

Human Impact Surveys in Mount Rainier National Park: Past, Present, and Future

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Abstract—Three survey methods were utilized to describe human impacts in one wilderness management zone of Mount Rainier National Park: wilderness impact cards, social trail and campsite surveys, and condition class surveys. Results were compared with respect to assessment of wilderness condition and ecological integrity. Qualitative wilderness impact cards provided location of point impact such as litter, human waste, and campsites. They did not provide data related to ecological integrity and were limited by their inconsistent implementation. Systematic social trail and campsite data provided quantitative estimates of bare ground impacts. Condition class surveys provided spatial documentation of wide range of impacts. Selection of a method is dependent on good articulation of monitoring goals and funding limitations.

Each year approximately two million people visit Mount Rainier National Park (Johnson and others 1991). For many visitors, the primary destination is within the subalpine parkland or alpine zone. Collectively, these two ecological zones only comprise about 35% of the entire Park, yet they absorb over half of all visitors, and use is generally concentrated within two to three summer months. Some specific areas of the Park, such as Paradise and Muir Corridor, have been popular attractions since the early 1890s—before the Park's establishment in 1899. In the 1890s, recreationists from the Seattle and Tacoma areas supported the establishment of the Park as a means of protecting the area from recreational impacts (Cotton 1996). This intense use for over 100 years has resulted in many human impacts such as campsites, informal trails and large denuded or eroded areas.

Surveys of human impacts have been conducted since the late 1960s (John Wilcox, personal communication). Survey methods have ranged from qualitative descriptions and photographs to detailed measurements. In 1988, with the passage of the Washington Wilderness Act, 97% of Mount Rainier National Park was designated as wilderness. The park's Backcountry Management Plan was replaced with a Wilderness Plan that included Limits of Acceptable Change indicators and standards (Samora 1989). Since 1994, concurrent with the Park's development of the General

Management Plan, LAC and VERP indicators and standards have been reexamined (National Park Service 1997; Stankey and others 1984).

Currently, three impact survey methods are used to document recreational impacts in wilderness areas of Mount Rainier National Park: wilderness impact cards, social trail and campsite surveys and condition class surveys. The objectives of our study were: to survey one study area using all three methods, to compare results from the three methods, to evaluate the results with respect to ecological integrity and wilderness conditions, and develop recommendations for future monitoring of wilderness areas.

Methods

Study Area

Mount Rainier National Park is located on the western slope of the Cascade Range, 60 miles southeast of the Seattle-Tacoma metropolitan area. It encompasses 235,622 acres and extends from old-growth forest (1,730 feet) through subalpine and alpine communities to the mountain's summit at 14,410 feet. The study area is referred to as Muir Corridor and is located within the Muir Snowfield Wilderness management zone, on the south central flank of Mount Rainier (figure 1). The area encompasses 425 acres and extends from treeline at 6,800 feet to Anvil Rock at 9,000 feet elevation. Five broad community types can describe vegetation of the area: heather, fellfields, sedge fellfields, talus, and snowbed (Edwards, 1980). Heather communities are dominated by one or two ericaceous species: *Phyllodoce empetriformis* (red heather), *P. glanduliflora* (yellow heather), or *Cassiope mertensiana* (white heather). Radiocarbon dating of buried plant stems has documented the persistence of some communities for 7,000 to 10,000 years (Edwards, 1980). Fellfields are flat, rocky areas with small, discrete clumps of plants growing among the rocks. Sedge fellfields are located in wet areas and often have continuous cover of several short sedge species. Talus slopes are steep rocky areas with larger rocks than fellfields. Plants grow in protected cracks and crevices. Snowbed communities grow on the edge of late melting snowbeds. Some areas may remain under snow for several years during cool periods.

Approximately 8,000 climbers and an estimated 4,000-6,000 dayhikers travel through the area each summer. For many, the destination is Camp Muir at 10,000 feet elevation, the most popular climbing camp. Although park regulations require hikers to stay on maintained trails or snowfields, many visitors walk off-trail across fragile vegetation. Since 1989, camping has only been allowed at Camp Muir and on snow-covered areas in Muir Corridor. However, rangers

