THE IMPACT OF CAMPING ON VEGETATION IN THE BIGHORN CRAGS

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Submitted To:

Intermountain Forest and Range Experiment Station
U.S. Forest Service
Ogden, Utah

Amount Requested:

FY 77: $11,208
FY 78: 6,832

Duration:

21 months
October 1, 1976 - June 30, 1978

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22 April 76
Date

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4-22-76
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Proposal for a Study of the Impact of Camping on Vegetation in the Bighorn Crags

Management of subalpine ecosystems for wilderness recreation purposes requires an understanding of users' effects on basic ecosystem structure and processes. There is very little information available to support management planning activities in such areas. Wilderness managers need ways to define and measure physical overuse of wilderness campsites. The research proposed herein is a step towards the attainment of that end.

Objectives:

1. To describe the vegetation and soils associated with subalpine campsites in the Bighorn Crags, Idaho Primitive Area.
2. To find what changes recreational camping produces in the species composition of subalpine vegetation.
3. To define several species which might be used as indicators of heavy use.
4. To discover if increaser[1/] species are representative of sub-climax vegetation.
5. To determine if the differences between increaser and decreaser species are caused by differences in:
    a) morphology and anatomy
    b) reproductive strategy
    c) phenology

[1/] Increaser species defined on p. 3.

Justification:

The Bighorn Crags is a subalpine section of the Idaho Primitive Area, now being managed as wilderness. Conditions vary from pristine to heavily used. Some of the heavily used sites have become devoid of vegetation and are deteriorating; however, no guidelines exist for rehabilitating them. Wilderness managers in other areas are increasingly trying to limit use to restore denuded sites. In hopes of allowing the natural vegetation to recover, the Bob Marshall Wilderness has set up a number of wilderness restoration sites on which visitors are requested not to camp. These efforts have met with varying degrees of success.[1/]

The problem as we see it is this: Sites are closed only after their vegetation has been removed, soil compacted, and erosion of surface layers begun. Once the site has reached this point, recovery will be slow. Merriam et al. (1973) report a five-year recovery time for a site used for only two years in the Boundary Waters Canoe Area. A trampled heath community in Europe required five years just to restore the moss (Westhoff, 1967). Over-grazed slopes at high altitudes showed no recovery even after 10 years of stock prohibition (Strand, 1972), and trampled alpine meadows may take a century to recover (Willard and Marr, 1971). Successful revegetation of campgrounds has been described (Beardsley, Herrington and Wagar, 1974; Fay, 1975), but this required reseeding with introduced species, fertilization, and irrigation methods which are difficult, if not impossible, within a designated wilderness.

[1/] Dollan, J., Wilderness Manager, Bob Marshall Wilderness Area, Flathead National Forest. Personal communication.

At present, bare ground is the only indicator of disturbance being used by wilderness managers. But other indicators of disturbance may be usable before ground cover has been drastically reduced. For an ecosystem component to be a reliable indicator of use there must be a causal relation between use and change in the component. As a corollary, the more a component changes with use, the better an indicator it is (Grigal, 1972).

With this in mind, we suggest the use of plant species as indicators, as is now common in range management (Stoddart, Smith and Box, 1975). A good indicator species is one which either increases or decreases with increasing use. Description of such indicators would give the wilderness manager a sort of "early warning system," informing him that a site was reaching the limits of its capacity to absorb human impact. This would permit him to decrease use intensity allowing for site improvement, or at least maintenance, in keeping with the goal of wilderness. The need for such indicators has been cited by Frissell (1973).

Such indicators will, however, be peculiar to the Crags' ecosystem and will be of little value elsewhere unless we attempt to understand why they behave as they do. Liddle (1975) has observed that "current work [on trampling impact] is now progressing beyond the initial observation stage, but there is still very little quantitative data on which to base predictive statements or general theories."

To allow extrapolation of our results to other plant communities, we intend to investigate several characteristics of each key species, as outlined in objectives 4 and 5. A wilderness manager could then investigate similar species in his own area as possible overuse indicators, even if his plant communities were wholly different from those in the Crags.

