HUMAN IMPACT ON THE ALPINE ECOSYSTEM OF MOUNT RAINIER

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Contents

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Purpose of the Study

The purpose of this study is to determine the requirements for long-term survival of alpine plant communities on Mount Rainier and to seek ways to minimise adverse human impacts on them. An important goal is to establish acceptable levels of environmental condition, especially at campsites and other impacted areas. This will provide an objective basis for management and make it clear when a management action is, or is not, needed. It will also provide a way to measure the success of a management manipulation.

Objectives, Phase I

1) To design a monitoring system using permanent sampling plots to assess long-term development of alpine plant communities.
2) To design a system to inventory campsites that is applicable to the alpine zone.
3) To record vegetation recovery following impact at campsites.
4) To record the extent and condition of alpine heath meadows.
5) To document any abnormal weather conditions and other natural environment factors.
6) To make interim recommendations for management actions.

Progress, Phase I

Introduction

This report deals with material from two sets of data. Firstly, it reports the design and setting up of the new long-term monitoring system in the summer of 1983. Secondly, it evaluates the rate of restoration of fell field habitats from the condition in 1976 when existing campsites were obliterated by NPS management personnel. This section clearly illustrates the value of a long-term monitoring system which periodically assesses permanently marked study plots.

Literature Review

Most published literature concerning wilderness impact assessment is of limited relevance to this study. This is because studies (Cole and Schreiner, 1981 : and Cole, 1983) have dealt with a single impact (campsites) in a relatively uniform environment (subalpine and montane areas), whereas the alpine zone on Mount Rainier concerns multiple impacts, plant communities, and physical environments. Therefore, it has been necessary to design a system specifically for the Mount Rainier alpine ecosystem.

In an extensive review of wilderness monitoring systems, Cole (1983) concluded that 1) a monitoring system based on the quantitative measurement of separate biological and environmental parameters (vegetation cover, substrate properties, aspects, slope), is superior to and gives more pertinent data than one based merely on a visual estimate of site condition and 2), if at all possible, a system should monitor all sites rather than depend on a sub-sample for data collection.

Baseline Data

Ecological studies I made earlier (Edwards, 1975-1980) have provided baseline data about the Mount Rainier alpine plant communities, their environmental requirements, and the factors that perturb them. But that five year study could draw few conclusions about future trends in vegetation development nor predict long-term effects of management actions. We now intend to identify long-term events and to develop a practical means to assess the significance of any trends that may become apparent in the future.

Design of Present Study

There are two general ways of assessing environmental impact at a site: a quantitative system and visual estimate. On the basis of Cole's (1983) conclusion, the present study is designed primarily as a precise, quantitative measurement system of all alpine localities around the mountain. In addition, a scheme for a visual estimate of site condition is being developed concurrently. If the quantitative system proves impracticable, we can then retreat to one of visual estimates. In this case, the Muir Snowfield locality, where permanent plots were set up this season, will serve as a quantitative control for the entire mountain. However, restriction of quantitative measurement to a single locality is ultimately undesirable, because the unique character of each locality makes the extrapolation of data from one to the other unsatisfactory.

A visual estimate system has merit in that it can provide a convenient summary of habitat condition of a plot or impacted area. It must be emphasised that an essential feature of this system is that its' criteria must be based on quantitative data, (in this case, from Edwards' baseline study of 1975-1980). A tentative outline for the visual rating system is shown below:

Condition Classes 0-5 apply to all plots; 6-10, specifically to campsites.

0) No impact, no sign of recent alteration.
1) Very little impact, plants not measurably altered, a few light footprints, substrate intact and stable.
2) Discernable impact, plants flattened but no permanent damage, substrate surface (gravel, leaf litter) still intact.
3) Community definitely altered, plants broken or worn away, stones and gravel moved, small trails, deep footprints, mineral soil exposed, substrate disrupted.
4) Drastic alteration, plants destroyed except at protected places, mineral soil eroded over most of area.
5) Community virtually destroyed, plants and soil gone.
6) Active soil erosion.
7) Tentpad stablized, but needle ice between stones.
8) Tentpad stablized, no needle ice.
9) Some plant regrowth evident; maybe seedlings. Substrate stablized.
10) Plant cover indistinguishable from that outside campsite area, substrate stable.

Assessment Criteria to Determine Environmental Condition

The assessment of plant and habitat condition is complex. The aim is to collect quantitative data that will be applicable to future assessments even though no one can be at all certain in which direction community development may go, since this will necessarily depend on the interaction of many factors - biological, environmental and human-related. On this basis the monitoring system is being developed with the following criteria in mind:

1) Are vegetation and habitat changes due to natural or human-related perturbations?
2) Are perturbation events short- or long-term?
3) What perturbation events are significant, ie. permanently alter the natural course?

