Journal for Nature Conservation 37 (2017) 73–82

Contents lists available at ScienceDirect

Journal for Nature Conservation

journal homepage: www.elsevier.de/jnc

Sustainable campsite management in protected areas: A study of long-term ecological changes on campsites in the boundary waters canoe area wilderness, Minnesota, USA

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ARTICLE INFO

Article history:
Received 27 September 2016
Received in revised form 23 March 2017
Accepted 24 March 2017

Keywords:
Recreation ecology
Sustainable recreation management
Campsite management
Longitudinal ecological change

ABSTRACT

Managers of protected natural areas seek to protect their natural conditions while providing opportunities for recreational visitation. Camping is an essential element of backcountry and wilderness recreation for a variety of protected natural areas in the U.S. and internationally. Furthermore, overnight visitors to protected areas spend a substantial portion of their time on campsites so their behaviors determine the nature and extent of resource impacts, and the quality of their recreational experiences can be affected by campsite conditions. The U.S. Forest Service manages nearly 2000 designated campsites in the Boundary Waters Canoe Area Wilderness. This research assessed resource conditions on 81 wilderness campsites and paired undisturbed controls in 1982 and 2014 to quantify long-term ecological changes. A comprehensive array of physical, vegetative, and soil indicators were measured to identify long-term trends over 32 years of continuous campsite use.

Our findings reveal substantial changes in area of vegetation cover, exposed soil, and soil erosion on campsites. Although mean campsite size is unchanged, the proportion of campsite area in the "core" has decreased, shifting some use and impact into peripheral "satellite" tenting areas just beyond campsite borders. The ecology of campsites has been significantly altered by a large reduction in number and cover of campsite trees. The number of campsite trees decreased by 44% from 1982 to 2014. Visitors are cutting both on- and off-site trees for firewood, and tree seedlings are rarely able to germinate and survive due to visitor activity.

These findings reveal that older campsites are not stable. Long-term camping impacts that are ecologically, managerially, and experientially meaningful are occurring; these impacts could be minimized through more sustainable management practices. These include selecting more resistant sites, such as those with resistant rocky shorelines, and sloping terrain that constrains campsite expansion. Construction and maintenance of tenting sites can attract and spatially concentrate camping impact. Actions to halt tree cutting are also critical. Heavy long-term visitation in protected natural areas requires more sustainable and intensive visitor impact management actions.

1. Introduction

Most protected areas internationally are managed to preserve natural conditions, biodiversity, and natural processes, often excluding many forms of human development while accommodating recreation visitation (Leverington, Costa, Pavese, Lisle, & Hockings, 2010). For example, the U.S. National Wilderness Preservation System (P.L. 88–577) charges agencies to administer these protected areas: "for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness." In light of increasing visitation, managers must discover and implement improved visitor use management practices that minimize resource degradation. For this to occur, protected natural area managers need to better understand what visitation-related ecological changes occur over time and what factors most strongly influence the extent of change. Such knowledge can then be applied to inform the selection of management actions able to sustain intensive visitation with minimal degradation.

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http://dx.doi.org/10.1016/j.jnc.2017.03.004
1617-1381/

Environmental degradation from visitor activities can contribute to a range of resource impacts that vary by type and severity. Even low levels of trampling disturbance can reduce vegetation height, cover, and biomass (Cole, 1995a; Cole, 1995b; Growcock & Pickering, 2011; Marion, Leung, Eagleston, & Burroughs, 2016). Higher levels of trampling lead to more complete vegetation loss and compositional change as plants are lost or replaced by more resistant species (Cole, 1995b; Marion & Cole, 1996; Smith & Newsome, 2002). Concentrated traffic also pulverizes soil leaf litter and humus layers, which are either lost through erosional processes or intermixed with underlying mineral soils. Exposed soils are more vulnerable to displacement, compaction, and erosion (Marion et al., 2016; Monti & Mackintosh, 1979). Compaction reduces soil pore space and water/air infiltration, increasing water runoff and erosion rates. Additional impacts specific to camping activities include campfire-related impacts such as tree damage, felling, and depletion of woody material (Hall & Farrell, 2001; Reid & Marion, 2005; Smith & Newsome, 2002).

This study examines long-term resource impacts on agency-designated campsites in a U.S. wilderness area. Two management strategies applied to minimize camping impacts include *dispersal,* where campers select a pristine site with durable substrates or vegetation, or *containment* – where campers concentrate their activity on a limited number of small, resistant, well-established or designated campsites (Hammitt, Cole, & Monz, 2014; Marion, 2016). Research and management experience have found the containment strategy to be most effective in moderate to high use areas (Leung & Marion, 1999; Marion, 2016; Reid & Marion, 2004). Due to increasing visitation, managers are funding studies like this one to investigate long-term impacts and improve guidance on *campsite sustainability*: which we define as the ability of campsites to accommodate intensive long-term use while remaining in good condition, with minimal maintenance or restoration. Research questions include: 1) How do campsite conditions change over several decades of continual use, 2) What use-related, environmental, and managerial factors most strongly influence long-term campsite conditions, and 3) What are the implications of these findings for improving the sustainability of campsite management?