Literature Review:

Numerous workers have investigated the effect of trampling on ground vegetation (Burden and Randerson, 1972; Dotzenko, Papamichas and Romine, 1967; Ketchledge and Leonard, 1970; Landals and Scotter, 1973; Lutz, 1945; Magill and Nord, 1963; Michaud, 1967; Scott-Williams, 1967; Settergren and Cole, 1970; Westhoff, 1967; Willard and Marr, 1970 and 1971). Frissell and Duncan (1965), LaPage (1967), and Merriam et al. (1973) reported loss of 80, 45, and 50% of the original ground cover, respectively, in the first season of camping on three sites. The exact percentage, of course, depends on edaphic conditions, slope, and depth of the water table (Orr, 1971). The most interesting finding of these studies, however, is that after the initial change there is little further alteration in percent ground cover with increasing use. LaPage (1967) found after 3 years of use that all relationship between bare ground and cumulative use had disappeared. Similarly, Merriam et al. (1973) found that the changes in new campsites stabilized after five years, but there was no recovery.

These results are not as optimistic as they may appear, however. In no case did the ground cover even approach its former levels. Merriam and Smith (1974) noted continuing expansion of campsites, increasing the total amount of bare ground. While soil compaction leveled off after 2 years, recovery required 5 years. Likewise, Magill (1970) claims to have observed campsites adjusting to impact, but while cover increased slightly during 5 years' use, it never exceeded 25%. Finally, LaPage (1967) found that, while ground cover remained around 30%, the total number of species on the area was reduced by more than half.

Trampling not only reduces cover, but it also changes the species composition. This may be partly the effect of altered soil conditions. In a detailed study of grass adaptations, Bates (1935) created puddled soils on some experimental fields, and noticed that Poa pratensis became dominant over the previously important Agrostis spp. and Cynosurus cristatus. LaPage (1967) found an increase in compaction and drought-resistant species on new campsites and almost complete elimination of forbs. Low growing herbs survive more trampling than shrubs, and sedges and grasses are more resistant than forbs (Burden and Randerson, 1972; Landals and Scotter, 1973). Shifts in composition of herbaceous vegetation are also common on and around trails, and will be discussed later.

Palmer (1972), Bell and Bliss (1973), and Landals and Scotter (1973), have attempted to quantify the effect of trampling by setting up plots, each of which was walked over a given number of times. Cieslinski and Wagar (1970) simulated trampling by using a heavy roller. Palmer (1972), like Landals and Scotter (1973), found grasses and sedges to be substantially more resistant to trampling than forbs or thick stands of Phyllodoce spp. In general, he found that the vegetation of alpine areas (where his study was conducted) could only be stepped on five or six times in one day before it became permanently flattened or destroyed. Bell and Bliss' (1973) work showed similar results. Areas trampled more than five times a day did not recover even with several days of rest. Damage was greatest in wet snow bank communities, where loss of cover proceeded rapidly. Recovery, on the other hand, was far quicker than that of drier site communities. This is supported by Cieslinski and Wagar's (1970) finding that vegetation survival is greatest on moist northeast slopes, although durability decreases with elevation. It is also reinforced by Willard and Marr (1971) who found a four-year recovery time for dry sites that had been used for one year. Landals and Scotter's (1973) work described less sensitive vegetation which may be the result of a drier site or of more productive vegetation. Liddle (1975a) has found a high positive correlation between the productivity of a community and its ability to withstand trampling damage.

Bell and Bliss (1973) extrapolated from their data to conclude that use by 50 people might destroy 80% of the ground cover inside of 2 weeks, and 98% might be destroyed by 100 people. While more immediately useful than any other data, its limitations must be recognized. It assumes concentrated use - i.e., 50 people walking over exactly the same piece of ground every day. It is also quite specific to the area of study and cannot be translated directly to other localities. Landals and Scotter (1973) concluded that a given amount of trampling causes more damage if applied all at once rather than in stages.

