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HUMAN IMPACT ON BACK COUNTRY TRAILS
WITHIN THE GRAND CANYON NATIONAL PARK

Final Research Report

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Submitted by:

Steven W. Carothers
Head of Biology Department
Harold S. Colton Research Center
Museum of Northern Arizona
Flagstaff, Arizona 86001

Compiled by Biology Department Staff:

Arthur M. Phillips, III
Barbara G. Phillips

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INTRODUCTION

Recreational use of the backcountry in Grand Canyon National Park has increased considerably during the past few years. There are three main methods of entering the Inner Canyon area: hiking on the trail system from the rims, entering on mules on the Bright Angel trail, or float trips on the Colorado River through the Grand Canyon. Mule trips will not be considered further here; their impact is limited to the single corridor trail leading to Phantom Ranch from both rims.

Interest, and impact, of both backpackers and river runners focuses on the fragile riparian areas of side canyons having springs or perennial streams. Frequently these areas are in the Inner Gorge near the Colorado River. In cases where they are easily accessible from both the rim and the river, problems of impact are especially apparent and difficult to deal with. It is almost impossible to make accurate estimates of the number of users in such areas, and records which would allow assessment of the relative impact of backpackers and river runners are not available. The areas chosen for this study, however, were selected to show different use levels and use patterns, and quantitative data and inferential observation in the field bears out the selection of sites.

MATERIALS AND METHODS

Study areas

Three side canyon areas in the Inner Gorge of the Grand Canyon were preselected as study areas: Hermit Creek, Tapeats Creek, and Clear Creek. They have in common a perennial stream, a narrow floodplain supporting a well-developed natural riparian community, and a scenic and recreational attractiveness.

The Hermit Creek trail system receives heavy use from hiking parties converging on Hermit Camp from the Hermit Trail and the Tonto Trail. Below the camp the trail winds down to Hermit Creek and follows the creek for about one mile to the Colorado River, passing through a well-developed riparian community along Hermit Creek. The trail starts out as a well-defined remnant of the old Hermit Trail, but shortly after reaching the creek the trail becomes a complex network of several parallel trails and short interconnecting segments and spurs leading to the creek. Assessment of the impact of a multiple trail system on the riparian community is the purpose of this study, and a segment of the system about 100 m in length was selected for quantitative vegetation analysis (Figure 1). The section studied is about one-half mile from the Colorado River and receives impact primarily from backpackers hiking to Hermit Rapids, and secondarily from river parties hiking up Hermit Creek.

The Tapeats Creek-Thunder River trail system receives use from several trails from the North Rim converging on Thunder River, and from river runners hiking up Tapeats Creek to Thunder River or to Surprise Valley and Deer Creek. Below Thunder River the valley widens for about one mile until it narrows for the final plunge through the Precambrian schists to the Colorado River. The open part of the valley supports several parallel trails in some places,

although a flash flood in August 1976 which severely damaged the riparian vegetation also washed out the trails along the creek (Figure 2). The heaviest use of this system below Thunder River is probably by river-based parties. *used system*

The Clear Creek study area is located about two miles upstream from the Colorado River and covers the area from the point where the Clear Creek Trail reaches the creek to an area about one mile downstream where the canyon narrows. Access to the area is almost entirely via the 9 mile long trail along the Tonto Platform from Phantom Ranch. There are several short sections of the canyon floor that have several parallel trails (Figure 3). Frequent flooding of the creek apparently wipes out trails in the riparian zone along the creek; the areas with well established multiple trails are on old benches slightly above the area of riparian vegetation. Clear Creek receives the lightest use of the three areas, and it is used almost entirely by backpackers rather than by river runners. *from 1976 to 1977*

Sampling techniques

The focal point of this study is a series of permanent transects established in each of the study areas to evaluate human impact on the natural vegetation. The transects were established in September and November, 1976; the data collected are summarized in Tables 1-9. Transects were marked at each end with metal stakes (reinforcement bar), allowing future analysis of the study sites.

Sections of each study area were selected to show the effects of a multiple trail system on the canyon floor habitat. In each area, transect

sites were selected using the following criteria:

- 1) presence of multiple trails
- 2) two roughly parallel trails at least 50 m long connecting at both ends
- 3) both trails go through uniform and similar vegetation types
- 4) potential for blocking one trail in favor of the other
- 5) trails with about the same level of impact/use

Study sites meeting these criteria were selected in each of the three canyons. Three transects were established in each area: one along a trail which was blocked from further use, one along a parallel trail which was left open, and one perpendicular to and crossing these trails. Trail transects were run along the middle of the trail; perpendicular transects were run at right angles to the creek and other trails across the canyon floor.

The length of transects was either 50 or 100 meters and was determined by field conditions. The distance between the upper and lower junctions of the two trails studied determined the length of the trail transects; the width of the floodplain determined the length of parallel transects.

No additional "control" transects were established for several reasons. In no case was there a large enough portion of the floodplain free from the anastomosing trail systems to run a control transect completely through undisturbed vegetation. A transect crossing only undisturbed areas would have to be run on the slopes of the canyon, a meaningless comparison since the slopes support desert species quite different from the adjacent floodplain. It was also felt that the parallel transect provided an adequate control under the circumstances as it crossed largely undisturbed natural vegetation except where meeting trails. We were impressed by the apparent lack of disturbance in most areas between trails.