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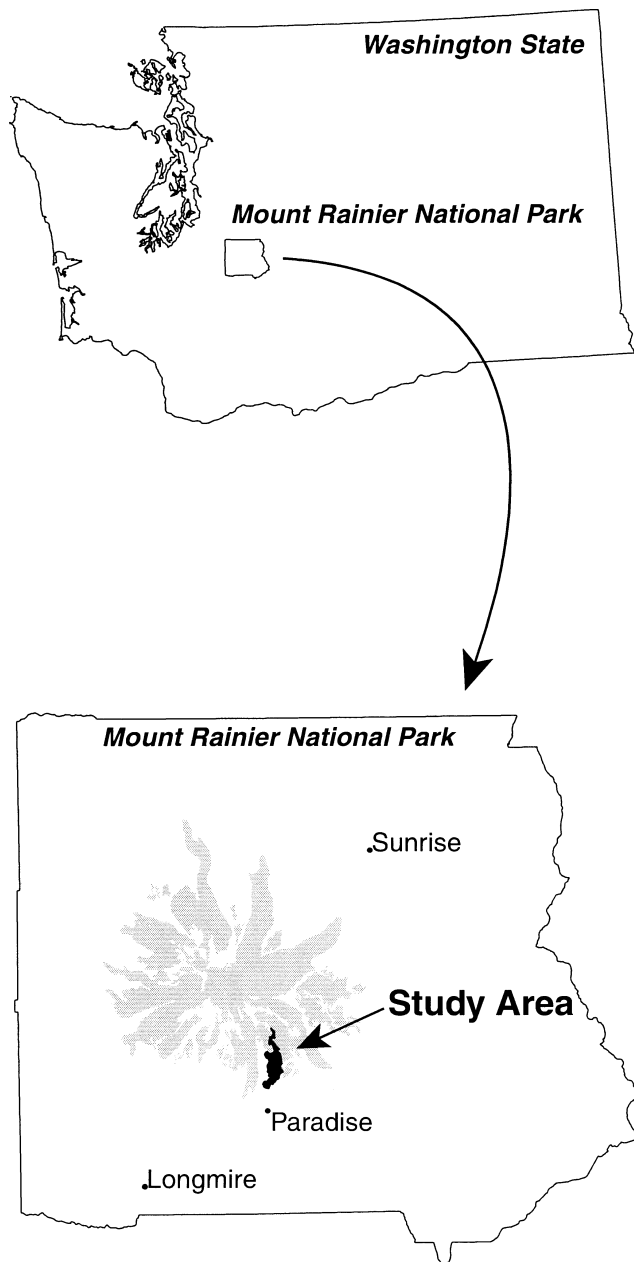


Figure 1—Location of the study area in Mount Rainier National Park.

frequently find people camping on nonsnow sites in the corridor. Both hikers and climbers camp in the zone, but the majority of overnight use is by climbers (fig. 2). Off-trail hiking, illegal camping and camping prior to 1989 has resulted in extensive resource damage. Impacts range from trampled plants to removal of entire plant communities and severe erosion.

History of Human Impact Surveys

John Dalle-Molle initiated a park-wide human impact monitoring system in the early 1970s. Originally, this system utilized backcountry impact cards on which rangers documented impacts using a brief description of both the

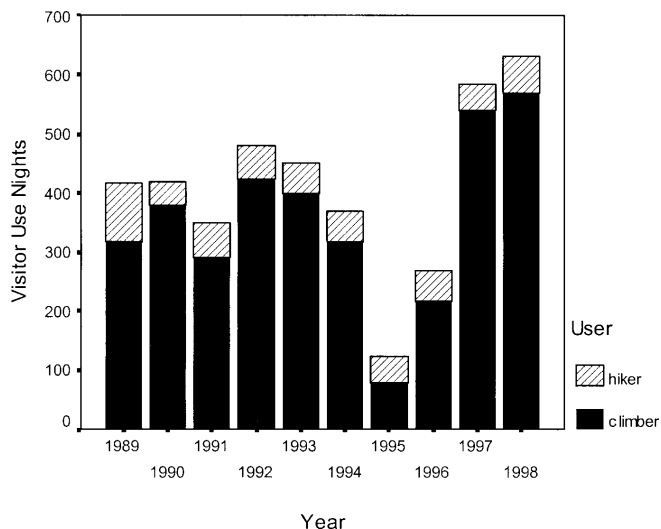


Figure 2—Overnight visitor use of Muir Corridor.