4) What long-term trends take place in undisturbed communities?
5) What are the rates at which these trends proceed?
6) How are normal trends and their rates deflected or altered by impacts?
7) What level of impact has a negative long-term effect? That is, what impact causes irreparable alteration in a community?
8) What are the long-term effects of management response to impacts?
9) What is the recovery potential in different alpine communities?

Sampling Hierarchy

The Mount Rainier alpine zone contains many different kinds of plant habitat, each determined by its local environment (substrate, microclimate, aspect, topography). In turn, each habitat supports a particular type of plant community made up of species adapted to grow there. To bring order to this heterogeneity, for sampling purposes, the alpine zone area is subdivided. Definitions of the subdivisions in order of decreasing scale are:

1) Locality: A locality refers to a major segment of the mountain, extending from just below treeline (6,500 feet) to the upper limit of flowering plants (10,500 feet). Examples would be the land bordering the Muir Snowfield that lies between the Nisqually and Paradise Glaciers; or the ridge running to Mt. Ruth and Steamboat Prow between the Emmons Glacier and Interglacier.

Substrate properties depend upon the local distribution of ash, pumice, lava and mudflow debris. Interactions between the substrate and local climate determine the composition of the plant communities present. Thus each locality has its own distinctive character. For instance, the Muir Snowfield locality faces the prevailing storm tracks so conditions there are generally cool and wet, while the Mt. Ruth locality lies in the rainshadow and summers are comparatively warm and dry.

2) Sampling Area: Each locality is divided into several sampling areas. A sampling area is a natural land form, a distinct geographic unit, or perhaps a narrow elevation band. Several kinds of plant habitat may occur there, but these are sufficiently similar that the sampling area can conveniently stand as a single unit. For instance, the Panorama Point - McClure Rock sampling area within the Muir Snowfield locality lies between 7000 and 7400 feet. It contains fellfield communities along its ridges which grade into heath communities in the intervening swales.

3) Permanent Plot: This is a particular segment of a sampling area. It supports a single plant community, for example, heath or fellfield. Its actual size depends on the local topography which determines the extent of the community, but it typically ranges between 250 and 500 sq. m. There may be several permanent plots within a single sampling area. It is within a permanent plot that long-term trends concerning natural community development, species population numbers, and natural disturbances (erosion, accretion, climatic vagaries) are to be monitored.

The permanent plot also serves as a control plot against which changes in a similar community in the immediate vicinity resulting from human impacts can be contrasted and assessed (camping, trails, trampling).

4) Transect: Within each permanent plot a belt transect is laid out containing twenty 50 x 50 cm. quadrats from which quantitative data on plant and substrate cover is to be collected. In addition, within each quadrat, grid sketch maps and photographs will augment identification and location of substrate components and individual species. This technique will be especially helpful in detecting any small but significant changes in the habitat that may arise in future years.

Data Collection

I have begun preparation of a field survey package designed for use, with trained supervision, in routine monitoring of the plant communities and impacts. It is now in working draft form and will be further field-tested during the second season. The package is necessarily complex because the parameters to be measured are complex. But with explanatory manual, it could be used by a survey team with basic ecological expertise. There are two complementary parts: data sheets and photographs.

Data sheets: (Figure 1, a-f). Data sheets record the following information:

a. General characteristics of the permanent plot.
b. Disturbances, threats and management concerns within a permanent plot.
c. Plant and substrate components within the transect quadrats.
d. Sketch map of quadrats.
e. Life history of plant species.
f. Campsite inventory.

Photographs: (Figures 2-7) provide an important visual record of data recorded on the sheets above, and are important to:

a. Orient new survey personnel to an area.
b. Locate the permanent plots within a sampling area; locate the endpoints of the transects.
c. Relocate campsites and record their condition.
d. Illustrate exact plant and substrate coverage within the quadrats.
e. Document any other features of concern that may appear.

Permanent Plot and Campsite Identification

The permanent plots and the features within them must be carefully marked so that they can be readily relocated for later monitoring. This is not easy and there are several reasons for the difficulty. The complex alpine topography, poor visibility during bad weather, inadequate scale of published topo maps, and inaccuracy of compass and altimeter readings all make unambiguous map location difficult. Conspicuous flagging or signing is inappropriate in the National Park setting. Vandalism of markers is likely at congested sites.

A flexible combination of three methods has been devised for marking based on reference photographs (Fig. 2), metal stakes and paint patches. Each situation demands a unique solution and the details of each must be recorded on the appropriate data sheets.

Permanent Plots Set up to Monitor Long-term Trends

During the field survey this season in the Muir Snowfield locality, sampling areas were delimited, permanent plots were established, and transects laid out, documented and photographed.

Companion photographs were printed and filed for future monitoring teams and for analysis.

Campsite Inventory

All known campsites between Panorama Point and 9000 feet elevation were inventoried and photographed. For each campsite a permanent plot acts as a control against which damage at the campsite can be assessed.