The sampling method used in this study was a belt transect 50 m to 100 m in length and 1 m in width to sample perennial vegetation, and 1 m² quadrats placed at 10 m intervals along the transect to sample annual vegetation. For the transects run along trails, the plot frame was placed so that the transect line ran through the middle of the plot. In this way the plot was subdivided into three parallel strips, each about .3 x 1 m, with the trail as the middle third. These three strips, designated "Left", "Center" (trail), and "Right", were recorded and analyzed separately. Density and intercept were recorded for each species on the belt transect; from these relative density, relative cover (dominance), and importance values were calculated. Frequency, density, and cover were recorded for each species within the quadrats; the relative values of each of these and importance values were calculated (Canfield, 1941; Curtis, 1959; Mueller-Dombois and Ellenberg, 1974). The canopy coverage method of Daubenmire (1959) was used to measure cover of annuals. This involves estimation of the cover of each species within the quadrat by placing it in one of six coverage classes: 1) 0-5%; 2) 5-25%; 3) 25-50%; 4) 50-75%; 5) 75-95%; 6) 95-100%. In analysis of the data, the midpoint of each of the percentage classes is used (Daubenmire, 1959, 1968).

Relative values were calculated for each parameter as follows (Mueller-Dombois and Ellenberg, 1974):

$$\text{Relative Density} = \frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100$$

$$\text{Relative Cover} = \frac{\text{Cover of a species}}{\text{Cover of all species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Sum frequency of all species}} \times 100$$

Importance value is defined as the sum of the above relative values (Curtis, 1959). This was converted into an importance percentage (based on 100 instead of 300) by dividing by 3 (Risser and Rice, 1971). The importance value allows comparison of the species within a sampling area, or comparison of a species between sampling areas.

As noted above, frequency was recorded only for the 1 m^2 quadrats and not for the perennial species analyzed with belt transects. This was done because the sampling areas were selected on the basis of uniform composition, making frequency of minor importance. Importance value for perennial species is based on relative density and relative cover, and the percentage I.V. is found by dividing by 2 instead of by 3 (Daubenmire, 1968). Tables 1-9 show the data obtained from vegetation sampling.

Trail mapping

Aerial photographs were taken from a helicopter to determine the number of trails and extent of trail systems in each of the three study areas. The photographs were pieced together to form a mosaic for each area, and maps were drawn showing the trail systems and location of transects. These maps cover most, but not all, of the area in which multiple trails occur in each canyon; they do cover the most heavily impacted areas and illustrate the vast array of trails present in these areas. The maps are shown in Figures 1-3. Figures 4-6 are aerial photographs illustrating extent and type of trail systems in each of the three study areas.

RESULTS AND DISCUSSION

Hermit Creek

From a point just below where the Hermit Trail reaches the creek below Hermit Camp, to the mouth of Hermit Creek at the Colorado River, the canyon widens out and a well-developed but narrow ribbon of riparian vegetation nearly obscures the stream from view. Baccharis glutinosa (seepwillow), Salix exigua (coyote willow), Baccharis emoryi, Cladium californicum (saw-grass), and scattered Tamarix chinensis (tamarisk) form a dense but narrow streamside riparian community. Away from the creek but still within the canyon floor a canyon vegetation type is dominated by Acacia greggii (catclaw), Haplophragma acradenium (goldenweed), Gutierrezia lucida (snakeweed), Encelia farinosa (brittlebush), and various annual and perennial grasses. A complete list of species encountered on the transects is found in Tables 1-3. Above the canyon floor the steep talus slopes of the canyon walls support sparse desert vegetation. From the density of vegetation on the canyon floor, it appears that no serious flash flooding has occurred in Hermit Creek for many years, although there is evidence of some erosion and gullying along old trails in some places.

This mile-long stretch along the floor of Hermit Canyon is riddled with an incredible array of trails (see Figure 1). Through the entire stretch at least two and sometimes as many as five or six parallel trails wander up and down the canyon, with frequent secondary trails connecting main trails and providing access to the creek. In addition there are several large bare areas about 10 m in diameter that serve as campsites.

About 10% of the area intercepted by the perpendicular transect was heavily disturbed by human activities. This included six trails and one trampled area. Although these areas were bare of vegetation, the other 90% of

the transect was essentially undisturbed natural vegetation. Trails have a heavy impact only on the immediate area through which they pass; natural vegetation prevails immediately adjacent to the trampled area. This may be seen by comparing coverage and density data on the trail transects. Coverage is very low, with only about one-third of the species present that were recorded for density. Coverage measured only plants overhanging the transect line down the center of the trail, while density was measured by counting plants rooted in the strip .5 m either side of the transect line. The diversity of species and density values were very similar for the strips along the trails and the perpendicular transect, indicating a negligible effect of the trail on natural vegetation less than a meter away from the actual trampled area of the trail (Tables 1-3).

The effect of the trails on annual species was similar. The cover of Bromus rubens (red brome), an introduced grass, was about 50% on the perpendicular transect; it was about the same on the right and left strips of the 1 m² plots, but was about 2% on trails. Late fall rains had resulted in heavy germination of red brome seedlings, and these were scattered on trails where they had not yet been trampled. Another introduced annual species, Erodium cicutarium (filaree), was also found along the trail, especially near a large bare camping area which was covered by large numbers of filaree seedlings. This species, an indicator of disturbance, was not observed in undisturbed areas.

