Applying Recreation Ecology Science to Sustainably Manage Camping Impacts:
A Classification of Camping Management Strategies

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Wilderness and other protected natural areas like national forests, parks and refuges are managed to provide high quality recreational opportunities while preserving natural resource conditions. In managing recreation visitation, land managers could allow visitors to create their own infrastructure of trails and campsites, or they could choose to apply an impact management strategy to provide an infrastructure that includes sustainably designed trails and campsites. Recreation ecology studies have repeatedly demonstrated that informal "visitor-created" trails and campsites are generally not sustainably designed or located (Cole 1981, Cole 1982a, 2013, Marion 2016, Wimpey and Marion 2011). For example, informal trails frequently occur in flat terrain where trail widening and muddiness can be chronic problems, or are fall-aligned (perpendicular to contour lines) in sloping terrain, where they are considerably more vulnerable to soil loss and widening (Marion et al. 2016, Marion and Wimpey 2017). Similarly, visitors are highly attracted to flat terrain near water for camping, where they frequently create substantial numbers of large and unnecessary campsites at densities that threaten visitor solitude, experiential qualities, and natural resources.

While wilderness managers have consistently adopted a professional approach to trail management that emphasizes sustainably-designed, constructed, and managed formal trail systems, they have inconsistently applied a similar strategy to camping management. Based on a review of the literature this paper describes the consequences of largely unconfined "dispersed" camping that *emphasizes visitor-selected and -created campsites* at locations of their choosing, with limited additional guidance. We present and describe a simple classification system of camping management strategies and options and urge managers to consider adopting a more proactive and sustainable camping "containment" strategy that emphasizes using a reduced subset of *management-selected and -created campsites* based on evaluations of their resource and social sustainability.

Finally, we examine the "wilderness character" trade-offs associated with trail and camping infrastructure decision-making and suggest that the clear benefits of having an infrastructure of formal trails are also true for having an infrastructure of sustainable campsites, as part of an impact containment strategy. Finally, we examine several recreation ecology research studies that demonstrate how a combination of management strategies and actions have been applied to significantly reduce aggregate camping impact and promote high quality social conditions.

Camping Management Strategies

Protected area managers have a diverse array of strategies and actions in their management "toolbox" for achieving resource protection and visitor management objectives (Cole et al. 1987, 1997, Leung and Marion 1999, 2004, Marion 2016). Related to camping, managers commonly seek to achieve the following core objectives: *limit campsite numbers and the aggregate areal extent and severity or resource impact, promote high quality social conditions, and preserve visitor freedom to camp in desirable locations.* We further suggest that a key measure of agency success in achieving resource protection objectives is to minimize the *aggregate area of camping impact* by minimizing both campsite numbers and sizes.