Plant Recovery at Campsites

In past years camping has been popular in fellfield habitats bordering the Muir Snowfield locality between Panorama Point and Camp Muir. Several newly-made campsites were documented in 1976 (Edwards). During their construction all the stones and gravels were removed from the tentpad area and the underlying soil was levelled out to make smooth sleeping surfaces (Figures 5a, 6a).

A typical fellfield surface comprises about 20% stones firmly set into a matrix of about 80% gravels which overlie sandy-loam textured soil. Plants establish only next to stones of at least 20 cm diameter and which are deeply set into the substrate. These stones shelter the plants in several ways: they deflect meltwater, modify moisture and temperature regimes, and alter wind and snow deposition patterns. Indeed, of the 55 species growing in the fellfield habitats, only five typically establish into stone-free areas. Thus, removal of the stones is immediately accompanied by death of the associated patches of vegetation.

The intervening gravels settle in between the stones forming a desert pavement which effectively protects and insulates the underlying soil against frost lifting. The sandy-loam fraction of the fellfield soils is particularly prone to lifting by needle ice (Fig. 4). Soil particles are raised above the surface (newly germinating seedlings are subject to the same hazard) and are then subject to removal by wind or water erosion.

In the fellfield environment where the soils are very stony, porous and well-drained, soil erosion proceeds slowly but presumably will continue until a new gravelly pavement is established. During the past eight years, there has been very little evidence of soil erosion at any of the campsites, beyond the micro-movements caused by the diurnal lifting of the ice needles.

In 1979, NPS management personnel obliterated some of the campsites by putting some stones back into the tentpad areas (Figures 5,6). This year, 1983, several of these campsites were re-examined. It is very clear that there has been absolutely no return of vegetation to the tentpads during the eight years since the campsites were used, either by establishment of seedlings or by spread of pre-existing plants. Even in completely undisturbed fellfield habitats, seedling establishment is sporadic. Hardly any cotyledonous seedlings were found there during the past eight years. At the moment, there is little potential for seedling establishment. The most obvious cause for seedling failure is repeated frost-lifting (needle ice) in tentpads where the stone and gravel replenishment was incomplete. This can be verified from the photographs (Figs. 4,5), and by comparing the present tentpad surface with that of the adjacent fellfield.

The significance of persistent frost-lifting in the fellfield campsites was not evident at the time they were rehabilitated in 1979, but now it must be concluded that, while meeting visual standards, the rehabilitation effort has not restored the original surface with its assortment of stones and gravels. It now seems apparent that plants will not establish until the stones settle further and the fine soil at the surface is replaced once more by a protective gravel pavement.

Aesthetically, the campsites have been restored; they are no longer a distracting bare patch (Fig. 5) and their re-use is unlikely - particularly since 1979 when camping was prohibited in this area.

The value of adequately documented photographic records has become evident in the course of the current re-examination of the sites discussed above, and should be a continuing requirement of all survey activity.

Heath Meadow Extent and Condition

Survey photographs were taken during 1983 of impacted heath meadows near Panorama Point by the trail leading to Pebble Creek. Comparison with 1978 photographs shows considerable loss of plant cover and soil at some places. This is a different type of environment from the fellfield one where the campsites have been made. Instead, for the stone-free soils under the old heath meadows (up to 10,000 years), there is no possibility of recovery once erosion sets in and the entire soil profile, as much as a meter deep, may disappear. Unlike the fellfields, where soil erosion is much slower and there is still potential for recovery because of the stony substrate, the heath meadow soil, along with its plant cover, is irretrievably lost.

Abnormal Weather Conditions and Other Natural Factors

The alpine summer season of 1983 was apparently later starting than any others during the past 10 years. Some plant communities did not emerge at all from snowcover and consequently may have experienced less impact this season. However, they will have lessened vigor when they emerge next year, making them more vulnerable to impact then.

Interim Recommendations for Possible Management Actions

Vegetation has not begun to recover during the past eight years at impacted camping sites with a present Condition Class rating of three or higher (visual estimate system). Therefore, I consider a rating of three to be the point of unacceptable change, the point at which the vegetation has been unable to return towards its pre-impacted condition.

Given present restoration technology for alpine plants and the known requirements of the local alpine flora, there is little likelihood that the recovery potential will change in the foreseeable future. Consequently, the optimal management strategy would be to restrict any form of perturbation that results in impacts beyond condition class two.

In fellfield communities this strategy means vigilant enforcement of camping restrictions. If the old campsites are to be effectively restored to a natural condition, the substrate must first be returned to something approximating its original condition. If left alone, needle ice and soil erosion will continue until a new gravel and stony layer is eventually exposed. Only then will the surface be stabilised and once more provide a potential habitat for plants. The natural process is slow (Fig. 7) and must be reckoned in decades or hundreds of years.