Changes in vegetation on trails are similar to those in campgrounds. Grasses and grasslike plants on good soil are highly resistant to light and intermittent trampling (Laing, 1961), but soon a characteristic gradient of disturbance develops perpendicular to the trail with bare ground at the center of the gradient (Bates, 1935; Westhoff, 1967). Species composition shifts to native invaders, exotics, drought-resistant species, and those that can tolerate puddling and trampling (Helgath, 1975; Bates, 1935; Westhoff, 1967). Bates (1935) found that many of these "footpath species" were well adapted to trampling, because of their small folded leaves and tough stems that allowed them to resist compression. This is not to say that these species grew particularly well under these conditions - they were severely stunted in both shoot and root growth, but remained able to complete their life cycle. Their only competitors in the most disturbed areas were annuals, probably coming from outside seed sources. This community appeared to be a fairly "stable" disturbance community, neither significantly deteriorating nor reverting back to its previous composition.

Bates (1935) was one of the few workers to consider why some species are trampling-resistant. He attributed their hardiness to morphological characteristics, as did Liddle (1975 a and b) who pointed out that plants with basal apices and meristems tolerate trampling better than plants without those characteristics; hence, his description of a predominantly monocotyledonous flora on trampled sites. There is, in fact, a general agreement among British workers that *Poa pratensis*, *Bellis perennis*, *Plantago spp*. and *Agrostis tenuis* are all trampling resistant because of growth form (Burden and Randerson, 1972; Liddle and Grieg-Smith, 1975).

Landals and Scotter (1973), working in the Canadian Rockies, similarly found that trampling eliminated tall herbaceous species and most shrubs, replacing them with prostrate forbs, grasses and sedges. Among these *Antennaria lanata*, *Ranunculus eschscholtzii*, and *Sibbaldia procumbens* appeared to be resistant in all plant communities. They attributed this to their propensity for regrowth.

Resistance, then, may be because of morphology or phenology (Liddle, 1975a). It may also be because of the plant's potential for rapid early season growth and/or late fall regrowth, during times of low disturbance. Such potential depends in part on carbohydrate reserves, which Mooney and Billings (1960) have shown to be highly variable. Carbohydrate reserves have been shown to influence a plant's susceptibility to grazing pressure (Hyder and Sneva, 1959; Donart and Cook, 1970); they should also affect its sensitivity to trampling. Liddle (1975b) found that trampling reduced both leaf length and the number of tillers per plant in several grass species. He then suggested that survival after damage may be helped by transport of assimilates from unharmed plant parts. This needs to be tested.

Differences in reproductive strategy may be a characteristic of trampling resistant species. Gadgil and Solbrig (1972) concluded that, in areas with high density-independent mortality, selection should favor r-strategists, i.e. plants with a high potential rate of increase. This rate of increase is a function of seed output and vegetative reproduction. These are, in turn, influenced by age at first seed production and the amount of biomass devoted to reproduction. Early flowering favors a high potential rate of increase, as does a high investment in flower production (Gadgil and Solbrig, 1972; Harper, 1967; Putwain, Machin and Harper, 1968). Gadgil and Solbrig (1972) found plants in a disturbed community devoted more biomass to reproductive tissue than to vegetative tissue.

Mere seed production, however, is insufficient evidence of a plant's ability to increase in numbers. Harper, Williams and Sagar (1965) pointed out that seedling establishment in the field is not equivalent to germination capacity, but is related large to the existence of "safe sites"; i.e. areas where the microclimate is suitable for that species. Trampling resistant species, therefore, must have a high potential rate of increase and an ability to exploit the microsites available on a trampled area.

From the foregoing it is apparent that species composition changes in response to disturbance. Why such changes occur, however, is less well known.

Initial Investigations:

Study Sites

Preliminary investigations were begun in July, 1975 in the Bighorn Crags at the eastern edge of the Idaho Primitive Area. We looked primarily at the campsites on Shoban, Birdbill and Gentian Lakes (Fig. 1). Shoban Lake is about one mile off the Ship Island trail, south of and above Airplane Lake. Birdbill and Gentian Lakes are on either side of the same trail at the junction where it meets the Big Clear trail coming in from the north. Use at Birdbill-Gentian is, as expected, far greater than use at Shoban.