While land managers have most commonly applied some form of unconfined or largely unregulated camping, recreation ecology research has revealed the greater merits of two core camping impact management strategies, dispersal and containment, derived from an improved understanding of the relationship between amount of use and resource impact. Experimental trampling and camping studies have consistently demonstrated that the majority of biophysical changes occur with initial and low levels of use, generally less than 15 nights/year over the first 2-3 years (Figure 1) (Cole 1982b, Cole and Monz 2003, Marion 2016). Above this level, per capita impacts diminish substantially and campsite conditions stabilize, achieving a relatively constant equilibrium over time (Cole 2013, Marion and Cole 1996). Even doubling use on a well-established campsite only marginally increases measurable resource impacts, particularly for sustainably selected campsites that resist site expansion.
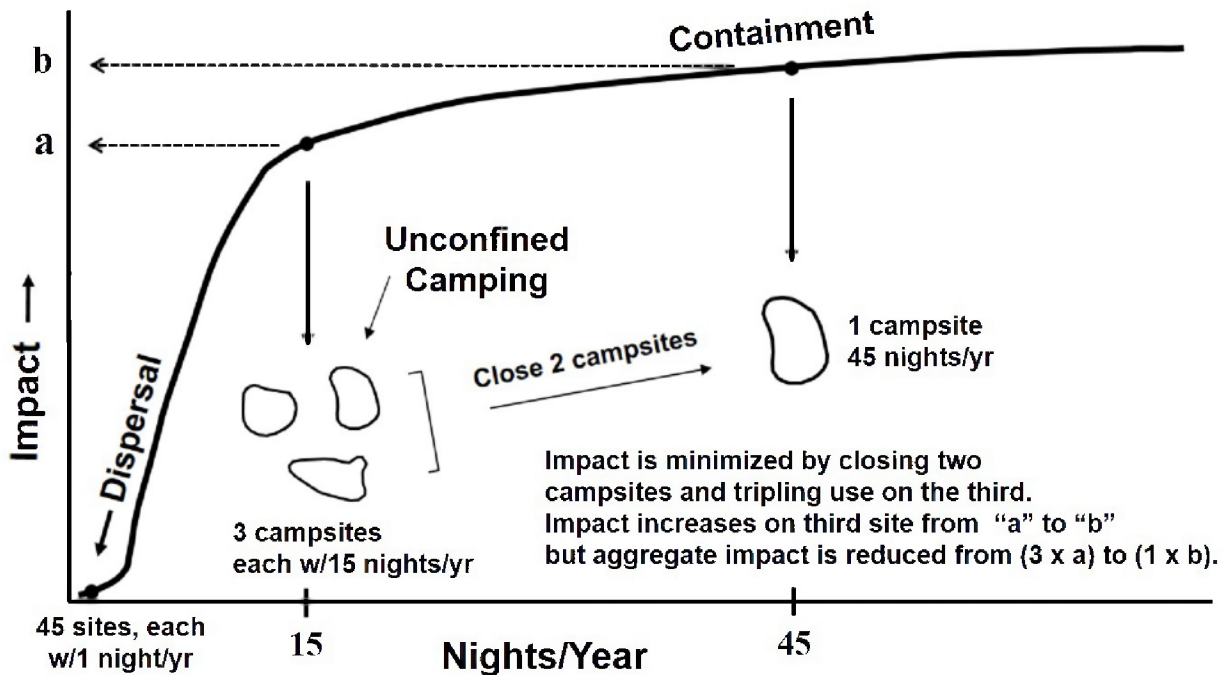

Figure 1 - A generalized model of the use-impact relationship for camping on vegetation and soil illustrating the empirical basis for effective Dispersal and Containment strategies. In this example, aggregate impact under many unconfined camping policies, three times an "a" level of impact, is substantially reduced under a Containment strategy that closes two campsites and shifts their use to a single site with a "b" level of impact. Alternately, if camping could be fully dispersed to 45 sites used only once a year (and/or to highly resistant substrates), *no* lasting impact would occur (from Marion 2016).

This asymptotic relationship between camping use and resource impact has significant implications for devising effective camping impact management strategies (Figure 1). A clear implication is that managers can employ a **Dispersal Strategy** to avoid resource impacts by reducing use to levels that prevent impacts lasting more than a year. Alternatively, managers can employ a **Containment Strategy** to minimize aggregate camping impact by concentrating use on a limited subset of more heavily used sites (Leung and Marion 1999, Marion 2016). These two preferred strategies are featured in the following classification of Camping Strategies, along with unconfined camping (Table 1).

Table 1 - Camping management strategies, options, and guidance.

Camping Strategy	Use Level	Description and Guidance
UNCONFINED (Dispersed Camping)	All	Visitors have the freedom to select or create a campsite in the location of their choice, sometimes modified by guidance to avoid locations close to water or formal trails or to use an existing site. Campsite proliferation, excessive aggregate resource impact, and high density camping are frequently significant problems in popular areas.
DISPERSAL STRATEGY Pristine Site Camping	Low-Mod	Visitors are asked to camp on durable *previously undisturbed* surfaces at low use levels that avoid lasting impact. Difficult to achieve in high use areas and requires visitors to learn and consistently apply low impact pristine site camping practices.
CONTAINMENT STRATEGY Established Site Camping	All	Visitors are *encouraged to camp* on a subset of well-established sustainable campsites selected by managers to promote resource protection and desired social qualities. Supporting actions include campsite maps to aid visitors in finding the selected campsites and a program to close and restore non-selected campsites.
Designated Site Camping	Mod - High	Visitors are *required to camp only* on a subset of sustainable designated campsites selected by managers to promote resource protection and desired social qualities. Managers generally mark designated campsites on maps, have signs and/or some facilities, and remove hazardous trees. Designated sites are managed as "first-come first-served" or, more rarely through a reservation system.