In heath communities, trampling which opens up the surface leaf litter layer to expose the fine stone-free soil underneath, seems to be the prime initiator of severe impact. The only possible recommendation is to route traffic away from the vulnerable heath communities.

Conclusion: Future Monitoring

In the fellfield campsites, the slowness of change during the past five years suggests it is sufficient to reassess their condition every three to five years.

Experience from the 1983 field season confirms that only a precise measurement system will make possible a realistic distinction between different ecological trends in the alpine plant habitats with their complex topography, dwarfed vegetation, and overwhelming enviromental constraints.

The field survey system has been designed to require modest ecological experience for data collection. However, its analysis will require direction by personnel familiar with current theories of ecological interpretation and significance of biological trends. Definitive results will take time because many of the events in the ecosystem move slowly. Damage can often be swift, but recovery is extremely slow. An estimate of rates of change has already been possible by comparing data from 1976 and 1983. Accumulated data will become more and more vaulable as the long-term collection continues.

Summary

1) A two-level survey procedure has been developed specifically for use in the alpine zone taking into account its special features. Examples of the working draft are submitted in this report.

2) Resurvey in 1983 of fellfield campsites made in 1976 reveals unanticipated barriers to restoration of the vegetation.

References

Cole, David N. 1983. Monitoring the Condition of Wilderness Campsites. Res. Pap. INT-302. Ogden, UT: U.S.Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, 10 p.

Cole, David N., and Edward G.S.Schreiner, Compilers, 1981. Impacts of Backcountry Recreation, Site management and Rehabilitation - an annotated bibliography. USDA For. Serv. Gen. Tech. Rep. INT-121, 58 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Edwards, Ola M. 1975-1980. Research on the "Climbing Zone", Mount Rainier: Vegetation Impact Study. Unpublished reports to Mount Rainier National Park Service.

Edwards, Ola M. 1980. The Alpine Vegetation of Mount Rainier National Park: Structure, Development and Constraints. Ph.D. thesis, University of Washington, 280 pp.

Figure 1a.

PERMANENT PLOT SURVEY: Characteristics

LOCALITY ____________ SHEET # _____ of _____

SAMPLING AREA ____________ DATE ____________

PERMANENT PLOT NO. ____________ RECORDER ____________

COMMUNITY TYPE ____________

PLOT POSITION: elevation ________ aspect ________ slope ________

PLOT BOUNDARIES (moraine, snowpatch, another CT, ecotone etc.) ________

PARENT MATERIAL ________ TOPOGRAPHY (complex, level) ________

SOILS: texture ________ stability ________

MANAGEMENT ACTIVITY: trails ________ signs ________ rehab ________

other ____________

DISTANCE TO NEAREST DISTURBANCE ________ type ________

ATTRACTION: Scenic ______ Destination ______ Flowers ______ loop trail ______

Wildlife ______ Climbing ______ Other ______

TRANSECT: Lenth ______ Direction ______ Quadrat placement ______

ID: photos ______ stakes ______ rock ______ paint patch ______ other ______

COMMUNITY DEVELOPMENT: climax ________ successional ________

____

____

____

____

CONDITION CLASS (0-5) ________

PREVIOUS SURVEY: DATE ________ photos

PHOTOS: B/W roll # ______ frames ______

Color roll # ______ frames ______

DIRECTIONS FOR RELOCATION: Locality map with topo. features, transect, disturbances, trails, campsites, photopoints, ID markings.

Figure 1b.

PERMANENT PLOT SURVEY: Disturbances, threats, management

LOCALITY ____________ SHEET # ____ of ____

SAMPLING AREA ____________ DATE ____________

PERMANENT PLOT NO. ____________ RECORDER ____________

NATURAL PERTURBATIONS

Erosion: none ___ meltwater ___ wind ___ frost ___ animal ___ other ______

Accretion: none ___ ash ___ talus ___ other ____________

Biological: ____________

Climatic: winter ____________ summer ____________ snowmelt ______

Other: ____________

HUMAN IMPACTS

No. of campsites: old ________ new ________ distance from plot ______

trails (no type)____________ trampling __________ stones moved ___

trash ________ feces ________ other ____________

Damage to plant community: ____________

____

Factors in plant survival: ____________

____

VISUAL CONDITION CLASS (0-5) __________

0) no impact, no sign of recent alternation; 1) very little impact, plant not measurably altered, a few light footprints, subvstrate intact and stable; 2) discernable impact, veget. flattened but no permanent damage, substrate surface (gravel, leaf litter) still intact; 3) community definately altered, plants broken or worn away, stones & gravel moved, small trails, deep footprints, mineral soil exposed, substrate disrupted; 4) drastic alteration, plants destroyed except at protected places, mineral soil eroded over most of area; 5) community virtually destroyed, plants and soil gone.