impact and its location. In 1988, 97% of the Park was designated as wilderness and the cards were redesigned to complement the Wilderness Plan. Cards were renamed to wilderness impact cards and the impact description was revised to include an entry of impact type by category (for example, landscape conditions or sanitation) that corresponded to LAC indicators listed in the Wilderness Plan (Samora, 1989). Descriptive locations of impacts were supplemented with Universal Trans Mercator coordinates in 1993 and in 1995, all data from wilderness impact cards was entered into a database linked to the Park's Geographic Information System (GIS). During the 1970s, intensive surveys of designated and informal campsites and social trails (informal trails) were initiated in specific areas of interest. A park-wide program to document quantitative measurements of social trails and campsites was initiated in 1985 to provide a baseline for restoration of human impacts. Measurements were used to rate and rank impacts and to develop supply and materials lists. Dr. Ola Edwards introduced a third method of monitoring human impacts to the park in late 1970s: condition class assessments (Edwards 1985). These methods have been utilized and revised for use in all three broad vegetation zones of the Park: alpine, subalpine, and forest.

Field Survey Methods

Three human impacts survey methods were used: wilderness impact cards, social trail and campsite surveys and condition class surveys. Field personnel generally complete wilderness impact cards when they notice human impacts. Data collected on the card includes date of observation, observer, location of impact is marked on a topographic site map, the category and type of human impact, details and action taken. An example of an impact category is sanitation, the type of impact would be human waste and detail might be 4 piles of human waste/toilet paper. Impact categories correspond to LAC indicators in the Wilderness Plan (Samora 1989). Wilderness impact cards can be used

every day, but in reality, use of cards is subjective, both temporally and spatially.

Social trail and campsite inventories are quantitative surveys that were systematically conducted throughout the zone in 1988, 1995, and 1997. Field personnel walked all accessible areas, within the study zone, in a manner similar to a search for lost people. In 1988, campsites and social trails were mapped using aerial photos, topographic maps and compasses. In 1995 and 1997, a Global Positioning System was used with orthophoto quads and locations were directly downloaded into the Park's GIS. Campsite centers were mapped using a single, differentially corrected and averaged GPS location. A local site map illustrating site shape and landmarks was drawn to assist with future relocation and monitoring and a photograph was taken. Campsite area was calculated by measuring eight radial transects and summing the area of the eight triangles. Slope, aspect and plant community were recorded at each campsite. Social trails were divided into segments both for mapping and measurements. Within each segment, width, depth, length, slope, aspect and vegetation type were recorded. A GPS line feature was recorded for the length of the segment, as well as GPS points (180 minimum) at the beginning and end of each segment. Point collection at the beginning and end of each segment was added to improve accuracy of mapping due to data collection difficulties caused by the steep terrain. Points were differentially corrected and averaged to produce an acceptable measurement. After each survey period, all campsites were obliterated by removing rock walls and restoring the desert pavement (most campsites were in fellfields or talus areas), thus, campsites documented during each time period were recently established.

Condition class surveys were conducted systematically throughout the study area in 1998. First, a 25-m by 50-m grid was superimposed over the area using the Park's GIS. Each point became the center point for a 0.1 ac circular plot in which site condition class, vegetation type, slope, aspect, bareground cover, vegetation cover, and elevation were recorded. Notations were also made if the sample plot included a campsite, social trail, or litter within its perimeter. If a point fell on permanent snow or ice, that was noted and condition class was not recorded. GPS coordinates of sample points were loaded into military GPS receivers for locating plots. Plot centers were also plotted on aerial photos to provide crews with field maps. Military GPS receivers are available to government agencies and were used because they provide access to a more accurate GPS signal than civilian GPS receivers. The latter require post-processing and entry into a GIS to provide acceptable locations. Our goal was to relocate systematically located points so as not to bias our results and to enable future relocation of the same sample points. Plot centers that fell on permanent snow or ice were disregarded, as were points that were inaccessible or hazardous to field crews. A total of 336 plots were inventoried. Five condition classes were used: 0 or pristine, 1 or little change, 2 or significant change, 3 or severe change, and 4 or habitat destroyed (see Table 1).

Table 1—Description of condition classes.