Unconfined: For more than four decades U.S. federal land managers have favored a largely unregulated camping strategy that promotes visitor freedom to select and create campsites in locations of their choosing, with limited additional guidance. Managers typically refer to this strategy as "Dispersed camping," though it can encompass a range of policies which may not seek to disperse or reduce site use. In practice, many managers who employ dispersed camping urge visitors to select well-established campsites and/or apply educational guidance or regulations to shift campsites away from water bodies, and more rarely from formal trails or popular destination areas. Some managers have additionally sought to close and restore campsites that are unnecessary, too close to water, trails, or other campsites, or are considered less sustainable – when combined with a request to camp on established campsites this scenario is similar to the Established site camping strategy described below. We note that the "dispersed camping" nomenclature is inconsistent with that conveyed in Figure 1, where dispersal explicitly refers to the reduction of use to levels that avoid lasting resource impact. For the purpose of clarification in this paper we refer to dispersed camping as an "unconfined" camping strategy because visitors, not managers, are mostly free to select or create campsites, generally with little regard to sustainability attributes that promote the protection of resource and social conditions. This and other policies can be applied to entire wilderness areas or to specific zones.

Dispersal Strategy: A pure and the only true form of a dispersal strategy is **Pristine site camping**, where visitors are asked to: 1) locate an area out-of-sight or distant from trails, water, and campsites with no evidence of visitor trampling or camping *and* trampling-resistant surfaces that show little evidence of camping impact, 2) camp one to several nights, concentrating use on the most resistant surfaces and departing before lasting impact is created, and 3) restore and naturalize the site to mask visible impacts and deter future campers from finding and reusing it. Trampling-resistant surfaces include durable rock,

gravel, or snow, areas with little to no vegetation (e.g., shady forests, sandy shorelines, dry washes), or dry grassy areas (Marion 2014). Cole and Benedict (1983) and Marion (2014) describe this form of camping, cautioning that visitors must apply these low impact practices to avoid the creation of new campsites. Though this form of camping is permitted in many protected areas, few managers have directly marketed it to visitors, perhaps because when ineffectively applied it can lead to campsite proliferation.

Containment Strategy: Recreation ecology studies support a containment strategy as the most effective option in moderate to high use settings, with visitors *encouraged* to use a limited number of carefully selected **Established sites** that meet agency guidance, or *required* to use only **Designated sites** (Cole 2013, Marion 2016, Reid and Marion 2004). Since use is to be concentrated on a subset of highly visited campsites under this strategy, a key component for successful implementation is that managers carefully select campsites that are *"sustainable"* to promote the protection of both natural resource and social conditions. We define a sustainable campsite as one that *can accommodate the intended type and amount of use over time without unacceptable levels of expansion, degradation, maintenance, and social crowding or conflict.*

Supporting Actions from the Management Toolbox: In addition to implementing a camping management strategy, agency staff can rely on a variety of tools, or actions, from the "management toolbox" (Cole et al. 1987, Marion 2016). When choosing tools, managers should consider the potential impacts of management actions on visitor freedom, access, and the quality of their experiences. These tools may be grouped as regulatory, educational, and site management actions that range along a management continuum from less to highly intensive.

Problems in Paradise: The Chronic Failures of Unconfined Camping

Particularly in wilderness, many managers have preferred some form of an unconfined (dispersed) camping strategy that allows visitors the freedom to find and select a campsite of their choice, with minimal regulatory interference. One common regulation that managers have applied has been to prohibit camping within various specified distances of water bodies, as described in another paper in this issue (Marion et al. 2018). Recreation ecologists who study the impacts of visitor use in protected areas have consistently documented some substantial avoidable and unacceptable natural resource and experiential impacts associated with unconfined camping policies (Cole 1982 a,b, 2013, Leung and Marion 2000, 2004). Three common/chronic problems include: 1) visitors frequently create non-sustainable campsites in flat terrain close to popular attraction features or destination locations, water, and formal trails, 2) visitors create high-density clusters of large campsites with unacceptable levels of resource and social impact in the most popular areas, and 3) site proliferation over time leads to exceptionally large numbers of unnecessary campsites. These topics are examined and illustrated with data from campsite monitoring surveys and research in various U.S. regions.