Another aspect of the effect of trails was gullying and erosion caused by runoff along trails. This was noted in several places within the study area, including the lower end of the blocked trail. Washout of the original

trail through gullying was probably a major reason for the making of new trails, resulting ultimately in the network of trails now present along Hermit Creek. It should be emphasized that the problem of erosion is compounded by increasing the number of trails and the effect on the natural vegetation of the canyon by trail-caused erosion may ultimately be much greater than the effects of the trampling. justification for upkeep of wilderness re.

Tapeats Creek

From the junction of Thunder River to a point about one mile downstream, Tapeats Creek flows through a wide valley with slopes which are quite gentle compared with those of Hermit Creek. The wide valley ends abruptly as the creek enters the Tapeats sandstone and forms a narrow chasm.

Until August, 1976, there was a well-developed riparian community along Tapeats Creek below Thunder River. However, a flash flood has wiped out virtually all vegetation along the canyon floor except for some large cottonwoods, and caused nearly 2 meters of arroyo cutting in some places. Only a few remnants of battered Phragmites communis (common reed), Salix exigua (coyote willow), Baccharis glutinosa (seepwillow), and Baccharis emoryi remains. The trail system which once crisscrossed the streamside vegetation has been destroyed.

While the riparian community is gone, the canyon vegetation away from the stream was unaffected by the flood. Dominated by Acacia greggii (catclaw), Haplopappus spinulosus (goldenweed), Ephedra nevadensis (Mormon-tea), and Gutierrezia lucida (snakeweed), this vegetation type is more open than at Hermit Creek with less of an herbaceous understory. It blends more gradually with the desert slopes, which are more gentle than at Hermit Creek, and many

of the desert shrubs and succulents are scattered among the canyon species at Tapeats.

The remaining trails are found in both the canyon and desert vegetation types. Most of the blocked trail (Table 4) is in canyon vegetation, while the upper part of the unblocked trail (Table 5) goes through predominantly desert vegetation. The perpendicular transect starts at the edge of an arroyo cut on the bank of the creek and extends 100 m through the canyon vegetation and onto the desert slopes (Table 6). The last 50 m are beyond the trails but pass through vegetation similar to the upper part of the unblocked trail. Unlike the perpendicular transects at Hermit and Clear Creeks, the one at Tapeats includes nearly twice as many species as the trail transects. This is the result of its passing through a greater diversity of habitats, rather than because of impact on the plants by the trails. The impact of trails at Tapeats is similar to that at Hermit; the trails are bare, but the effect is very local and does not extend beyond the area which is actually trampled. Four trails cover slightly over 3% of the intercept on the perpendicular transect; trampling and campsite impact was not noted in the study area, although impact of this sort is probably more important near Thunder River. Bromus rubens (red brome) was again the most important annual species, and its coverage at the edges of trails is about the same as in non-trail areas on the perpendicular transect. It was also found on the trails themselves, with just less than 10% cover on the blocked trail (Table 4) and about 0.5% cover on the unblocked trail (Table 5). This indicates lower usage levels of these trails than those at Hermit. The blocked trail, a connector between two trails, is considerably less used than the unblocked trail. Red brome

responds rapidly to rain (within 3 days) and is readily killed by trampling. It is a good short-term indicator of weather and impact.

As shown in Figure 2, the trail system of Tapeats Creek is much less complex than that of Hermit Creek (Figure 1). There are trails on each side of the creek, but there are fewer secondary and connecting trails. The situation was much more complex before the flood, but the area impacted by the flood is now greater than the area affected by trails in the vicinity of the transects. It is apparent that hikers are establishing new trails along the creek and within the new creek bed, and the situation will remain in a state of flux until the creek channel is stabilized and new trails become well established.

Clear Creek

Combining several characteristics of the previous two areas, Clear Creek is a narrow, steep-walled canyon with a poorly developed riparian zone and an apparent equilibrium with frequent minor flash flooding. Cottonwoods grow along the creek in many places, but the other riparian species are only occasionally found. Channel cutting through alluvium has lowered the creek to bedrock near the transects, but there is no evidence of recent catastrophic erosion. A large bouldery area upstream from the transects is similar to the newly scoured area in Tapeats, but in Clear Creek it contains fairly dense vegetation of canyon bottom species. Terraces are present in places on the canyon floor but above the creek; the transects were run on a stable terrace dominated by Acacia greggii (catclaw), Haplopappus acradenius (goldenweed), Opuntia phaeacantha (prickly pear), and Opuntia basilaris (beavertail cactus), a combination of desert species and canyon bottom species.

A complete list of species present on the transects can be found in Tables 7-9.

The trail system in Clear Creek is less well developed than in the other areas. In the upper part of the study area the trail goes through a section with cobbles, and is somewhat difficult to follow (Figure 3). Spurs lead to the creek, and there are several areas along the creek which have been denuded by campsite development. Below the cobbles much of the canyon has only one trail through a narrow section. The transects were run on a bench near the lower end of the mapped study area, in one of the few areas where a true trail system is found. Two parallel trails cross the bench, one near the creek bank which was left open, and the other midway across the bench which was blocked. Both were somewhat obscure at some points.