Both Shoban and Birdbill-Gentian are in north-facing cirques at about 8650 ft MSL (2635m). Habitat type seems to be the *Vaccinium scoparium* phase of the *Abies lasiocarpa-Luzula hitchcockii* type (Steele et al., 1975), although the Crags area has never had any formal habitat typing. The area is in the Idaho Batholith and bears the marks of the mountain glaciers of the Pleistocene.

Sixteen campsites were sampled as a part of these preliminary investigations; three on Shoban (lightly used), three on Gentian (lightly used), and 10 on Birdbill (heavily used). We assumed that the center of the campsite was the fire ring. Use was determined only relatively - by personal observation of where people camped, and by conversation with people who had spent time in the area in previous summers.

Experimental Design

We estimated percent cover and frequency using a 20 x 50 cm quadrat. Daubenmire (1959) and Lindsey (1956) have both pointed out that cover is a good measure of species dominance within a community, and Hanson (1950) reported that frequency is excellent for showing small changes in vegetative composition. Similar studies on rangeland have used productivity, but such sampling is impossible in the present study because of its destructive nature.

From the fire ring we marked concentric circles of 8, 16, and 24 foot radii with a knotted cord stretched from a nail. Data were collected by moving around the circle and placing the quadrat every 40 cm, thus sampling about 50% of each circle. (This high sample size was calculated from earlier data.) A small wire ring with an area of 5% of the quadrat was used for help in cover estimations. On each plot two point samples were also taken to assess the percent cover of litter, vegetation, soil, rock and erosion pavement.

Finally, a crude map of each site was constructed noting trees, rocks and fallen logs to allow possible stratification of data at a later date. We also took two pictures to augment each map and to provide baselines for any future studies.

Data were recorded and later analyzed by species and distance from the center.

Preliminary Results

Data are presented in Tables 1, 2, and 3.[1/] Cover values all had variances greater than their respective means, probably due to the

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[1/] Notice: The data included herein are of a preliminary nature, and are not for use in the open literature without permission from the authors.

aggregation of most of the species; thus, they are not useful for statistical inferences.

Ground cover data show changes in the percent vegetation and percent erosion pavement significant at the 5% level. Differences in the amount of rock between lightly and heavily used sites are also significant, but the difference may not be a direct result of trampling.

Frequency data indicate that there may be increasing and decreasing species on these campsites, just as one would find on a grazed range. Coniferous seedlings, *Pedicularis contorta*, *Carex sp.*, *Poa spp.*, *Juncus drummondii*, *Erigeron sp.* and *Hieracium gracile* all increase with light trampling pressure, before dropping off in the face of greater impact. *Chionophila tweedyi*, *Vaccinium scoparium*, *Luzula hitchcockii*, *Phyllodoce empetriformis* and *Arnica latifolia*, in contrast, decrease with trampling pressure.

We might infer from this that the increasing species are more resistant to trampling than are the decreasing species.

Study Plan for 1976:

The study will be continued in the summer of 1976. We will resample the sites on Birdbill, Gentian and Shoban Lakes and will add sites on Airplane and Big Clear Lakes. This should give a total of about 40 sites.

To obtain better use data, registration boxes will be installed on the sites. Boxes will contain a simple questionnaire asking party size, dates of arrival and departure, and number of stock.

Sampling will be by the same methods used in 1975 with two exceptions: The sample size will be smaller: 20, 40 and 60 samples for the inner, middle and outer circles, respectively. These sizes were calculated from the preliminary frequency data; they should be adequate to sample frequency within 10 percent of the mean at the 95 percent level. (2) Observations will be located randomly instead of systematically. We believe sufficient information is available to conclude that the vegetation on the lightly used and heavily used sites, respectively, comprise the same plant community, and can be lumped for analysis purposes. We make this conclusion on the basis of physical parameters, overstory vegetation, and indices of similarity of understory vegetation (Table 4). If, during the continuation of the study, it becomes appropriate to stratify into more than one community, we will do so; however, we can set no basis for stratification a priori.