In 1999, the Appalachian Trail management community sought to identify the worst camping locations trail-wide, and initiate consulting and management actions to resolve resource and social impacts (Marion 2003). Seventeen locations in eight states were identified and visited by an interdisciplinary team of land managers, volunteers, and scientists. Annapolis Rocks, a scenic overlook and popular camping spot in Maryland, was judged to be the "worst" location in 1999. It had been managed under an unconfined (dispersed) camping policy that permitted visitors to create a large cluster of 19 campsites in flat terrain adjacent to the vista, with exceptionally high levels of resource and social impacts (Figure 2). Mean campsite size was 2,271 ft^2, including three mega-sites exceeding 5,000 ft^2 formed by the expansion and merging of several proximate sites (Daniels and Marion 2006). The aggregate area of camping impact was

43,099 ft^2, including 23,116 ft^2 of exposed soil, 83 damaged trees, and 137 tree stumps. A questionnaire examined visitor satisfaction with camping in the area using a scale of 1 (highly dissatisfied) to 5 (highly satisfied) to evaluate 22 utility, environmental, and social indicators. Indicators with the four lowest scores were "privacy of my campsite" (3.26), "noise from other groups" (3.27), "amount of bare soil" (3.27), and "number of people camped near me" (3.31) (Daniels and Marion 2006).

Figure 2 - One of three "mega-sites" within a cluster of 19 campsites at Annapolis Rocks, MD, identified by the Appalachian Trail management community in 1999 as its "worst" example of resource and social camping impacts. This location illustrates the chronic problems that an unconfined camping policy allows: excessive site proliferation and campsite expansion occurring in large flat areas that creates unacceptable resource and social conditions.

In a survey of 11 U.S. Forest Service wilderness areas managed for unconfined camping in Virginia, Leung and Marion (2000) found that a large majority of campsites (72%) created by visitors were located along and within sight of formal trails, with 38% less than 25 ft from formal trails. Campsites were unevenly distributed, with visitors creating high densities of campsites in large flat areas close to camping shelters and streams. Results suggest that visitors *rarely* select campsite locations based on a desire for solitude or privacy, and their proximity to trails and camping shelters reduces the potential for solitude of other hikers and campers. *Neither were these campsites in resistant locations*; most were located under forest canopies on fragile forest herbs in flat terrain where site expansion and proliferation have and will always be chronic problems (Leung and Marion 2000).

Virginia's Shenandoah National Park wilderness managers applied a modified unconfined camping policy beginning in 1974 that actively sought to shift visitors away from trails and water by prohibiting camping within 25 ft of water and within sight of formal trails (Williams and Marion 1995). However, a comprehensive census survey in 1992/93 found that 68% of all sites (n=725) were in violation of these polices, including 25% located less than 25 ft from water and 56% within sight of formal trails (58% were <150 ft from trails). Based on permit data managers estimated that campsite visitation ranged from 0 to 50 nights/yr, with the majority of sites receiving 5 to 20 nights/yr. Scientists and managers who examined the survey findings and permit data concluded that there were large numbers of campsites receiving low levels of use that, if eliminated, would substantially reduce aggregate camping impact.

Recreation ecology studies in the western States report similar findings to these eastern examples. In a study of wilderness campsites in Oregon's Eagle Cap Wilderness, Cole (1982a) found that most campsites were concentrated at just a few popular destinations. Within two popular lake basins permit data suggests

that about 10 groups/night camped on 221 campsites during the core part of the use season, an occupancy rate of only 4.5%. The unconfined camping policy had allowed excessive campsite proliferation to occur, most of which were "within a few hundred feet of water sources and within sight of a trail." Cole's recommendation was to reduce aggregate camping disturbance by concentrating use on "only a small proportion of the sites," noting that their research also found that "the most frequently used sites were not disturbed much more than sites used no more than once a week" (Cole 1982b). A later study reported that the number of campsites at the seven high-use lakes increased by 134% over 15 years, with campsite density in 1990 exceeding two sites per hectare and "many clusters of sites so dense that it is difficult to tell where one site ends and another begins" (Cole 1993).

In a similar study of Montana's Lee Metcalf Wilderness Cole (1993) documented campsite proliferation that increased site numbers 84% from 1972 to 1988, which he attributed to "an increase in site-pioneering behaviors" and "passive campsite management programs." He concluded that "campsite proliferation is a highly significant problem that demands more attention from wilderness managers." The authors noted that reducing use levels at popular destination areas "would likely have more negative than positive consequences," and that "neither encounter levels nor physical impacts would be reduced to any meaningful extent." The authors concluded that: 1) the primary physical impact problem associated with camping is the large aggregate areal extent of camping impact, which is largely linked to campsite proliferation, 2) that education by itself is insufficient to concentrate use, and 3) that direct management in the form of an intensive program of site management is needed to shift use to a subset of existing campsites (Cole et al. 1997).