Trails covered about 4% of the intercept on the perpendicular transect. The low use levels of the Clear Creek Trails is shown by the presence of Bromus rubens seedlings and dead mature plants and dicot seedlings in the trail, with cover of 9% on the blocked trail and 44% on the unblocked trail. The blocked trail is in a more open area, while the unblocked trail is in an area near the creek with more shade from cottonwoods and catclaws, probably more responsible for the difference in coverage than differing usage levels.

There is evidence that these poorly defined trails make frequent small deviations, going a different way around a shrub or a prickly pear growing into the trail. This was not as apparent on the better-developed trails at Hermit and Tapeats. There appears to be a tradeoff between greater use but better established trails and less use but more frequent deviation. The less-used trails would be expected to recover more quickly upon abandonment than

well-defined trails; future analysis of the permanent transects established during this project on blocked trails will give an indication of relative rates of recovery.

CONCLUSIONS

1. Multiple trail systems exist on the canyon floors of Hermit Creek, Tapeats Creek, and Clear Creek. These include parallel trails which separate and come together in a distance of 50 to 100 m, spur trails leading to creeks, and connecting trails. Areas which have been used as campsites are also present.
2. Most of the trails are redundant. One or two trails could easily serve where up to six are present. Spur trails, especially at Hermit Creek (see Figure 1), are unnecessarily abundant.
3. The direct impact of trails on vegetation is extreme along the trampled path of the trail, but is negligible away from the trampled area. The vegetation at the edge of the trail is very similar in diversity and density to undisturbed areas in the same habitat. Areas with lightly used, poorly established trails may show greater impact because of frequently shifting trail position, as opposed to well established trails which remain fairly stable.
4. Erosion along a trail may have a greater effect on the environment than trampling. Gullying of an established trail is probably a major cause for developing new trails. Occasional routine maintenance is necessary to repair eroded areas on main trails and prevent gullying and washouts. } Relate Canyon District
5. Permanent transects have been established along 2 trails in each study area, one blocked at both ends and the other left open. A perpendicular transect serves to assess total trail impact across the area, and defines natural vegetation in non-trail areas. These transects should be monitored twice annually for at least five years to determine recovery of vegetation along the blocked trail. } ever done again

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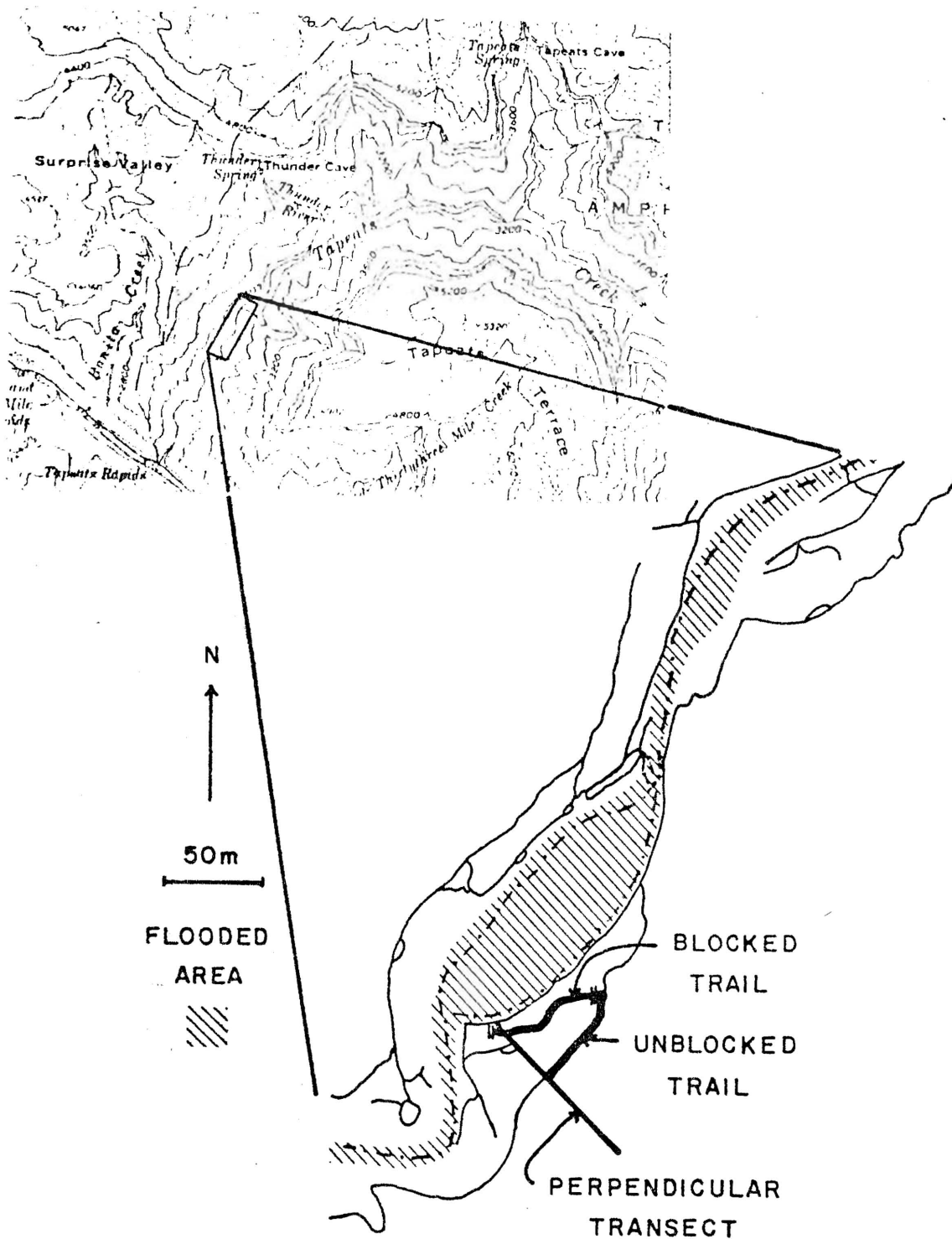


Figure 2. Sketch map of trails in Tapeats Creek study area enlarged from 15' Powell Plateau Quadrangle, U.S.G.S.