In addition to collecting baseline data, we will select at least one lightly used site for an impact experiment. We will camp on the selected site(s) throughout the summer to simulate heavy camping pressure. Moreover, the campsite will be stratified; on one side there will be no horse grazing, and, on the other, we will keep the vegetation closely cropped using one or two horses. We will sample the vegetation and soil on a weekly basis.

Data will be analyzed for percent cover and frequency. Cover values will be averaged for each species and radius length. Likewise, frequency values will be computed for each species at each radius. In addition the soil will be described and classified in terms of current erosion and erodability using standard Forest Service procedures.

By comparing non-used, lightly used, and heavily used sites, and by further comparing vegetal and soil changes between inner and outer rings, it is our intention to reach tentative conclusions on objectives

1, 2, and 3, as stated above. Data analyses are planned as follows: First, since cover and frequency data are proportional, they will be normalized with the arcsin transformation. Comparisons between circles and sites will be by t-test. We will use two levels of significance, $\alpha = .20$ and $\alpha = .05$.

To reach objective 4, we will set up exclosures on three lightly used campsites. These will be sampled at the beginning and end of the 1976 and 1977 field seasons. If, as we expect, the plant communities of the inner ring are seral, they should, over two years, begin to revert to climax condition as represented by the outer ring.

In an undisturbed area we will observe changes in plant communities on 0.25m^2 plots given different trampling treatments. The treatments will consist of a control, and stepping on the appropriate plot 10, 20, 40 or 80 times once each week throughout the growing season (Landals and Scotter, 1973). Each treatment will be replicated, giving ten plots in all. Each week we will record data on the following parameters: seedling establishment, plant death, percent cover, density, number of flowering shoots on each plant, and shoot height. We will also consider the morphology of each species, noting especially rhizomes, stolons or deep tap roots, basal meristems, flat or rosette forming leaves and height of buds.

To investigate reproductive strategy, we will collect samples of each of the major campsite species. These will be clipped off at ground level during flowering and the inflorescences separated from the other plant parts. We will air-dry the tissues and weigh them on returning to the laboratory. The ratio of reproductive to non-reproductive tissue will be averaged for each species.

If weather conditions permit maturation of fruits, we will collect seed from several samples of each species to compare seed number and size. Additionally, germination studies will be conducted in the greenhouse if time permits.

We hypothesize that trampling resistant species should have one or more of the following characteristics:

a) high seed number

b) large number of seedlings established

c) high ratio of reproductive to non-reproductive tissue

d) large number of flowering shoots

e) high vigor and survival of mature plants on trampled sites

f) rhizomes or tap roots

g) basal meristems

h) flat or rosette-forming leaves

i) low, protected buds

From our data, we can test these hypotheses and produce a list of those attributes that appear most consistently in resistant species. A manager in any area could then sample for these attributes to determine the ability of his particular plant communities to resist trampling, without needing detailed information on individual species.

The 1976 summer field season will be funded by sources internal to the University of Idaho.

Study Plan for 1977:

Field research will conclude during the summer of 1977 (FY77). During this field season we will expand our observations to include other habitat types such as may be found adjacent to lakes at different elevations like Terrace Lakes, Cathedral Lake, Goat Lake, and Roaring

Creek Lake. We expect to refine our procedures from results obtained during the previous two years.

Final data analyses and synthesis is scheduled for the nine-month period following the 1977 field season. By June 30, 1978 we will expect to have accomplished all five of the objectives previously stated.