While unconfined camping policies allow visitors the ability to select and create preferred campsites, that freedom comes with a significant "cost" related to the creation of large numbers of unsustainable campsites in flat terrain near water and trails. It also reveals that use reduction is a poor tool for constraining campsite proliferation, aggregate camping impact, and crowding/conflict concerns, particularly in higher use areas (Cole et al. 1997). Nor have assisting direct actions like camping setbacks or indirect actions like education been very successful. Our review demonstrates that in popular high use areas managers frequently experience chronic problems with dense clustering of campsites near trails and water that threaten visitor solitude and social conditions, and that site proliferation can also be a problem in low and moderate use areas.

Implementing a Containment Strategy

The dispersal and containment campsite impact management strategies (Figure 1 & Table 1) are directly derived from recreation ecology experimental trampling and camping studies and empirical research on campsites (Cole 1995a,b, Marion 2016, Marion and Farrell 2002, Reid and Marion 2004). These studies also provided the basis for the national Leave No Trace program's guidance to concentrate use on campsites in popular areas while dispersing use in remote or low use areas (www.LNT.org, Marion 2014). For example, Cole (1982a) suggests camping dispersal on sedge meadows in the Eagle Cap Wilderness can be tolerated several nights/year as long as campfires are not constructed. However, his core recommendation was a containment strategy, to reduce aggregate camping disturbance by encouraging visitors to use a subset of the existing campsites.

Established campsites can be marked or unmarked on the ground, they typically have few or no facilities, and are generally more numerous and offer greater visitor choice than designated campsites, which are marked and may have greater infrastructure development, such as anchored steel fire rings, primitive

toilets, or food storage facilities. Because visitors are required to use designated campsites a management agency generally assumes greater responsibility for periodically surveying for and removing hazardous trees. Under established site camping visitors are encouraged to use management-selected sustainable campsites but retain the freedom to camp elsewhere so agency liability for hazardous trees is reduced (however, we note that some managers have "required" the use of established campsites). The smaller sizes of sustainable designated and established sites make it easier for agency staff to manage hazard trees, and agency control over campsite locations allows for shifting them to more open settings with fewer trees and more trampling-resistant grassy ground vegetation. Designated site camping is typically necessary only in the most popular and intensively visited areas. In some of these areas, managers additionally operate rationing or reservation systems that restrict the number of groups to the number of designated sites, or even assign groups to specific sites by date.

Several studies reveal that shifting camping to locations in sloping terrain is the most important sustainability factor in spatially concentrating camping activity on small campsites that will resist future expansion and campsite proliferation (Marion and Farrell 2002, Daniels and Marion 2006, Eagleston and Marion 2017). Other sustainability factors include durable surfaces such as rock, barren trampling-resistant substrates such as gravelly or sandy shorelines, dense shade that supports little vegetative ground cover, sunny locations with grassy vegetation, and extreme rockiness in off-site areas (Marion 2016). A 32-yr study by Eagleston and Marion (2017) discovered that selecting campsites in dense woody vegetation is only temporarily effective in deterring site expansion, as woody vegetation is removed over time by insects, disease, fires, or felled by visitors for firewood.

Current studies by the authors on the Appalachian and Pacific Crest Trails (AT and PCT) is focused on the development, testing, and refinement of protocols for evaluating the sustainability of existing or new sites with ground- and computer-based Geographic Information System (GIS) assessments. The objective of this research is to identify sustainability criteria and develop GIS methods that can be efficiently applied to large numbers of agency backcountry and wilderness campsites. Unfortunately, GIS methods will require accurate Global Positioning System (GPS) campsite locations and high-resolution topographic data (e.g., aerial LiDAR derived DEMs) that are not yet available for many areas.

Preferred designated or established campsites can be identified through a careful selection process that emphasizes the selection of the most sustainable existing campsites, and over time, the creation and use of new highly sustainable locations identified by managerial actions. Campsites that are not sustainable, unnecessary, or are too close to water, cultural/historic sites, or that threaten wildlife, rare species, or sensitive habitats can be omitted and closed for restoration. Inclusion of social criteria such as campsite amenities and scenic beauty, and proximity to trails, other sites, or day-use areas like vistas can also be incorporated to promote high quality social conditions and visitor satisfaction (Daniels and Marion 2006). An important consideration is matching the availability of established or designated campsites to campsite demand within travel zones.