ACCEPTABILITY OF PRESENT ENVIRONMENTAL CONDITION Visual: ____________

Vegetation: ____________

Substrate stability: ____________

RECOMMENDED REHAB TECHNOLOGY ____________

PRIOR MANAGEMENT (Revegetation, restricts etc.) ____________

SUGGESTED REMONITORING DATE ____________

SUMMARY-COMMENTS ____________

____

____

____

____

____

Figure 1c.

TRANSECT SURVEY: Cover values

LOCALITY ______________________________ SHEET # _____ of _____

SAMPLING AREA ________________________ DATE ________________

PERMANENT PLOT NO. __________________ RECORDER ____________

QUADRAT NO.	1	2	3	4	5	6	7	8	9	10	mean	s.d.	med.
m. from origin													
COVER (%) stone													
gravel													
bare soil													
litter + dead													
moss & lichen													
flw. plants													
NO. OF SEEDLINGS* SPECIES COVER*(%)													

SPECIES IN PLOT BUT NOT IN TRANSECT: ______________________________

____

*denotes rare

Figure 1d.

TRANSECT SURVEY: Sketch maps of quadrats

LOCALITY ____________________ SHEET # _____ of _____
SAMPLING AREA ____________________ DATE ____________
PERMANENT PLOT NO. ____________ RECORDER ____________

No ___, ______

KEY

No ___, ______

No ___, ______

No ___, ______

No ___, ______

No ___, ______

No ___, ______

No ___, ______

No ___, ______

No ___, ______

Figure 1e.

PERMANENT PLOT SURVEY: Autecology of plant species

LOCALITY ____________________ SHEET # _____ of _____

SAMPLING AREA ____________________ DATE ____________

PERMANENT PLOT NO. ____________________ RECORDER ____________

NOS. OF QUADRATS SURVEYED ____

SPECIES	leaves	buds	flowers	seeds	seedlings	mean diameter # below 5cm # above 5cm	mean height	vigor	mortality	status (rare, common)	numbers of plants

COMMENTS:

CAMPSITE SURVEY

LOCALITY ______________________ SHEET # _____ of _____

SAMPLING AREA ______________________ DATE ______________

PERMANENT PLOT NO. ______________ RECORDER ______________

CAMPSITE NO.________ old________ new________ date made________ area(m)________

COMMUNITY TYPE____

NEAREST TRAIL (m)____

CONSTRUCTION tentpad_____ stonewall_____ soil excavated_____ other________

STONES MOVED: from tentpad________ beyond tentpad_________ no. in wall______

DAMAGE TO PLANT COMMUNITY:______________________________________

RECOVERY POTENTIAL____

COVER PERCENTAGE: Tentpad: plant_____ stone_____ gravel_____ bare soil_____

Adjacent: plant_____ stone_____ gravel_____ bare soil_____

RARE ENDANGERED SPECIES ______________________________________

CONDITION CLASS (6-10) Tentpad____________ adjacent ground______________

6) active soil erosion; 7) tentpad stabilized, but frost-lifting between the stones; 8) tentpad stabilized, no frost-lifting; 9) some vegetation regrowth, maybe seedlings, substrate stabilized; 10) vegetation indistinguishable from that outside campsite area, substrate stable.

REHABILITATION: no_____ yes_____ date_____ no. of stones replaced/m^2________

no. stones outside campsite/m^2__________

Effectiveness: visual______________________________

biological______________________________

substrate stability______________________________

PLOT ID: photos_______ stakes_______ rocks______ paint patch______ other_____

PREVIOUS SURVEY DATE________ PHOTOS______________________________

PHOTOS: B/W roll #______ frames_______

Color roll #______ frames_______

DIRECTIONS FOR RELOCATION: Locality map with topo. features, transect, disturbances, trails, campsites, photopoints, ID markings.

Figure 2. Sample photograph to show location of endpoint for transect in permanent plot, Sampling Area 4, Muir Snowfield Locality 2650m taken Sept. 14, 1983. NPS No Camping sign at edge of snowfield; Moon Rocks in middle distance.