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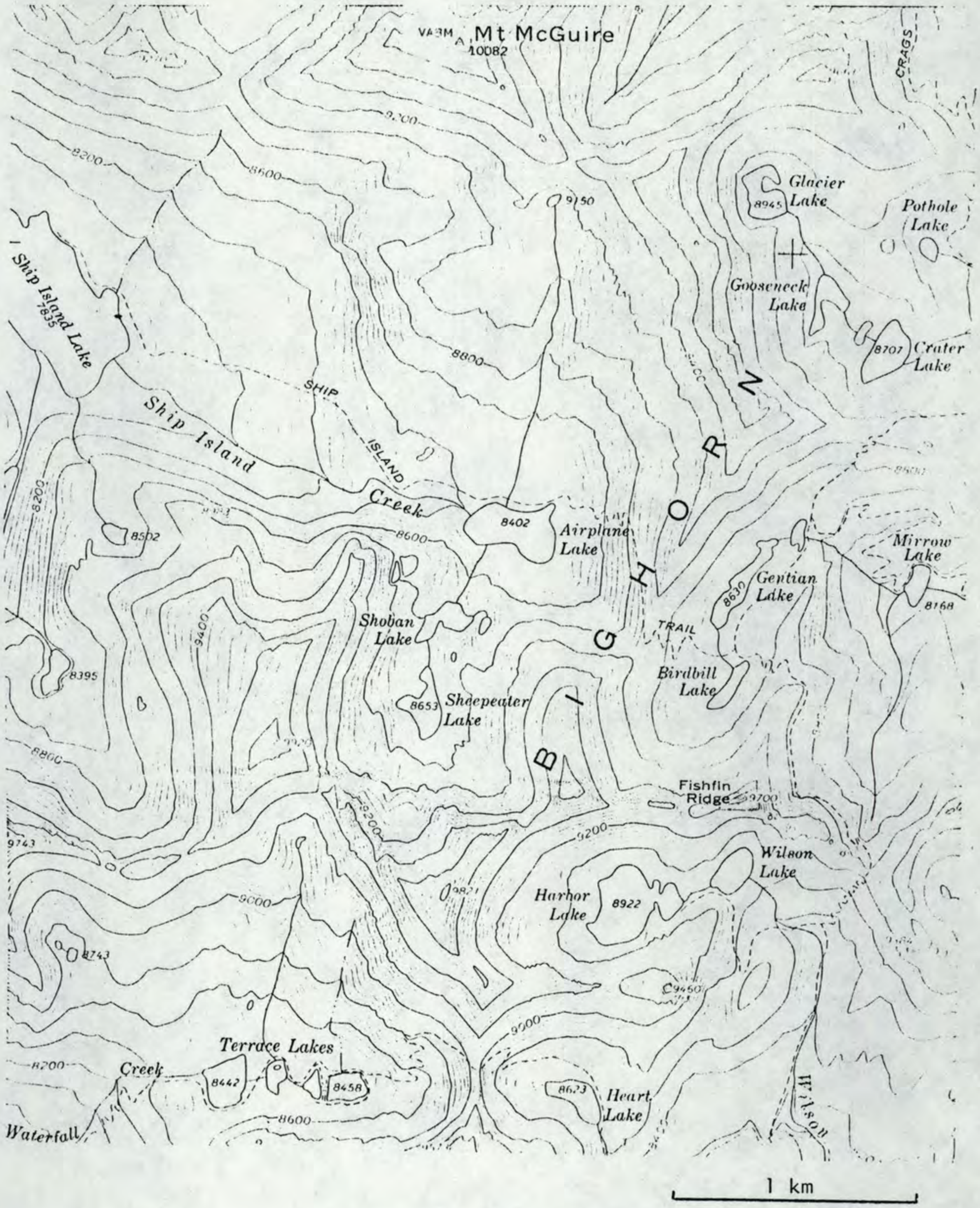

Fig. 1. Bighorn Crags area of Idaho Primitive Area (from Mt. McGuire Quadrangle).

Table 1. Summary of percent ground cover (with 95% confidence intervals) on heavy and light use campsites in the Bighorn Crags of Central Idaho.

	Heavy Use Sites			Light Use Sites		
Distance From Center	8 ft.	16 ft.	24 ft.	8 ft.	16 ft.	24 ft.
Litter	42 ± 7	43 ± 5	42 ± 4	44 ± 7	43 ± 5	42 ± 4
Vegetation	4 ± 3	11 ± 3	12 ± 3	28 ± 6	30 ± 4	33 ± 4
Rock	13 ± 5	16 ± 3	17 ± 3	5 ± 3	10 ± 3	12 ± 3
Soil	15 ± 5	9 ± 3	11 ± 3	16 ± 5	13 ± 3	11 ± 3
Erosion Pavement	26 ± 6	21 ± 4	17 ± 3	7 ± 4	4 ± 2	2 ± 1

Table 2. Summary of percent cover by species (± one standard deviation) on heavy and light use campsites in the Bighorn Crags of central Idaho.