Condition class	Description
0 Pristine	No signs of human use of the area
1 Little change	Small and temporary indications of use caused by people or animals, such as litter, trampled vegetation, scuffed soil, footprints but no lasting damage such as plant loss, erosion, or broken stems
2 Significant change	Human impacts are easily recognizable, but limited in severity or distribution; examples include uprooted plants, clearing of forest litter thus creating a trail or campsite, clearing of pebbles or rocks in fellfields or compacted soil, but not erosion; area of individual impacts should be small (< 0.8 sq. ft. or 1 ft. in diameter) and covering a small portion of the sample area (<10-15%)
3 Severe change	Few severe impacts or many moderate impacts with an extensive distribution so that the sample area is fragmented; severe impacts include walled campsites in an alpine area, eroded social trails (greater than 1" deep), very large compacted sites; extensive, moderate impacts could cover up to 50% of the sample area
4 Habitat destroyed	This level of impact is reached when 50% or more of the site is covered by permanent impacts such as plant or soil loss or erosion.

Data Analysis

All spatial data were entered into Mount Rainier National Park's Geographic Information System. Descriptive and quantitative data was entered into dBase or SPSS databases. Historical patterns of impacts were reviewed by looking at the number and distribution of wilderness impact cards and the distribution of campsites recorded in the social trail and campsite surveys. Numbers of wilderness impact cards were examined for 1989 to 1998 and compared with visitor use nights spent within the wilderness zone. Current impact levels were assessed using the 1998 wilderness impact cards, the 1998 condition class survey, and the 1997 social trail and campsite survey. Geographic distribution of impacts, recorded by each of the three methods, was displayed and visually compared using ArcView. Types of impacts and severity of impacts were also compared between the three methods. Number and severity of impacts was compared between vegetation types for campsite surveys and condition class surveys. Correlation of condition class with elevation and slope was explored using correlation analysis.

Results

Wilderness Impact Cards

Over the past 10 years, 245 wilderness impact cards have been submitted for the Muir Corridor (fig. 3). Comparison of annual visitor use nights (fig. 2) and number of wilderness impact cards submitted (fig. 3) does not reveal similar trends. Visitor use peaks occurred in 1992, 1993, 1997 and 1998. The submission of wilderness impact cards peaked in 1991, 1993 and 1998, relatively low numbers of impact cards were submitted in 1992 and 1997. This is surprising in that numbers of impacts might be expected to increase during years with higher visitation. In the summer of 1998, 53 cards were submitted within five impact categories: smoke, ground disturbance, human waste, litter, and trampled vegetation (fig. 4). There was just one card that listed smoke from multiple stoves as an impact to air quality. Ground disturbance generally referred to the construction of a campsite by clearing rocks, pebbles, and vegetation and often construction of a rock wall to serve as a windbreak. Trampled vegetation was usually noted in the lower portion of the study area where vegetation is lushier than the higher elevation fellfields. Time to complete this survey is difficult to estimate because it was a collateral duty, but cards were completed over 19 days. Spatially, the 1998 impacts are concentrated in the northern portion of the study area (fig. 5).

Social Trail and Campsite Inventories

Social trail and campsite surveys were initiated in 1986. In 1987 and 1988, 86 campsites and 74 social trails were documented. All campsites were obliterated in 1989, stabilization and restoration of social trails was initiated (Rocheport 1989) and a campsite-monitoring program was established. Since no camping off snow-covered surfaces was allowed, all campsites discovered were illegal and obliterated. In 1995, 21 new campsites were inventoried and destroyed. In 1997, another

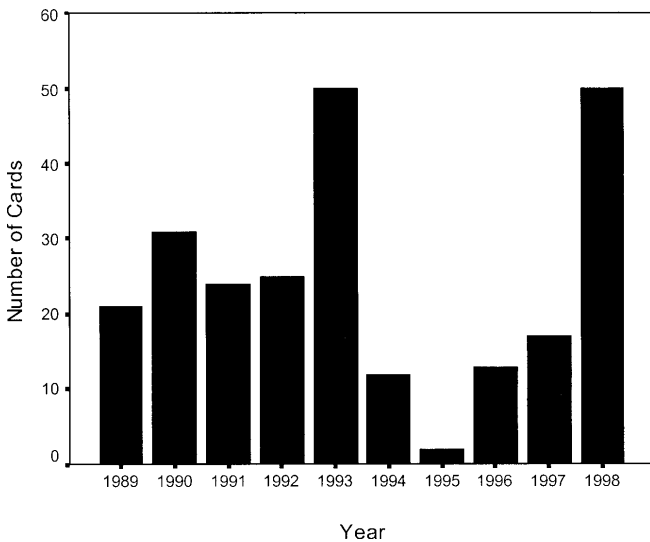


Figure 3—Number of wilderness impact cards submitted since 1989.