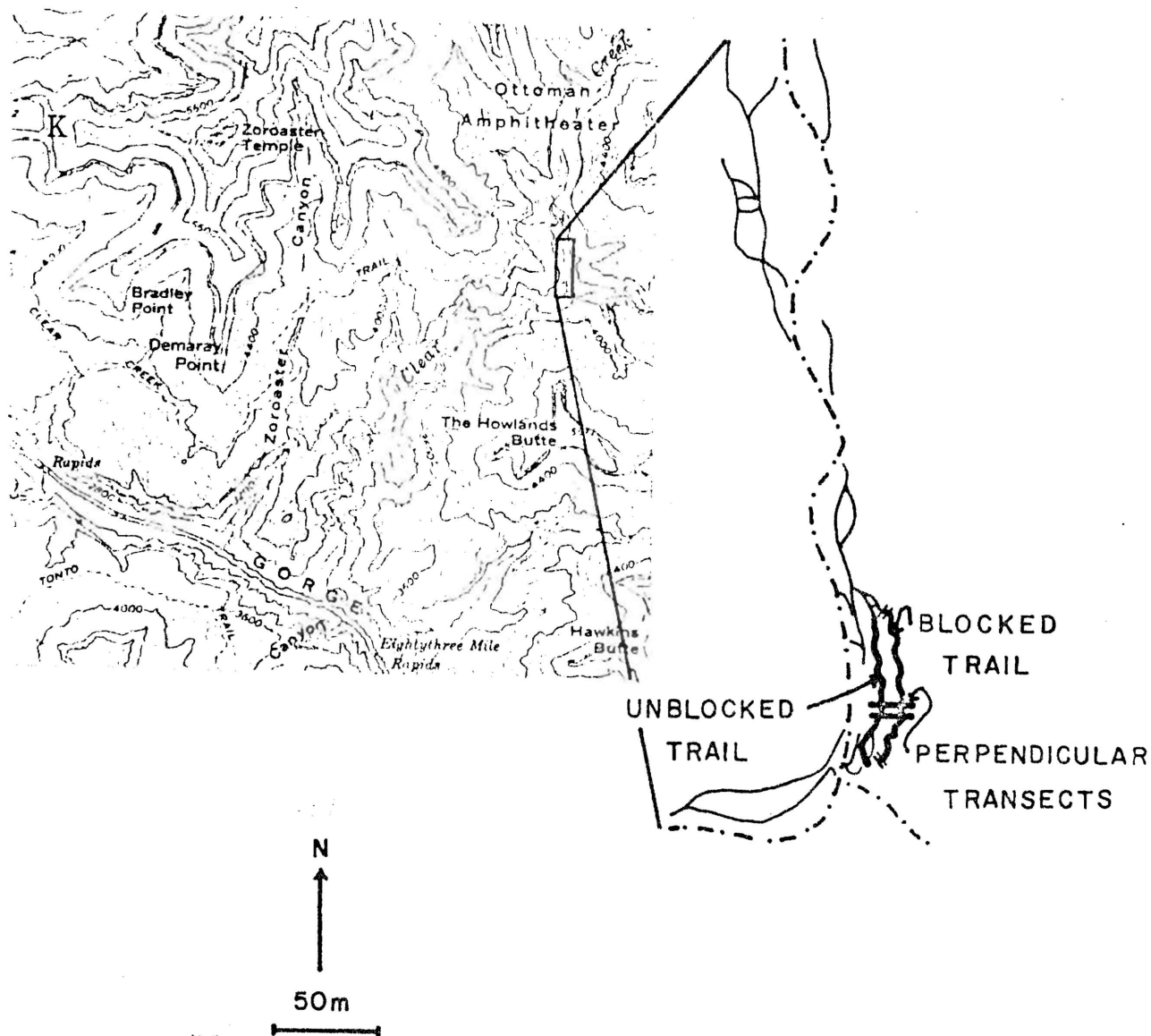


Figure 3. Sketch map of trails in Clear Creek study area enlarged from 15' Bright Angel Quadrangle, U.S.G.S.



Figure 4. Aerial photograph of anastomosing trail system in Hermit Creek study area.



Figure 5. Aerial photograph of Tapeats Creek study area showing trail remaining above flash flooded area, flooded area along creek, and cottonwoods remaining after flood.



Figure 6. Aerial photograph of trails in Clear Creek and bouldery stream channel.