	Heavy Use Sites			Light Use Sites		
Distance From Center	8 ft.	16 ft.	24 ft.	8 ft.	16 ft.	24 ft.
Pedicularis contorta	0.18 ± 1.37	0.74 ± 2.61	1.52 ± 12.94	5.62 ± 9.37	3.39 ± 7.15	2.92 ± 7.72
Chionophila tweedyi	0.95 ± 3.24	1.18 ± 3.47	1.24 ± 3.44	1.49 ± 3.41	2.89 ± 6.25	3.48 ± 8.27
Carex sp.	1.21 ± 4.63	1.64 ± 5.55	1.19 ± 4.67	3.13 ± 6.48	2.84 ± 6.65	2.17 ± 5.42
Vaccinium scoparium	1.68 ± 6.20	5.83 ± 11.11	6.78 ± 12.91	5.56 ± 11.63	9.64 ± 18.11	12.95 ± 18.77
Luzula hitchcockii	1.85 ± 7.11	1.78 ± 7.38	1.51 ± 6.31	9.32 ± 13.27	10.02 ± 15.70	10.90 ± 17.34
Phyllodoce empetriformis	0.61 ± 4.42	1.54 ± 14.26	2.18 ± 10.17	1.72 ± 6.80	3.06 ± 10.10	6.74 ± 16.65
Juncus sp.	0.01 ± 0.15	0.24 ± 2.23	0.13 ± 1.04	5.74 ± 11.43	5.46 ± 12.77	3.56 ± 10.39
Moss	0	0.04 ± 0.40	0.02 ± 0.33	4.38 ± 10.29	3.39 ± 8.07	3.49 ± 13.05
Erigeron sp.	0	0.05 ± 0.81	0.06 ± 0.69	2.25 ± 5.43	0.98 ± 3.16	0.67 ± 3.34
Antennaria sp.	0	0	0.01 ± 0.14	3.08 ± 8.31	3.23 ± 9.12	2.47 ± 9.33

Table 3. Summary of percent frequency by species (with 95% confidence interval) on heavy and light use campsites in the Bighorn Crage of central Idaho.

	Heavy Use Sites			Light Use Sites		
Distance From Center	8 ft.	16 ft.	24 ft.	8 ft.	16 ft.	24 ft.
Coniferous seedling	24 ± 6	25 ± 4	22 ± 4	31 ± 6	23 ± 4	21 ± 3
Pedicularis contorta	4 ± 3	13 ± 3	12 ± 3	47 ± 7	33 ± 5	27 ± 4
Chinophila tweedyi	18 ± 6	21 ± 4	23 ± 4	30 ± 6	30 ± 4	34 ± 4
Carex sp.	13 ± 5	18 ± 4	19 ± 3	49 ± 7	36 ± 5	31 ± 4
Vaccinium Scoparium	20 ± 6	46 ± 5	44 ± 4	46 ± 7	59 ± 5	58 ± 4
Luzula hitchcockii	12 ± 5	9 ± 3	8 ± 2	49 ± 7	50 ± 5	50 ± 4
Phyllodoce empetriformis	3 ± 3	4 ± 2	7 ± 2	10 ± 4	14 ± 3	23 ± 3
Juncus sp.	1 ± 1	2 ± 1	2 ± 1	44 ± 7	34 ± 5	21 ± 3
Moss	0	1 ± 1	1 ± 1	35 ± 7	29 ± 4	26 ± 4
Erigeron sp.	0	1 ± 1	1 ± 1	23 ± 6	14 ± 3	13 ± 3
Hieracium gracile	0	3 ± 2	3 ± 2	43 ± 7	34 ± 5	30 ± 4
Arnica latifolia	0	0	0	2 ± 2	10 ± 3	10 ± 2

Table 4. Indices of similarity (2w/a + b) based on presence-absence data on 10 campsites in the Bighorn Crags of central Idaho.