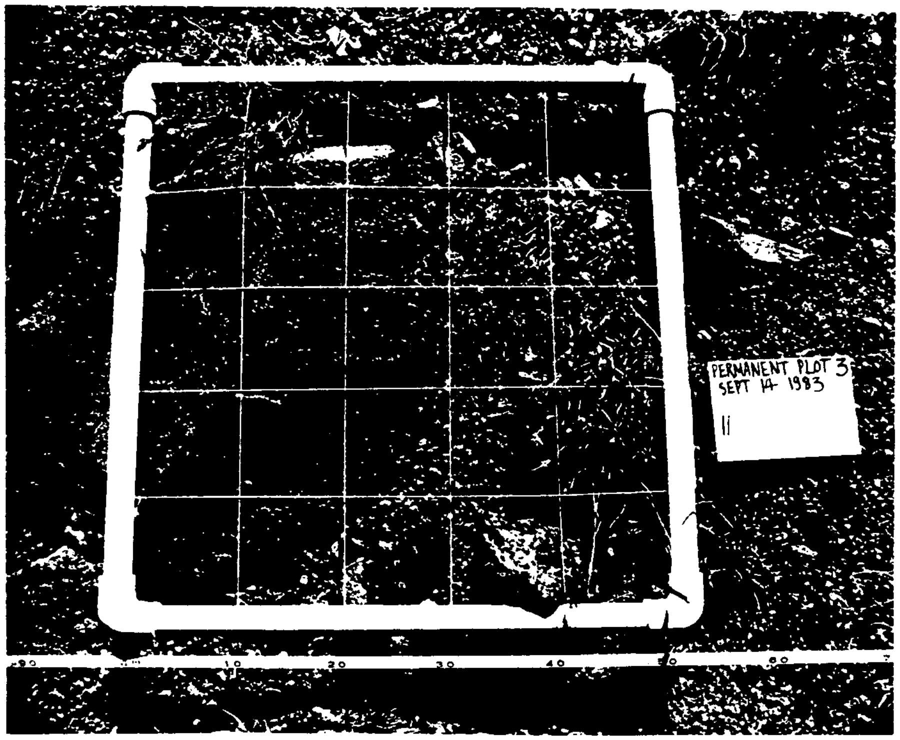

Figure 3. Quadrat frame along the transect line shown in Fig. 2. Plant clumps from top to bottom are *Carex phaeocephala*, *Lupinus lepidus*, *Polemonium elegans*, *Spraguea umbellata*. These are named and mapped on a survey sheet (Fig. 1d). Steel rod quadrat-marker shows at bottom right-hand corner.

Figure 4a. Campsite #3, Sampling Area 2, Muir Snowfield Locality. Needle ice in campsite tentpad. Note absence of needles in gravelly patch below stone at right.

Figure 4b. Needle ice lifting throughout tentpad area of campsite shown in Fig. 4a