Table 1. Hermit Creek - transect along blocked trail.

a. Perennial species. Transect length: 100 m

Species	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Acacia greggii</u>	4.2	71.2	37.7	1
<u>Gutierrezia lucida</u>	26.6	6.2	16.4	2
<u>Haplopappus acradenius</u>	16.0	12.5	14.2	3
<u>Encelia farinosa</u>	22.3	0	11.2	4
<u>Aristida arizonica</u>	11.7	0	5.8	5
<u>Ephedra nevadensis</u>	1.1	10.0	5.6	6
<u>Porophyllum gracile</u>	8.5	0	4.2	7
<u>Dyssodia thurberi</u>	2.1	0	1.0	
<u>Erigeron sp.</u>	1.1	0	.6	
<u>Mirabilis bigelovii</u>	2.1	0	1.0	
<u>Opuntia chlorotica</u>	1.1	0	.6	
<u>Sphaeralcea grossulariaefolia</u>	2.1	0	1.0	
<u>Tridens muticus</u>	1.1	0	.6	
Total cover: 8%				

b. Annual species. Transect length: 50 m.

Species - Right	Rel. Freq. %	Rel. Dens. %	Rel. Cover %	I.V./3	Rank
<u>Bromus rubens</u> - dead	35.7	40.9	55.6	44.1	1
<u>Bromus rubens</u> - seedlings	35.7	48.2	39.1	41.1	2
Dicot seedlings	21.4	3.5	1.7	8.9	3
<u>Erodium cicutarium</u>	7.1	7.4	3.3	5.9	4

Total cover: 90%

Tortula: average cover 8.5%

Rocks: average cover 24.5%

Species - Left

<u>Bromus rubens</u> - dead	31.2	46.3	56.7	44.7	1
<u>Bromus</u> seedlings	31.2	46.6	38.6	38.8	2
Dicot seedlings	18.8	3.1	2.4	8.1	3
<u>Erodium cicutarium</u>	12.5	4.0	1.6	6.0	4
Dicot - dead	6.2	.1	.8	2.4	5

Total cover: 63.5%

Tortula: average cover 6%

Rocks: average cover 8%

Species - Center (trail)

<u>Bromus rubens</u> seedlings	80	64.3	80	74.8
<u>Erodium cicutarium</u>	20	35.7	20	25.2

Total cover 2.5%

Rock: cover 3% (15% in one quadrat)

Table 2. Hermit Creek - transect along unblocked trail.

a. Perennial species. Transect length: 100 m.

Species	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Haplopappus acradenius</u>	83.5	53.9	68.7	1
<u>Baccharis emoryi</u>	7.9	17.6	12.8	2
<u>Tamarix chinensis</u>	0	15.7	7.8	3
<u>Ephedra nevadensis</u>	1.6	7.8	4.7	4
<u>Acacia greggii</u>	0	4.9	2.5	5
<u>Mirabilis bigelovii</u>	2.4	0	1.2	6
<u>Agave utahensis</u>	.8	0	.4	9.5
<u>Baccharis glutinosa</u>	.8	0	.4	9.5
<u>Brickellia longifolia</u>	.8	0	.4	9.5
<u>Gutierrezia lucida</u>	.8	0	.4	9.5
<u>Porophyllum gracile</u>	.8	0	.4	9.5
<u>Tridens muticus</u>	.8	0	.4	9.5

Total cover 10.2%

Table 2. Hermit Creek - transect along unblocked trail.

b. Annual species. Transect length: 50 m.

Species - Right	Rel. Freq. %	Rel. Dens. %	Rel. Cover %	I.V./3	Rank
<u>Bromus rubens</u> - seedlings	45.4	61.7	58.8	55.3	1
<u>Bromus rubens</u> - dead	45.4	38.2	40.8	41.5	2
Dicot seedlings	9.1	.1	.5	3.2	3

Total cover: 105.5%

Tortula: average cover 12.5%

Rock: average cover 10.5%

Species - Left

<u>Bromus rubens</u> - seedlings	50	57.7	53.4	53.7	1
<u>Bromus rubens</u> - dead	40	41.9	45.9	42.6	2
Dicot seedlings	10	.3	.8	3.7	3

Total cover: 66.5%

Tortula: average cover 12.5% (62.5% in one plot)

Rocks: average cover 15%

Species - Center (trail)

Bromus rubens seedlings

Frequency: 80%

Density: 25.8/m²

Cover: 2%

Table 3. Hermit Creek - transect perpendicular to trails.

Length: 50 m.

Species	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Acacia greggii</u>	14.3	40.5	27.4	1
<u>Haplopappus acradenius</u>	28.6	24.7	26.6	2
<u>Muhlenbergia asperifolia</u>	8.6	9.6	9.1	3
<u>Gutierrezia lucida</u>	11.4	6.2	8.8	4
<u>Baccharis emoryi</u>	5.7	7.3	6.5	5
<u>Salix exigua</u>	8.6	2.7	5.6	6
<u>Porophyllum gracile</u>	5.7	1.5	3.6	7
<u>Encelia farinosa</u>	2.8	3.5	3.2	8
<u>Andropogon barbinodis</u>	2.8	1.5	2.2	9
<u>Cirsium</u> sp.	2.8	.8	1.8	10
<u>Opuntia chlorotica</u>	2.8	.8	1.8	10
<u>Cladium californicum</u>	2.8	.4	1.6	12
<u>Perezia wrightii</u>	2.8	.4	1.6	12

Total cover: 26%

Bromus rubens: 23.8 m/50 m 47.6%

Trails: 6 (3 main, 2 secondary, 1 abandoned)
4.2 m/50 m 8.4%

Trampled area: .8 m/50m 1.6%

Creek bed 4.6 m wide 9.2%

Table 4. Tapeats Creek - transect along blocked trail.

a. Perennial species. Transect length: 50 m.