An essential element of the containment strategy is for managers to restrict camping to a small subset of campsites. For example, National Park Service managers at Delaware Water Gap National Recreation Area substantially improved their designated site policy for backcountry riverside campsites in 1988 by reducing campsite numbers and installing anchored steel fire rings to specifically identify each legal campsite location (Marion 1995). Limited river patrols and enforcement efforts improved designated site camping compliance while closed and illegal campsites were left to recover naturally. A comparison of monitoring data from 1986 to 1991 revealed a reduction from 179 campsites (116 designated and 63 illegal) to 110 campsites (87 designated and 23 illegal). Even though designated campsite use levels

increased 28%, from 268 to 344 campers/site/yr, the aggregate area of camping impact for all sites decreased 50%, from 302,896 ft^2 to 150,910 ft^2. River rangers reported that campsite demand exceeded supply typically on only two peak use weekends each year.

A study by Reid and Marion (2004) evaluated actions at Shenandoah NP to convert an ineffective unconfined camping strategy to an established site camping strategy by asking visitors to only use "well-established" campsites. They also sought to close unnecessary and less sustainable campsites, assessed as sites with a higher potential for expansion potential based on topography, rockiness, and dense woody vegetation. Efforts were also made to increase the spacing of the selected sites from water, trails, and other selected sites to further protect resource and social conditions. Park staff performed limited restoration work once a year on the "closed" campsites, consisting of fire ring removal and placement of leaves, brush, and/or logs on barren areas to deter camping. Over three years, campsite numbers were reduced by 49%, aggregate campsite area by 50%, and area of vegetation loss by 44%. Campsite occupancy rates increased from approximately 19 to 29 nights/yr on the remaining sites but their mean size increased only 3%. We note that visitors frequently failed to find and use established campsites located out-of-sight from trails, so providing visitors with maps or GPS coordinates that identify campsite locations may be necessary.

Established site camping has also been implemented successfully in other wilderness areas when managers have implemented aggressive programs that target the closure and restoration of larger numbers of unnecessary, illegal, or non-sustainable campsites. For example, though not called established site camping, Cole and Ferguson (2009) describe how an active program of campsite closure and restoration in the Caney Creek Wilderness of Arkansas successfully reduced campsite numbers 40%, from 91 in 1994 to 54 in 2007. The largest decrease was in the number of highly impacted campsites, with median campsite size reduced from 2,500 ft^2 to 915 ft^2. Of particular note was the closure and relocation of a riparian corridor trail containing some of the most unacceptable camping impacts. Following the trail closure the old campsites were no longer accessed by visitors. Even greater success was achieved in Sequoia and Kings Canyon National Parks where visitors are directed to camp on "previously impacted areas." An intensive program of campsite closure and restoration was primarily responsible for a more than two-thirds reduction in aggregate camping impact from the late 1970's to 2007 (Cole and Parsons 2013). Park staff obliterated large numbers of unnecessary campsites in areas of high site densities and where campsites were close to water, and removed fire rings in areas where campfires were prohibited.

We stress that the efficacy of established site camping is improved when campsites are identified on maps and GPS coordinates and when managers are able to sustain efforts to actively close and restore non-selected campsites. We also suggest placing large flat "kitchen rocks" on established sites to attract and spatially concentrate intensive cooking activities to a single fixed location, and/or if campfires are permitted, ice-berging a few large rectangular rocks around a preferred campfire location (Figure 4) (Reid and Marion 2005).

Figure 4. Minimal site facilities like a large flat "kitchen rock" for stove use (left) or a small fire ring of large ice-berged rocks (right) can serve to identify, attract, and spatially concentrate camping activity on established campsites.

Side-Hill Campsites

Based on research at Isle Royale National Park, Marion and Farrell (2002) suggested that aggregate camping impact can be most effectively minimized by promoting camping on constructed "side-hill" campsites in sloping terrain (>20% slope), where the topography naturally inhibits campsite expansion and proliferation (Figure 5). This practice had been applied to create many of Isle Royale's campsites, achieving a very high level of camping activity concentration and constraining mean campsite size to 645 ft^2, representing the lowest mean area of camping disturbance per overnight stay documented in the literature (Marion and Farrell 2002). Side-hill campsites can be located to enhance social qualities and their small size and ability to provide pristine conditions in adjacent areas are also aesthetically pleasing to visitors.

