*, in 1988 all trees on informal campsites and at a distance of up to 10 m from them were surveyed for any damage judged to have been caused by visitors. The number of trees affected by visitors was registered, together with the type of damage they had caused, such as scars from knives and axes, saw marks on the trunk or branches, and/or branches judged to have been broken off by humans. Whether branches were broken by humans or by natural causes (e.g. the weight of snow, fraying caused by ungulates), was determined based on the position and type of damage (e.g. whether it was within reach of humans or animals, whether a branch was broken close to the trunk). The same procedure was followed in 2020, except that records of trees were limited to a distance of 5 m from the informal campsites. The number of trees damaged was so high that to record all as far as

[1]Per Wallsten, 'Rekreation i Rogen – tillämping av en planeringsmetod för friluftsliv', KOMMIT-rapport 2, 1988, Universitetet i Trondheim. Copies are held at a few libraries in Sweden (e.g. Lund University Library).

10 m from the campsites required more fieldwork capacity than was available in 2020.

Statistical tests

For data suitable for statistical testing, we used paired samples Wilcoxon tests in R to analyse whether there were significant differences in vegetation and soil impacts between 1988 and 2020. Paired tests are suitable for comparing sites recorded at two points in time, and the non-parametric alternative to a paired t-test is recommended when data are not normally distributed. To compare statistically the number of damaged trees at informal campsites in 1988 and 2020, we standardized the number of damaged trees per square metre by making the assumption that all campsites were circular in shape and determined campsite radius (r) as a function of campsite area. We then calculated the area investigated for 1988 data as $\pi \times (r + 10)^2$ minus campsite area, and for 2020 data as $\pi \times (r + 5)^2$ minus campsite area. The number of damaged trees per unit area was then calculated and subjected to statistical testing.

Results

The main registered impacts of informal campsites in 1988 and 2020 are presented in Table 1. The number of registered campsites increased from 1988 to 2020, both on Røsanden and along the river Røa, by 19% and 70%, respectively. The total registered area of bare soil at the campsites had also increased, to a limited extent on Røsanden but to a much greater extent along Røa (the average vegetation-free area increased from 8 m^2 to 26 m^2 per campsite). The average size of the campsites surveyed in 1988 was found to have reduced on Røsanden in 2020, but was not yet statistically significant, while it had increased significantly for the campsites along Røa. Similarly, the degradation state of the campsites was quite stable on Røsanden but increased significantly along Røa. It should be noted that due to the changed location of the bridge

Table 1. Vegetation loss and tree damage in two survey areas along the Røa and Femund watershed in Femundsmarka National Park in 1988 and 2020

Reorded impacts on vegetation and soils	1988	2020	% change	Statistics (Wilcoxon test)	Comments
Subarea: Røsanden					
Number of campsites	21	25	+ 19		
Total vegetation-free area (m^2)	665	738	+ 11		
Average vegetation-free area (m^2)	43.6	29.5		V(20) = 98, p = 0.920	Only campsites surveyed both in 1988 and 2020 included
Average vegetation-free area on campsites registered in 2020, not in 1988 (m^2)	-	5.0			
Average condition class (index 1–4)	3.0	3.3		V(20) = 24.5, p = 0.124	
Total number of campfires	52	29	-44		Managers actively removed excess campfires from 2016
Average number of campfires per campsite	2.2	1.2		V(20) = 97, p = 0.005	
Number of damaged trees (of total for 2020)*	112	241/320**			Numbers for 1988 and 2020 not directly comparable
Number of damaged trees per m^2	0.022	0.072		V(20) = 0, p < 0.001	Number of trees divided by estimated area were investigated. Only campsites recorded both in 1988 and 2020 were included.
Subarea: Røa river, south bank					
Number of campsites	10	17	+ 70		
Total vegetation-free area	53	438	+ 726		
Average vegetation-free area (m^2)	7.6	25.8		V(9) = 0, p = 0.022	Only campsites recorded both in 1988 and 2020 included
Average vegetation-free area on campsites registered in 2020, not in 1988 (m^2)	-	27	–	–	–
Average condition class	2.9	3.6		V(9) = 0, p = 0.089	
Number of campfires	33	25	-24		Managers actively removed excess campfires from 2016
Average number of campfires	2.3	1.5		V(9) = 8.5, p = 0.269	
Number of damaged trees*	8	163/221**			Numbers for 1988 and 2020 not directly comparable
Number of damaged trees per m^2	0.022	0.056		V(9) = 0, p = 0.016	Number of trees divided by estimated area were investigated. Only campsites recorded both in 1988 and 2020 were included.

Notes: *1988 – campsite + 10 m zone, 2020 – campsite + 5 m zone; **In 2020, also the total number of trees surveyed within the campsite + 5 m zone were registered

across Røa, when it was moved farther away from the lake Femund, had made it less practical for visitors to camp on the north side of Røsanden. Visually, it was obvious that several campsites on the north side of the Røa estuary were in a state of regrowth, while camping on the south side was still common in 2020 and those campsites were not recovering.