In this study, we seek to answer these questions by analyzing data collected in 1982 and 2014 on a large sample of designated campsites in the Boundary Waters Canoe Area Wilderness (BWCAW) in northern Minnesota. Specifically, we replicate an array of biophysical measurements on 81 BWCAW campsites and paired control sites to document and analyze 32 years of ecological change (Marion, 1984; Marion and Merriam, 1985a; Marion and Merriam, 1985b).

1.1. Longitudinal campsite studies

The BWCAW has served as an important study area for some of the earliest recreation ecology research, particularly for longitudinal studies. A study examining the effect of differing use levels on impacts found that even light use (0–30 days use/season) resulted in substantial loss of ground cover (Frissell & Duncan, 1965). A 1969 study by McCool, Merriam and Cushwa found that campsites on islands and along main canoe routes showed more substantial impacts, which they attributed primarily to higher use levels. Merriam et al. (1973) also reported that campsites are most highly affected by initial site use. Once an area is selected as a campsite, trampling quickly results in loss of organic and vegetative ground cover, while subsequent traffic results in diminishing per capita impact (Merriam & Smith, 1974). However, some impacts do increase over time and with increasing use levels, notably exposed soil. Some of this early work was continued by Merriam & Peterson (1983), who examined changes on eight BWCAW campsites over 15 years, finding that higher use sites expanded in size over time and that visitors were continuing to cut trees for firewood (Merriam & Peterson, 1983).

Elsewhere, Cole and his co-investigators have reported results from several long-term studies employing rapid monitoring-level ratings (Cole 2013; Cole & Parsons 2013; Cole et al., 2008). Monitoring of Grand Canyon National Park backcountry campsites over 20 years found campsite sizes to be stable (Cole, Foti, & Brown, 2008). While high-use sites were more degraded than low-use sites, within each use level resource impacts were relatively consistent over time.

We note that none of these early BWCAW and later long-term monitoring studies included detailed ecological measurements of both campsite and paired "control" site conditions replicated over time. There are several important limitations to these studies. First, plant communities vary with respect to plant cover and other attributes. Analyses designed to examine sustainability are most valid when they compare "absolute difference" values, computed by subtracting campsite indicator values from values assessed on adjacent environmentally paired undisturbed "control" areas. Second, these early studies and nearly all monitoring programs do not count tree damage and felling indicators both onsite and offsite and report them as density (#/ha) measures. Longitudinal comparisons for these indicators become less valid over time as campsite sizes change, and as campsite trees are cut down the number of damaged and felled trees reported in subsequent monitoring cycles must inevitably decline, indicating improving conditions when the opposite is true. Third, monitoring studies generally employ rapidly assessed ratings rather than accurate measurements. Ratings are a coarse approximation of actual change, particularly when large percentages of sites fall within a single rating category, or when substantial degradation occurs to sites in the "worst" category, which is open-ended (e.g. campsite size > 300m^2).

We found no other studies that avoided these limitations, which we've addressed in this research. In 2014 we returned to reassess ecological changes on BWCAW campsites and paired control sites first measured in 1982 (Marion, 1984; Marion & Merriam, 1985a; Marion & Merriam, 1985b). It provides a comprehensive dataset with longitudinal biophysical measurements and a larger sample size needed to improve understanding of long-term ecological changes and their implications for sustainable campsite management.

1.2. Campsite sustainability

A number of factors identified in the 1982 study relate to campsite sustainability and are reviewed here. While vegetative ground cover declined from an average of 94% offsite to 36% onsite, the amount and durability of vegetation cover increased significantly with increasing campsite sunlight exposure (Marion & Merriam, 1985a). Shade-tolerant plants are particularly susceptible to trampling while sun-loving plants, primarily grasses and sedges (graminoids), are more trampling-resistant. For example, mean dense vegetation ground cover was only 4% on campsites with 75–100% tree cover, but increased to 52% on campsites with less than 25% tree cover (Marion & Merriam, 1985a). Over time, trampling alters campsite plant composition as fragile plants are replaced by trampling-resistant, often non-native, species (Marion & Merriam, 1985a). Regression modeling found that soil compaction can be minimized by selecting sites in areas with thick organic soil horizons, which reduce compactive forces and intermix with underlying mineral soils (Marion & Merriam, 1985b).

A BWCAW campsite restoration, rehabilitation, and maintenance program seeks to enhance the sustainability of campsites kept open to use (Marion & Sober, 1987). Actions that enhance campsite sustainability include a designated camping policy that restricts camping to a limited number of durable sites, visitor entry