		Heavy Use Sites					Light Use Sites				
		B2	B3	B4	B5	B6	S1	S2	S3	G2	G3
Heavy Use Sites	B2		.786	.828	.786	.710	.727	.667	.686	.606	.765
	B3			.963	.846	.828	.710	.714	.727	.774	.813
	B4				.815	.800	.688	.690	.706	.750	.788
	B5					.759	.710	.786	.727	.839	.750
	B6						.750	.710	.722	.824	.857
Light Use Sites	S1							.710	.842	.667	.757
	S2								.800	.848	.882
	S3									.737	.872
	G2										.865
	G3										

Mitchell, John E. Assistant Professor Range Management

Education:

B.S. - Range Management, Washington State Univ., 1963
M.S. - Range Ecology, Utah State Univ., 1965
Ph.D. - Systems Ecology, Colorado State Univ., 1973

Experience:

Teaching:

Range Methods and Techniques
Range Communities
Models for Resource Decisions (Range)
Biometry

Research:

1) Land use management of forested rangelands.
2) Revegetation of mine spoils in northern Idaho.
3) Ecological relationships among components of subalpine campground ecosystems.
4) Influence of range insects in production and nutrient cycling.
5) Modeling of nutrient cycles in hardwood forests.

Graduate Students Advised to Completion:

None - Presently major professor to 3 M.S. students.

Publications:

10 publications in referred journals including the following:

1) A preliminary model for nutrient cycling in a deciduous forest ecosystem. In F.G. Howell (ed.) Mineral cycling in Southeastern ecosystems. USAEC Symposium Series (in press). 1976.
2) Variation in food preferences of three grasshopper species (Acrididae: Orthoptera) as a function of food availability. Amer. Midland Natur. 94:267-283. 1975.
3) The role of grasshoppers in a shortgrass prairie ecosystem. Environ. Entomol. 3:358-360. 1974.
4) An analysis of the beta-attenuation technique for estimating standing crop of prairie range. J. Range Manage. 25:300-304. 1972.
5) Soil physical properties in relation to plant community patterns in the shadscale zone of northwestern Utah. Ecology 47:627-630. 1966.

Affiliations and Awards:

American Association for the Advancement of Science
Alpha Zeta
Ecological Society of America
Sigma Xi
Society for Range Management
Xi Sigma Pi

Presentations:

Numerous local presentations and five presentations at national scientific meetings on various subjects dealing with range ecology.

Proposed Budget - FY 77

		Forest Service	U of I
1.	Salaries		
	J. Mitchell, Proj. Director (1 mo. @ 1600)	$ 1,600	$
	E. Coombs, Grad. Asst. (1 yr. @ 4,500)	4,500	
	Irregular Help (3 mo. @ 500)	1,500	
2.	Staff Benefits		
	16% of Faculty	256	
	8% of GRA and IH	440	
3.	Travel		
	Vehicle Travel (3,200 mi. @ .16)	512	
	Per Diem (150 man days @ $6)	900	
4.	Operating Expenses		
	Field Supplies	200	
	Secretarial Assistance	400	
	Pack and Saddle Horse Rental (8 da. @ $25)	200	
	Computer Costs	500	
5.	Publication Costs	200	
6.	Institutional Overhead (72.69% of salaries)		5,524
	TOTAL	$ 11,208	$ 5,524

Proposed Budget - FY 78

		Forest Service	U of I
1.	Salaries		
	E. Coombs, Grad. Asst. (9/12 yr. @ 4,800/yr)	$ 3,600	$
	Irregular Help (2 mo. @ 500)	1,000	
2.	Staff Benefits		
	8% of GRA and IH	332	
3.	Travel		
	Symposia/Meeting Travel (1 trip @ 600)	600	
4.	Operating Expenses		
	Computer Costs	500	
	Secretarial Assistance	200	
	Mailing and Phone Calls	100	
5.	Publication Costs	500	
6.	Institutional Overhead (72.69% of Salaries)		3,344
	TOTAL	$ 6,832	$ 3,344