Constructed side-hill campsites were recommended at numerous locations along the AT in 2003 as part of a larger campsite consulting study (Marion 2003), including as designated or established campsites. At Annapolis Rocks in Maryland side-hill campsites were constructed to resolve the substantial and unacceptable camping impacts there (Figure 2). The 19 visitor-created campsites that had resulted from unconfined camping were replaced in 2003 by 14 designated side-hill constructed campsites in sloping terrain just uphill from the former sites. The new campsites were distributed above and below a side-hill trail at locations to enhance the potential for solitude. The aggregate area of camping impact was reduced from 43,099 ft^2 to 6,243 ft^2 after 1 year and to 8,574 ft^2 after 9 years (Daniels and Marion 2006). A questionnaire examined visitor satisfaction with camping on the side-hill campsites using a scale of 1 (highly dissatisfied) to 5 (highly satisfied) to evaluate 22 utility, environmental, and social indicators. The indicator which had scored lowest for the clustered visitor-created campsites "privacy of my campsite" (3.26) became the highest score for visitors camping on the new side-hill campsites (4.30). The next three highest indicators were "number of people camped near me" (4.23), "security of my belongings at my campsite" (4.23), "noise from other groups" (4.21), and "naturalness of the area near my campsite" (4.18) (Daniels and Marion 2006).
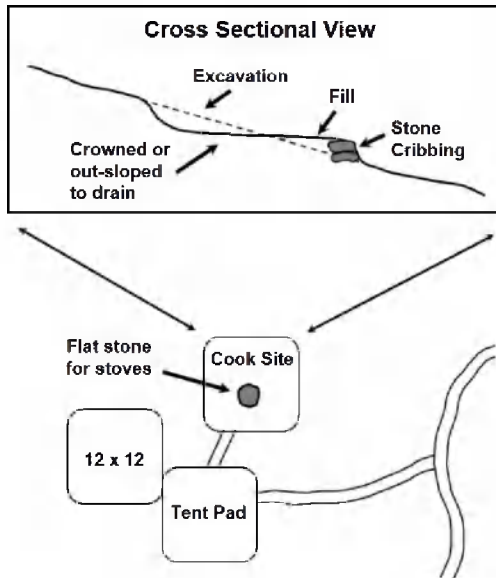
Figure 5 - Highly sustainable "side-hill" campsites can be constructed in sloping terrain to spatially concentrate camping activity on exceptionally small campsites. This site (right) was constructed along the AT at Annapolis Rocks, MD, and visitors expressed strong support and satisfaction with their creation (Daniels and Marion, 2006, Figure from Marion 2016).

Figure 5 - Current research on campsite sustainability along the Pacific Crest Trail identified these highly sustainable naturally-occurring "side-hill" campsites located in the Inyo National Forest at Thousand Island Lake, where surrounding topography and rockiness effectively inhibits site expansion and proliferation.

Current AT and PCT studies by the authors are investigating efficient ground- and GIS-based methods for identifying optimal locations for constructing side-hill campsites, and for locating "naturally-occurring" side-hill campsites (Figure 5). More than 800 side-hill campsites have been created along the AT since 2002 and they have proven to be highly sustainable and effective in reducing both resource and social/experiential camping impacts (Marion 2016). *A significant advantage of side-hill campsites is that visitors spatially concentrate their camping activities to campsites with a small "footprint" through natural interactions with surrounding topography, rather than in response to regulations and enforcement or their*

ethical knowledge and conscience (Marion and Farrell 2002). Shifting camping to constructed or naturally-occurring side-hill sites resolves the chronic management problems of campsite expansion and proliferation that have proven to be inevitable in flat terrain. The extremely small size of these sites also makes if substantially easier for agency staff to manage hazardous trees.

Wilderness Character Considerations

An examination of wilderness character concerns (Landres et al. 2015) reveals both "benefits" and "costs" associated with the provision of an infrastructure of sustainably selected campsites managed under a containment strategy. Research reveals that the successful application of this strategy can avoid or substantially reduce resource and social impacts from those occurring under an unconfined management strategy, particularly in high use settings. The reduced campsite numbers and impacts would improve the <u>natural conditions</u> of wilderness, the first core quality of wilderness character. The second quality, <u>solitude or a primitive and unconfined type of recreation</u>, is improved by separating campsites from trails and other sites but designated site camping would restrict visitor freedom to camp anywhere. The reduction in campsite numbers would improve the <u>undeveloped</u> character of wilderness, but any facilities provided on designated sites would detract. The fourth core quality of wilderness character, <u>untrammeled</u>, is somewhat compromised by the required use of designated sites. Finally, <u>other features of value</u> are preserved when campsites are more sustainably selected and located to avoid degrading sensitive archaeological, historical, or paleontological sites.

