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

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).

Scenic photo that could be used for article…