Despite the total increase in number of campsites, the number of campfires was reduced between 1988 to 2020, both on Røsanden and along Røa. The average number of campfires per campsite was especially reduced on Røsanden. This suggests that the management measure of limiting the number of campfires and improving and/or cleaning one campfire per campsite is a useful management approach, at least on Røsanden.

The numbers of trees impacted by visitors in 1988 and 2020 were not directly comparable, since a larger area around the campsites were surveyed in 1988 than in 2020. In 1988, the total number of trees affected by visitors on the campsites and within a radius of 10 m of each site was 120. In 2020, a total of 404 trees were registered as damaged within a 5 m radius of each campsite, which represented 75% of the total number of trees within the 5 m radius. Standardising the number of damaged trees by investigated area on campsites surveyed both in 1988 and 2020 indicated a three-fold increase in the number of damaged trees per unit area. Thus, many trees that were not damaged in 1988 had been damaged by visitors between 1988 and 2020. In addition, damaged trees were recorded on new campsites.

Discussion

When evaluating the findings, it is important to underline that the data are unlikely to be representative for Femundsmarka National Park as a whole. Together, the two surveyed areas represented a small share of the total area of the park. However, as far as we know, the findings constitute the only Norwegian dataset for the monitoring of how the impacts of recreation on vegetation and soils develop over time. The management authorities should be concerned about the fact that such impacts accumulate over time, and in our view the most dramatic impact is severe increase in tree damage. Visitors' use of trees not only affects the trees themselves, but also the habitats they provide for other organisms, as well as the amount of woody debris that falls to the ground (Hall & Farrell 2001; Hegetschweiler et al. 2008). Protection of the forest ecosystem is a major conservation objective for Femundsmarka National Park, and the volume of tree damage, as well as loss of woody debris, is problematic from a conservation perspective. The regulations about what is legal and illegal regarding visitors' use of twigs and branches seem to be confusing and until recently have not been actively communicated to users (Valan 2021).

Valan (2021) analysed secondary data relating to visitors to Femundsmarka National Park in the period 1988–2020, based on numbers of passengers on *Femund II*, nights spent in the Norwegian Trekking Association (DNT) cabins on Røvollen and at Svukuriset, and numbers of fishing licenses sold. He concluded that except for some variations across the years, there was little evidence that the observed increase in impacts was a result of increased volumes of users per year. Extensive research on ecological impacts shows that the impacts of trail and informal campsites generally show an s-shaped relation between volume of use and amount of impact (meaning that the impacts level off at some point in increased use), although environmental conditions could modify the shape of that relationship (Cole 2004; Hammitt et al. 2015). On trails and campsites subject to use over long periods of time, variations in on-site environmental factors such as vegetation type, soil erodibility, soil moisture, and terrain (steep versus flat) may affect degradation rates (Monz et al. 2013). Previous studies of forest recreation in the USA have documented that tree damage is common on and around campsites, including reduced recruitment of young trees (Marion & Cole 1996; Cole 2004). Tree damage may follow a different and more linear relationship compared with impacts on field and bottom layer vegetation, as the use of trees (especially for firewood, but also, for example, for tent pegs and barbeque sticks) seldom allows for reuse, and as time goes by and numbers of visitor days accumulate, visitors use new pieces of bark, branches, and twigs from trees already subject to damage to growth and/or at trees at increasing distances from the campsite (Marion & Cole 1996; Cole 2004).

Conclusions

Our study shows that there was a significant increase in negative impacts on soil and vegetation from 1988 to 2020 in the two surveyed areas in Femundsmarka National Park. Along the banks of the river Røa, we found a strong increase in the number of campsites and the total vegetation-free area, and that the state (condition class) of the informal campsites had deteriorated. Furthermore, we observed a strong increase in the number of damaged trees. We observed smaller changes at the Røsanden site, and while the number of campsites increased, the average vegetation-free area per campsite decreased. This was probably due to the significantly reduced access to the northern side of Røsanden after the bridge across Røa had

been moved farther away from the lake Femund. When assessing the increase in tree damage, the difference in methodology between 1988 and 2020 must be considered. Although the estimation of number of damaged trees per unit area investigated had some uncertainties, our results suggest a minimum of a three-fold increase in tree damage.

A monitoring programme should be established to control further development of negative ecological impacts due to recreation, especially those on trees. Monitoring should be combined with more detailed studies of visitors' behaviour regarding the use of campsites, with the aim to identify specific needs for improvements in the regulations for Femundsmarka National Park, as well as associated information and communication measures. Research on visitors' behaviour could be combined with systematic evaluation of management measures aimed to reduce ecological impacts from visitors in Femundsmarka National Park and similar protected areas.

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