In our evaluation the potential threats to wilderness character associated with formal trail systems that employ side-hill constructed treads, stone staircases, engineered drainage features, and treated dimensional lumber or steel in bridges greatly exceed those related to the use of designated site camping in high use areas. We presume that wilderness managers have evaluated wilderness character qualities and trade-offs for developed trail infrastructures and justified their need. While the "rewilding" movement has sought to restore native flora and fauna in protected areas, and even to remove and restore unnecessary roads (Switalski et al. 2004), we've not seen a retreat from the use of formal trail networks in wilderness. *An important question raised in this paper is why managers have generally not applied the same logic and decision-making to the professional management of wilderness campsites, and more consistently developed sustainable infrastructures of campsites?*

Challenges and Research Needs

We suggest that additional studies be focused on evaluating and improving the implementation of the pristine site camping strategy in low use areas and the containment strategy in moderate to high use areas. An important remaining challenge for implementing established site camping is developing compelling and effective education, communication, and navigation aids to direct visitors to established sites and to avoid using closed/illegal sites. Campsite closure and restoration programs applied to accomplish this are staffing intensive and difficult to sustain long-term, are frequently ineffective in closing well-used campsites, and cannot direct visitors to the most sustainable sites. The success of this work can be substantially improved by identifying established and designated site locations on printed and digital maps and in GPS files posted on websites, just as formal trail networks are. For example, Voyageurs National Park provides a digital file of GPS waypoints for all their backcountry campsites. Visitors are increasingly using smartphones and their connectivity to accurate GPS satellite networks allow a variety of phone apps to access easily updated digital maps for wildland navigation. For example, one popular phone app includes campsites and navigational aids to easily find them and welcomes collaborations with managers to substitute a listing of more sustainable sites. These new media also facilitate the communication of information on camping regulations and low impact practices based on a user's specific location.

Ongoing research by the authors on the PCT plant to test the use of printed and digital maps to direct visitors to the most sustainable established campsites. Such maps when viewed on GPS units or phone apps can utilize "digital fences" by depicting shaded regions that clearly illustrate camping setbacks from water or formal trails. The rapidly increasing use of digital maps by backpackers and hikers on GPS units and smartphone apps offer managers an innovative, inexpensive, and accurate method to create, update, and widely distribute information about regulations, low impact practices, and the locations of sustainable established or designated campsites. Our suggestion is contrary to some of our colleagues, who cite the expanding use of technological devices and their personal wilderness character concerns with the electronic connectedness of wildland visitors (Dustin et al. 2017). However, Harmon (2015) observed that long-distance hikers were not *constantly connected* and instead had *punctuated moments of interaction and use* of their smartphones; concluding that *disconnection* is less about unplugging from these devices and more about a *context shift, and social reconfiguration* that takes place in the wildland setting.

Recognizing that some managers may not view the use of such technological devices to be appropriate in wilderness, we suggest that: 1) device use is legal and optional, with visitors deciding whether or not to use them, 2) these platforms offer substantial advantages in effectively communicating relevant information, *particularly* for shifting visitors to a sustainable subset of existing campsites, and 3) not engaging via these technologies poses an increasing risk that agency communication efforts will become more irrelevant. Further, we recommend additional discourse between scientists, managers, and visitors, and additional research to evaluate the potential risks and opportunities of these expanding digital technologies on wilderness character, visitor experiences, and the efficacy of visitor use management actions.

Conclusions

Recreation ecology research and management experience reveal significant problems with unconfined camping, particularly in popular moderate to high use areas like riparian corridors and lake basins. We suggest that a dispersal strategy with pristine site camping can be a viable option in remote and/or low use areas, though more research and management experimentation are needed. In moderate to high use settings a containment strategy with either established or designated sites is a preferred strategy to concentrate camping on a more sustainable subset of campsites selected to promote improved resource and social conditions. Higher levels of use and impact generally require more intensive and direct visitor management actions such as designated site camping. Constructed and naturally-occurring side-hill campsites offer another option, particularly in popular high-use areas where other strategies and actions have proved ineffective.

Acknowledgements

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