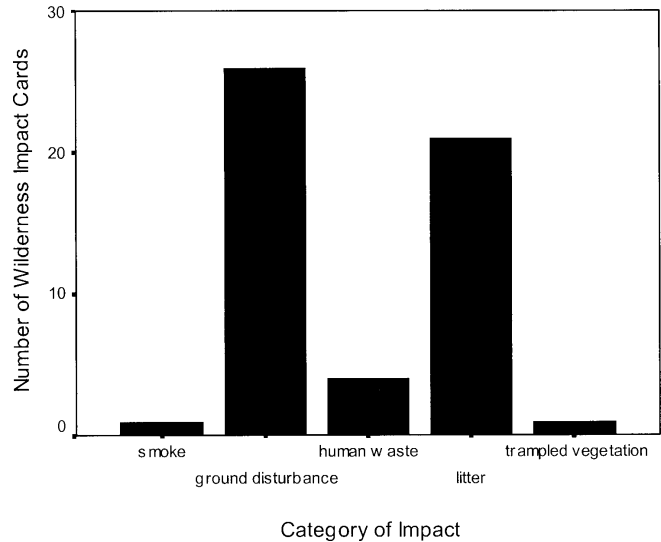


Figure 4—Category of impacts recorded by wilderness impact cards in 1989.

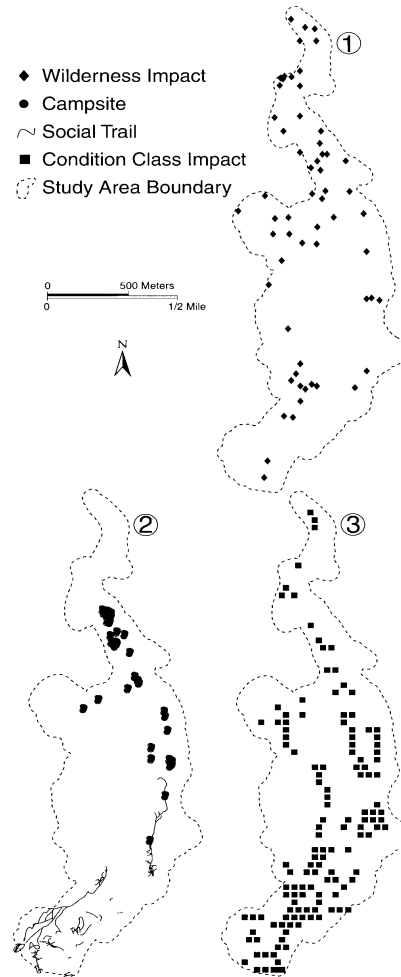


Figure 5—Spatial distribution of human impacts, in Muir Corridor, as recorded by 3 methods: (1) wilderness impact cards (1998), (2) social trail and campsite inventories (1997), and (3) condition class surveys (1998).

43 campsites were discovered and obliterated and all social trails were still visible. In most instances, campsites had been developed on new sites and were not re-establishments of existing sites. The time required to complete these surveys was as follows: 39 workdays (10 hour days) to document all campsites in 1987, 8 workdays to inventory campsites in 1995, 16 workdays to inventory campsites in 1997 and 22 workdays to inventory social trails in 1987. Most campsites, each year, were found in rocky areas such as fellfields and talus slopes (Table 2, fig. 6). Average campsite surface area decreased from 1987 to 1997. The size reduction may reflect the fact that campsites found in 1987 could have been established ten to twenty years before documentation and may have been enlarged with repeated use. Campsites found in 1995 could only have been established since 1988, while those documented in 1997 could have been a maximum of two years old.

A total of seventy-four social trails were documented in Muir Corridor. All trails were found in the southern portion of the study area. Social trails ranged in length from 4.3 m to 580.6 m in length (14 ft. to 1904.4 ft.), the average trail length was 59.3 m (194.5 ft.). Surface area of social trails ranged from 73.6-sq. m. to 633.3-sq. m. (88 to 757 sq. ft.), with a total surface area of 3502.7-sq. m. (4187 sq. ft.). Most social trails meandered through all vegetation types present.