Species	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Gutierrezia lucida</u>	34.5	30.0	32.2	1
<u>Haplopappus spinulosus</u>	19.1	26.7	22.9	2
<u>Aristida arizonica</u>	24.5	16.7	20.6	3
<u>Ephedra nevadensis</u>	6.4	13.3	9.8	4
<u>Ferocactus acanthodes</u>	5.4	10.0	7.7	5
<u>Porophyllum gracile</u>	.9	3.3	2.1	6
Compositae	3.6	0	1.8	7
<u>Opuntia erinacea</u>	2.7	0	1.4	8
<u>Acacia greggii</u>	.9	0	.4	10
<u>Galium stellatum</u>	.9	0	.4	10
<u>Stephanomeria pauciflora</u>	.9	0	.4	10

Total cover: 3%

b. Annual species. Transect length: 50 m.

	<u>F</u>	<u>D/m²</u>	<u>C</u>
<u>Bromus rubens</u> - right	100	107.4	41%
- center	80	41.0	9.5%
- left	100	139.0	45.5%
Dead grass - right	20	.6	.5

Rock: average cover - right 13.5%

center 6.0%

left 28%

a. Perennial species. Transect length: 50 m.

Species	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Ephedra nevadensis</u>	10.1	65.2	37.6	1
<u>Acacia greggii</u>	1.4	34.8	18.1	2
<u>Haplopappus spinulosus</u>	24.6	0	12.3	3
<u>Hilaria rigida</u>	18.8	0	9.4	4
<u>Encelia farinosa</u>	11.6	0	5.8	5
<u>Gutierrezia lucida</u>	11.6	0	5.8	5
<u>Aristida arizonica</u>	7.2	0	3.6	7
<u>Artemisia ludoviciana</u>	4.3	0	2.2	8
<u>Opuntia erinacea</u>	2.9	0	1.4	9
<u>Sphaeralcea grossulariaefolia</u>	2.9	0	1.4	9
<u>Ferocactus acanthodes</u>	1.4	0	.7	11
<u>Franseria dumosa</u>	1.4	0	.7	11
<u>Porophyllum gracile</u>	1.4	0	.7	11

Total cover: 2.3%

b. Annual species. Transect length: 50 m.

	<u>F</u>	<u>D</u>	<u>C</u>
<u>Bromus rubens</u> - right	100	166	33.5
- center	20	8	.5
- left	100	118	31.0

Table 6. Tapeats Creek- transect perpendicular to trails.

a. Perennial species. Transect length: 100 m

Species	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Ephedra nevadensis</u>	19.0	54.1	36.6	1
<u>Acacia greggii</u>	6.3	30.7	18.5	2
<u>Haplopappus spinulosus</u>	15.1	3.3	9.2	3
<u>Gutierrezia lucida</u>	15.1	.3	7.7	4
<u>Aristida arizonica</u>	7.9	.7	4.3	5
<u>Ephedra torreyana</u>	2.4	4.0	3.2	6
<u>Porophyllum gracile</u>	4.8	.7	2.8	7
<u>Artemisia ludoviciana</u>	4.8	0	2.4	8
<u>Galium stellatum</u>	3.2	1.6	2.4	8
<u>Haplopappus acradenius</u>	4.8	0	2.4	8
<u>Compositae</u>	.8	0	.4	
<u>Encelia farinosa</u>	2.4	0	1.2	
<u>Ferocactus acanthodes</u>	2.4	0	1.2	
<u>Franseria dumosa</u>	4.0	.3	2.2	
<u>Hilaria rigida</u>	2.4	0	1.2	
<u>Lycium andersonii</u>	.8	3.6	2.2	
<u>Muhlenbergia porteri</u>	.8	0	.4	
<u>Opuntia erinacea</u>	1.6	.3	1.0	
<u>Opuntia phaeacantha</u>	.8	.3	.6	
<u>Sphaeralcea grossulariaefolia</u>	.8	0	.4	

Total cover: 30.3%

Trails (2 used, 2 closed): 3.2m/100m 3.2%

Wash: 4.1m/100m 4.1%

b. Annual species. Transect length: 100 m.

Species	Rel. Freq. %	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Bromus rubens</u>	62.5	98.4	96.1	85.7	1
<u>Cryptantha</u> - dead	18.8	1.5	2.1	7.5	2
<u>Eriogonum</u> sp.	12.5	.1	1.3	4.6	3
Dicot - dead	6.2	.1	.5	2.3	4

Total cover: 38.5%

Table 7. Clear Creek - transect along blocked trail.

a. Perennial species. Transect length: 90 m.

Species	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Haplopappus acradenius</u>	59.1	90.2	74.6	1
Grass #1	13.0	3.3	8.2	2
<u>Opuntia basilaris</u>	3.2	4.9	4.0	3
<u>Yucca baccata</u>	6.5	0	3.2	4
<u>Muhlenbergia porteri</u>	5.2	0	2.6	5
<u>Ephedra torreyana</u>	2.6	1.6	2.1	6
<u>Echinocereus engelmannii</u>	2.6	0	1.3	7
<u>Ephedra nevadensis</u>	2.6	0	1.3	7
<u>Sporobolus contractus</u>	1.9	0	1.0	9
<u>Acacia greggii</u>	.6	0	.3	
<u>Opuntia phaeacantha</u>	1.3	0	.6	
<u>Sphaeralcea grossulariaefolia</u>	1.3	0	.6	

Total cover : 6.1%

Table 7. Clear Creek - transect along blocked trail.

b. Annual species. Transect length: 50 m.