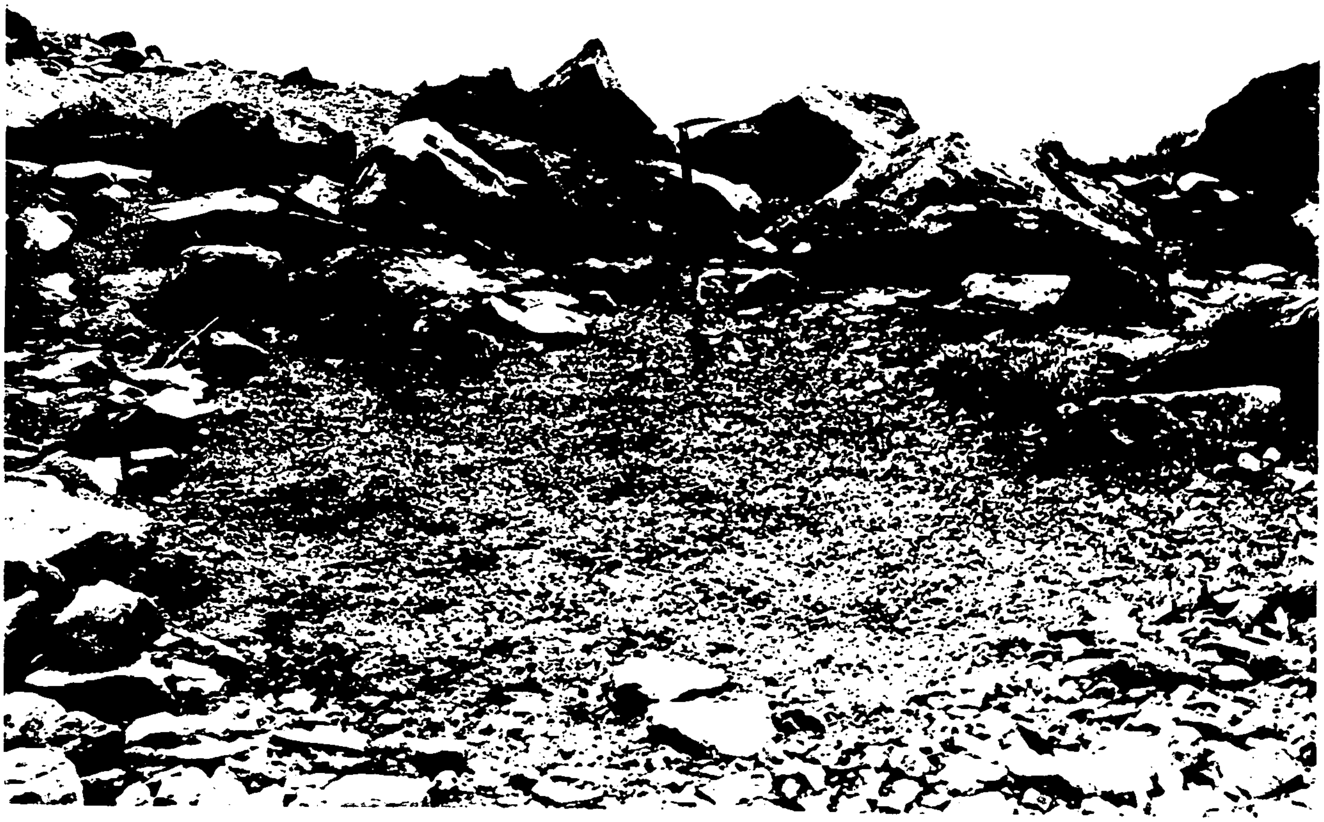

Figure 5a. Campsite #4, Sampling Area 2, Muir Snowfield Locality, 2200 m. taken after constuction, August, 1978.

Figure 5b. Same campsite as Fig. 5a, after rehabilitation by NPS management personnel in 1979. Photograph taken Sept. 8, 1983. Dark patches, well shown at near left corner, are soil lifted by needle ice.

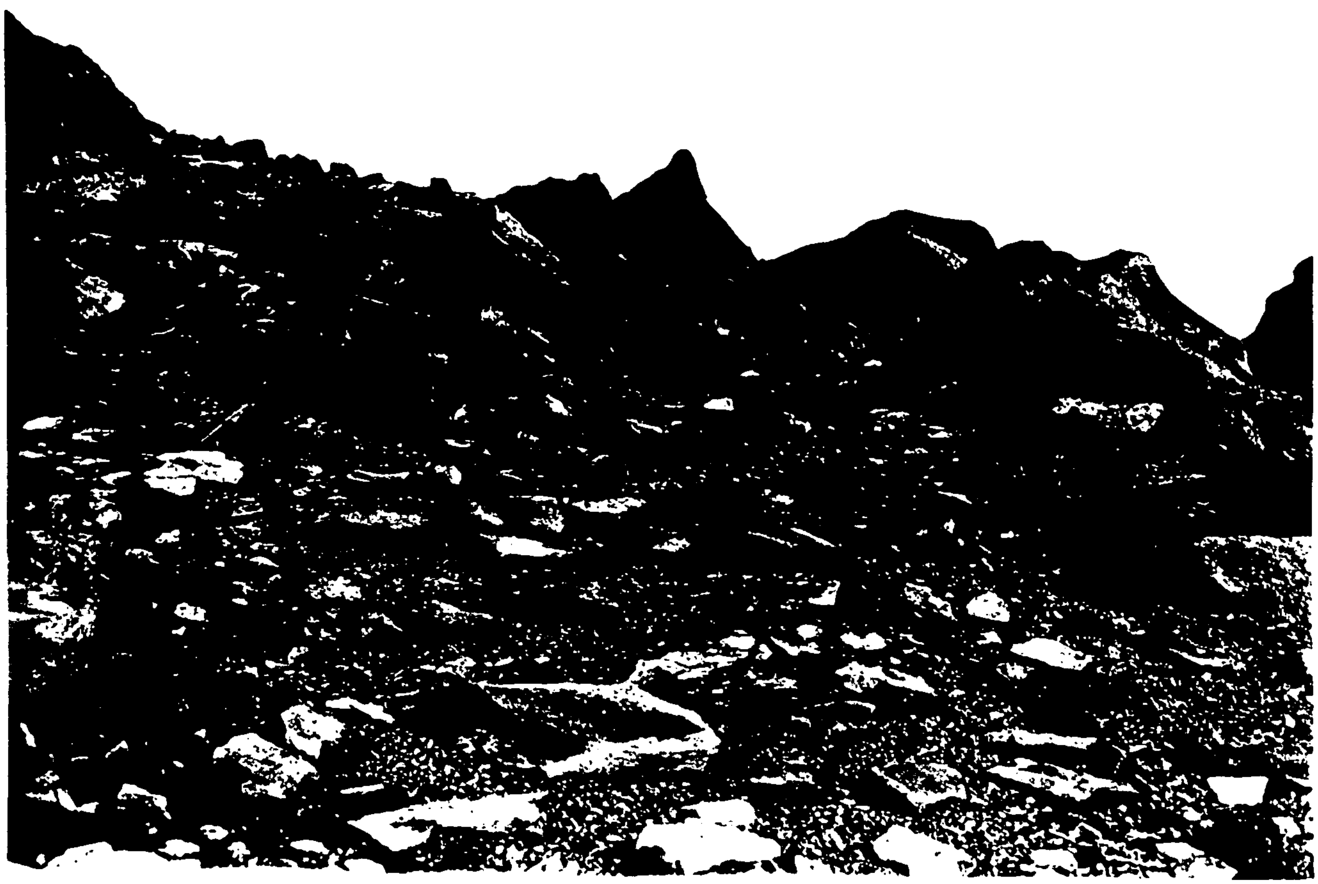

Figure 6a. Campsite #2. Sampling Area 4 Muir Snowfield, 2650 m. photographed after construction, July, 1978,

Figure 6b. Same campsite as Fig. 6a. rehabilitated by NPS management, 1978. Photographed Sept. 14, 1983. Note sparseness of stones and gravel replaced in tentpad area as compared with that in adjacent fellfield.