Condition Class Surveys

The 25-m by 50-m grid placed over the 425-acre study area produce 1419 intersections or potential sample points. Sites were only sampled, however, if they were on snow-free sites that were safe to walk to (that is, not too steep). Only 334 points qualified for these criteria. This survey required 31 person days over the course of 10 workdays with a crew of two to four people. Sixty percent of the sample sites were rated as condition class 0 or 1 (fig. 7). The remaining 40% of the sites were in classes 2, 3, or 4—categories that are out of standard in the Wilderness Plan. Contrary to the wilderness impact card surveys, the most severely damaged sites were in the southern portion of the study area. While the campsite-monitoring program documented campsites (the equivalent of a condition class 2, 3, or 4) only in talus and fellfields, condition class surveys also documented heather and sedge areas in condition class 2, 3, or 4. Calculation of Pearson correlation coefficients revealed a significant negative correlation between condition class and elevation ($r = -0.228$, $p = 0.0$, $n = 333$) indicating that condition class generally decreased with increasing elevation. Slope was also negatively correlated with condition class ($r = -0.269$, $p < 0$, $n = 332$) indicating that condition class decreased with increasing slope. This probably reflects the fact that flat areas are more accessible and more attractive to people for walking, sitting and camping.

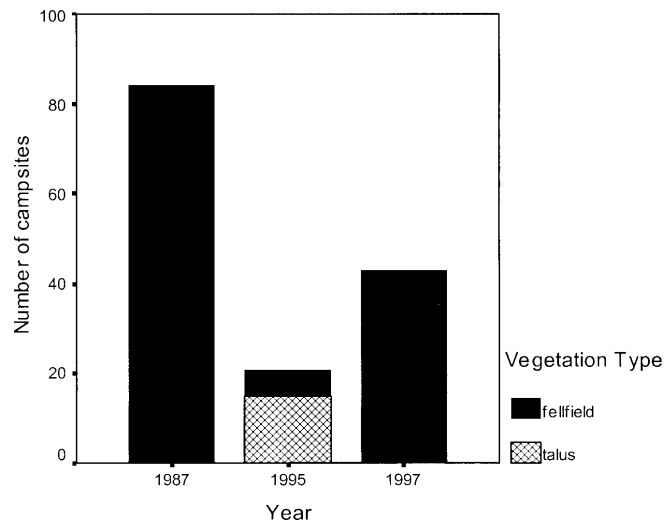


Figure 6—Number of campsites recorded by year and vegetation type.

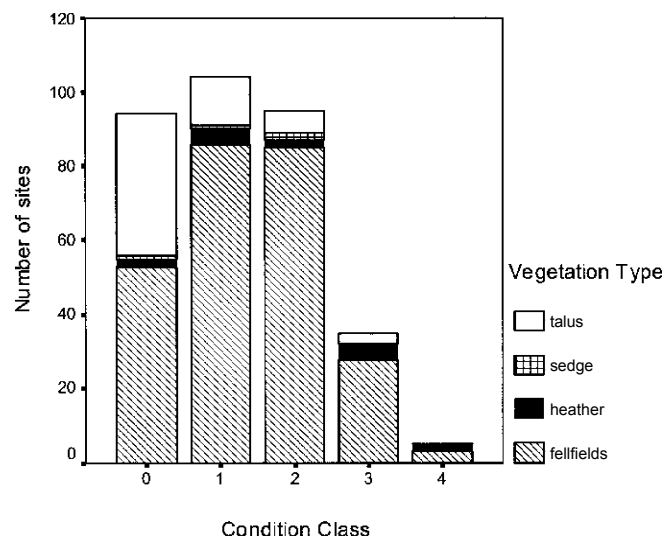


Figure 7—Condition classes recorded in 1998 survey of Muir Corridor.

Summary and Recommendations

Wilderness impact cards recorded point impacts such as campsites, litter and human waste. The cards were often used to record noncompliant personal encounters such as lack of a permit or camping away from snow-covered surfaces. The cards were limited by their inconsistent

Table 2—Characteristics of illegal campsites in Muir Corridor.