Species - Right	Rel. Freq. %	Rel. Dens. %	Rel. Cover %	I.V./3	Rank
<u>Bromus rubens</u> - dead	35.7	42.5	78.4	52.2	1
<u>Bromus rubens</u> - seedlings	35.7	55.2	18.6	36.5	2
Dicot seedlings	28.6	2.3	3.0	11.3	3

Total cover: 67%

Species - Left

<u>Bromus rubens</u>	41.7	64.5	89.3	65.2	1
<u>Bromus rubens</u> -seedlings	41.7	33.8	8.9	28.1	2
Dicot seedlings	16.7	1.7	1.8	6.7	3

Total cover: 56%

Species - Center (trail)

<u>Bromus rubens</u> -seedlings	62.5	95.0	83.3	80.3	1
Dicot seedlings	25.0	3.6	11.1	13.2	2
<u>Bromus rubens</u> - dead	12.5	1.4	5.6	6.5	3

Total cover: 9%

Table 8. Clear Creek - transect along unblocked trail.

a. Perennial species. Transect length: 100 m.

Species	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Haplopappus acradenius</u>	38.8	38.1	38.4	1
Unk. grass #1	12.9	28.6	20.8	2
<u>Acacia greggii</u>	.7	19.0	9.8	3
<u>Muhlenbergia porteri</u>	7.2	9.5	8.4	4
<u>Sporobolus contractus</u>	11.5	0	5.8	5
<u>Bouteloua curtependula</u>	7.9	0	4.0	6
<u>Echinocereus engelmannii</u>	5.0	0	2.5	7
<u>Opuntia phaeacantha</u>	5.0	0	2.5	7
<u>Baccharis emoryi</u>	0	4.8	2.4	9
<u>Bouteloua eriopoda</u>	2.2	0	1.0	
<u>Chrysopsis hispida</u>	.7	0	.4	
<u>Chrysothamnus nauseosus</u>	.7	0	.4	
<u>Ephedra nevadensis</u>	1.4	0	.7	
<u>Opuntia basilaris</u>	2.2	0	1.1	
<u>Quercus turbinella</u>	.7	0	.4	
<u>Salix exigua</u>	.7	0	.4	
<u>Yucca baccata</u>	2.2	0	1.1	

Total cover: 2%

Table 8. Clear Creek - transect along unblocked trail.

b. Annual species. Transect length: 50 m.

Species - Right	Rel. Freq. %	Rel. Dens. %	Rel. Cover %	I.V./3	Rank
<u>Bromus rubens</u> - dead	35.7	44.7	71.7	50.7	1
<u>Bromus rubens</u> -seedlings	35.7	53.0	25.6	38.1	2
Dicot seedlings	28.6	2.3	2.6	11.2	3
Total cover: 76%					
<u>Tortula</u> : average cover .5% (one plot)					

Species - Left					
<u>Bromus rubens</u> - dead	38.5	56.0	75.2	56.6	1
<u>Bromus rubens</u> -seedlings	38.5	39.6	18.8	32.3	2
Dicot seedlings	23.1	4.4	6.0	11.2	3
Total cover: 66%					
<u>Tortula</u> : average cover .5% (one plot)					

Species - Center (trail)					
<u>Bromus rubens</u> -seedlings	45.4	56.3	33.0	44.9	1
<u>Bromus rubens</u> - dead	36.4	38.2	59.1	44.6	2
Dicot seedlings	18.2	5.6	8.0	10.6	3
Total cover: 44%					
<u>Tortula</u> : none					

Table 9. Clear Creek - transect perpendicular to trails.

a. Perennial species. Transect length: 50 m.

Species	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Haplopappus acradenius</u>	46.6	45.4	46.0	1
<u>Opuntia phaeacantha</u>	16.4	36.9	26.6	2
<u>Echinocereus engelmannii</u>	12.9	0	6.4	3
Grass #1	7.8	4.0	5.9	4
<u>Ephedra torreyana</u>	1.7	6.6	4.2	5
<u>Ephedra nevadensis</u>	6.0	2.0	4.0	6
<u>Yucca baccata</u>	.9	5.0	3.0	7
<u>Muhlenbergia porteri</u>	4.3	0	2.2	8
<u>Sphaeralcea grossulariaefolia</u>	1.7	0	.8	9
<u>Sporobolus contractus</u>	1.7	0	.8	9

Total cover: 20%

b. Annual species. Transect length: 50 m.

Species	Rel. Freq. %	Rel. Dens. %	Rel. Cover %	I.V./2	Rank
<u>Bromus rubens</u> - dead	35.3	58.9	75.3	56.5	1
<u>Bromus rubens</u> -seedlings	35.3	35.8	18.6	29.9	2
Dicot seedlings	29.4	5.2	6.1	13.6	3

Total cover: 69%

Trails: (1 used, 1 blocked) 1.9m/50 m 3.8%