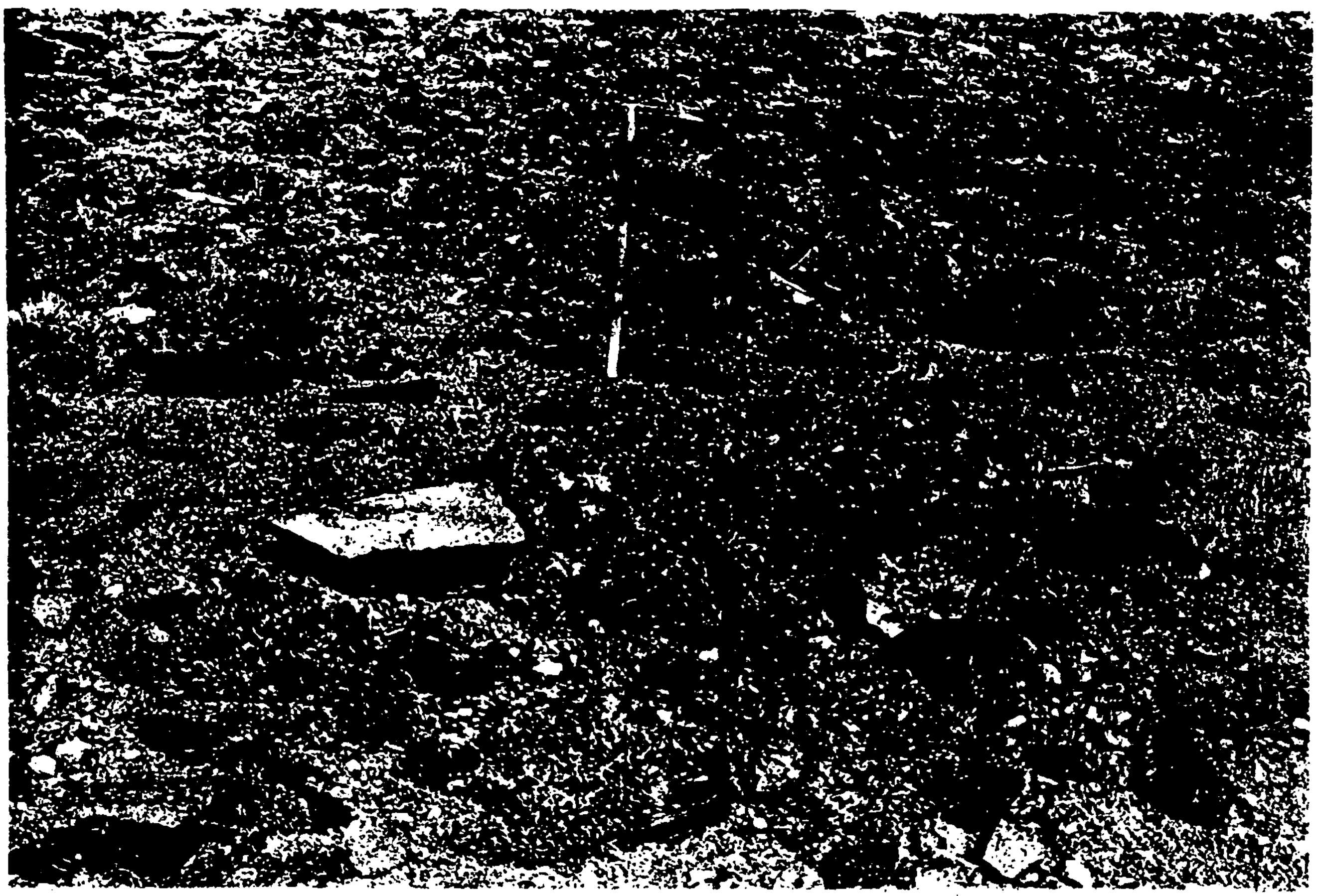

Figure 7a. Campsite #1, Sampling Area 2, Muir Snowfield, 2200 m. Campsite was made before 1975 (probably much earlier) and photographed in July, 1976.

Figure 7b. Same campsite as Fig. 7a, re-photographed Sept.7,1983. Dark patches in tentpad area are frost-lifted by needle ice. Differences in appearance of vegetation are due to different month of photograph. No plants have established in the tentpad area during the past nine years.