Year	No. of campsites	Vegetation type	Mean size (std. dev.) sq. m.	Size range sq. m.
1987	84	fellfield	27.1 (132.3)	0.9 - 1221.7
1995	5	fellfield	6.1 (1.7)	4.6 - 8.7
1995	14	talus	10.8 (4.4)	6.6 - 25.1
1997	42	fellfield	7.5 (4.6)	0.7 - 28.6

implementation and the absence of data fields related to ecological parameters such as vegetation or substrate. All data collected was qualitative, sizes of impacts were never recorded and minor levels of damage such as trampled vegetation was never recorded. Inconsistent implementation of cards was evident both temporally and spatially. There was no correlation between annual overnight use and number of wilderness impact cards (figs. 2 and 3). Since most of the impacts recorded were related to illegal campsites, we expected a correlation between these two factors. In addition, spatial distribution of wilderness impact card submissions showed no impacts in the southern area of the study zone. Based on complete impact surveys (social trails and campsites) and condition class surveys, we know that this area is heavily impacted. We feel this bias in the data reflects the area interests of the climbing rangers and the fact that 50% of the cards were filled out by one person (out of eight). Field personnel did not utilize wilderness impacts cards for recording social trail impacts. This may indicate a limitation of the card format or deficiency in training of field personnel who used these cards.

Social trail and campsite surveys provided the most complete impact inventories because all accessible areas were searched, and all recognizable impacts to soil and vegetation were recorded. In addition, since impacts were measured, this method provided the best quantitative description of impacts to soils and vegetation. Data collection was time-consuming, but if restoration efforts were needed, soil volumes, plant species and plant material volumes could be calculated from the data collected. However, observers did not generally record litter and human waste if it was not located next to a campsite or social trail. Neither this method nor wilderness impact cards recorded diffuse impacts—impacts where patches of vegetation or soil loss were smaller than a campsite or trail.

Condition class surveys described the broadest spectrum of impacts—from diffuse impacts to severely eroded social trails. This method was also adequate for recording litter and human waste. It provided a sample of the study area and probably will not locate all impacts in a study area. However, it was probably the best method for long-term monitoring because sample points were located with a GPS, and the sampling system could easily be modified to collect data of specific interest. In our study, observers recorded vegetation type, slope aspect, microtopography, cryptobiotic crusts and heather reproduction, in addition to condition class assessments.

In summary, we feel that the three survey methods we utilized represent a hierarchy of methods that could be utilized for impact assessments in wilderness or natural areas. Wilderness impact cards could be revised to incorporate ecological data fields and then used as an initial survey method to identify areas that might require intensive surveys or as a means of estimating field personnel needs. Data collection could be improved by systematic or complete surveys of study areas. Complete surveys of study areas in a concentrated time period may provide better assessment of field contact needs than sporadic surveys conducted over an entire field season.

Social trail and campsite surveys provided the best quantitative data, but were the most time-consuming survey method. If restoration of impacted areas is a priority, this

may be the survey method of choice. However, in the alpine area that we surveyed, this method still missed many of the impacted sites that the condition class surveys documented. This may be a reflection of the rocky fellfield substrate. People seem to disperse more readily over the flat areas versus walking through a lush subalpine meadow where temporary trails are easily visible, by trampled vegetation, for the next visitor to follow. While dispersed use did result in small discrete bare areas (condition class 2), these impacts did not readily fall into a category of campsite or social trail so they were not recorded in this method.

Condition class surveys were the optimal methods for assessing the overall ecological integrity of a large area and were relatively fast. Although in our study, only vegetation and soil characteristics were documented, data fields could be added for assessment of aquatic or wildlife resources. This method showed the largest distribution of human impacts within the study area and provided a baseline grid for future monitoring of site conditions. In summary, selection of the best method for any wilderness area is only possible if objectives for surveys and management are clearly articulated.

Future Directions

Currently, Mount Rainier National Park is investigating additional techniques to monitor wilderness and environmental conditions at the Park. During the summer of 1999, we plan to evaluate the use of digital, ortho-corrected, high resolution aerial photographs for mapping environmental conditions such as vegetation, wetland-hydrography features and impacted areas such as bare ground and social trails. We hope this method will be useful for monitoring areas that are difficult to access or infrequently used areas that are currently pristine. If aerial photos reveal impacts, intensive surveys may be detailed to those areas. The Park is also cooperating with the Remote Sensing Group at DOE Pacific Northwest National Laboratory to investigate the use of remote sensing techniques to study relatively small geographic areas. This study will investigate the use of new, higher resolution satellite technology, as well as remote sensing from low-elevation aircraft, to produce sub-meter resolution remote sensing products. It is our opinion that these technologies will enhance, not replace, wilderness monitoring techniques already in use at Mount Rainier. These new methods may give the Park additional tools to monitor larger areas with reduced costs, but also with less then precise results. Results from this type of monitoring may be use provide a trigger for the Park to engage in a more intensive monitoring program such as the social trail and campsite surveys or condition class surveys.

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