

**BASLINE MONITORING OF HUMAN IMPACTS
AT SUNSET ROCK, LOOKOUT MOUNTAIN
CHICKAMAUGA-CHATTANOOGA NATIONAL MILITARY PARK**

Robert Sutter
Sarah Rollins
Gayle Livingstone

Southern Heritage Task Force
Southeast Regional Office
The Nature Conservancy
Chapel Hill, North Carolina 27515

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INTRODUCTION

Sunset Rock is a dramatic outcropping of sandstone along the western rim of Lookout Mountain just north of the Georgia-Tennessee state line (Figure 1). The views from the top of Sunset Rock have attracted humans for decades, if not for centuries. As a result, the area immediately above and below Sunset Rock has been greatly impacted by human use. Currently, hikers and climbers enjoy the views at the top of the outcrop and hike below the cliff-face and climbers use sites above and below the rock face as staging areas for climbing the 100 foot cliff face (Figure 2). The use of this area for technical rock climbing has increased dramatically in the last two decades, from only a few climbers in the early 1970s to its recognition as one of the principal climbing areas in the Southeast United States, attracting climbers from Chattanooga and Atlanta, and from distant states such as Florida. Documented use of this area dates back over 100 years, with Generals Braxton Bragg and James Longstreet observing Federal forces from Sunset Rock in the fall of 1863, a photographer building his office at the top of Sunset Rock in the late 1800s (Figure 3), and extensive visitor use in the late 1800s and early 1900s, including a narrow gauge railroad built to the base of the outcrop (Figure 4).

The human use of Sunset Rock, both current and past, has profoundly affected the vegetation and soils of the areas immediately above and below the outcropping. There has most likely been a decrease in herbaceous and shrub cover, a decrease in younger age classes of tree species, damage or death of older trees, an increased exposure of soil and rock, and increased erosion and compaction of soil. Evidence of each of these is currently found at Sunset Rock.

Quantitatively documenting these changes, however, is difficult. There are no previous monitoring studies with which to compare current conditions. Another method for assessing the extent of change at a site is the comparison of an impacted site with a similar undisturbed site in the immediate vicinity. No comparable undisturbed sites for Sunset Rock were found in this study. The other outcrops along the western rim of Lookout Mountain are different in height, the extent of the exposed outcropping, the amount of Table Mountain Pine (*Pinus pungens*), aspect, and the amount of historic and current disturbance. All outcropping along the western rim of Lookout Mountain showed some level of disturbance. Documenting the causes for these changes is also difficult. There is no way to separate the impacts of climbers from hikers, or even current impacts from impacts that have occurred over the last 100 years.



Figure 1. View of Sunset Rock, facing north, with the Tennessee River in the background.

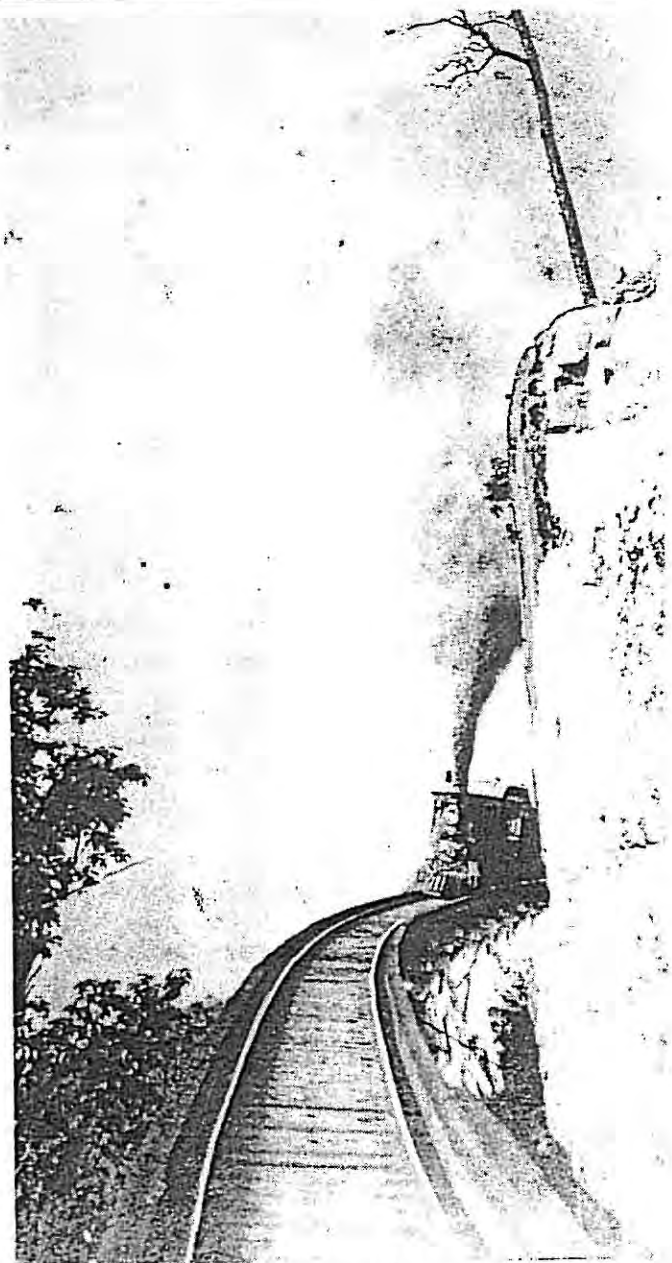


Figure 2. Section of Climbing Wall at Sunset Rock



Early photographer has unique perch overlooking the Tennessee River.

Photo studios were located at both the Point and at Sunset Rock after the Civil War.



Engine on the Narrow Gauge puffs around trestle at the edge of the bluff.

This line went from the Point to Sunset Rock and was later extended to Natural Bridge.

Figure 3 and 4. Photographers house built on Sunset Rock sometime after the Civil War and narrow gauge railroad build at the base of the bluffs from the Point to Sunset Rock near the turn of the century. (from John Wilson's book, Lookout, published in 1977 by the author)

This report presents baseline monitoring data for the area immediately above and below Sunset Rock. These data can be used to assess future changes at Sunset Rock, whether they arise from continued human impact, natural causes, or the effect of restoration efforts.

PROJECT OBJECTIVES

This study was done to: 1) establish a baseline from which future changes at Sunset Rock can be assessed, and 2) search for rare species in the vicinity of Sunset Rock. The monitoring was directed to the areas immediately above and below Sunset Rock; monitoring changes on the cliff-face was not included in this project. The field work was completed during August of 1993.

METHODS

Three methods were used to monitor human impact at Sunset Rocks. These were: 1) photographic monitoring (photopoints), 2) site mapping, and 3) quantitative data collection of vegetation cover. These methods were chosen because they monitor change with different levels of precision and efficiency. Photopoints are the most rapid of the three, and were completed in a half day. Site mapping is intermediate in precision and time, taking one day to complete. The collection of cover data is the most quantitative but also the most time consuming, taking two days to complete.

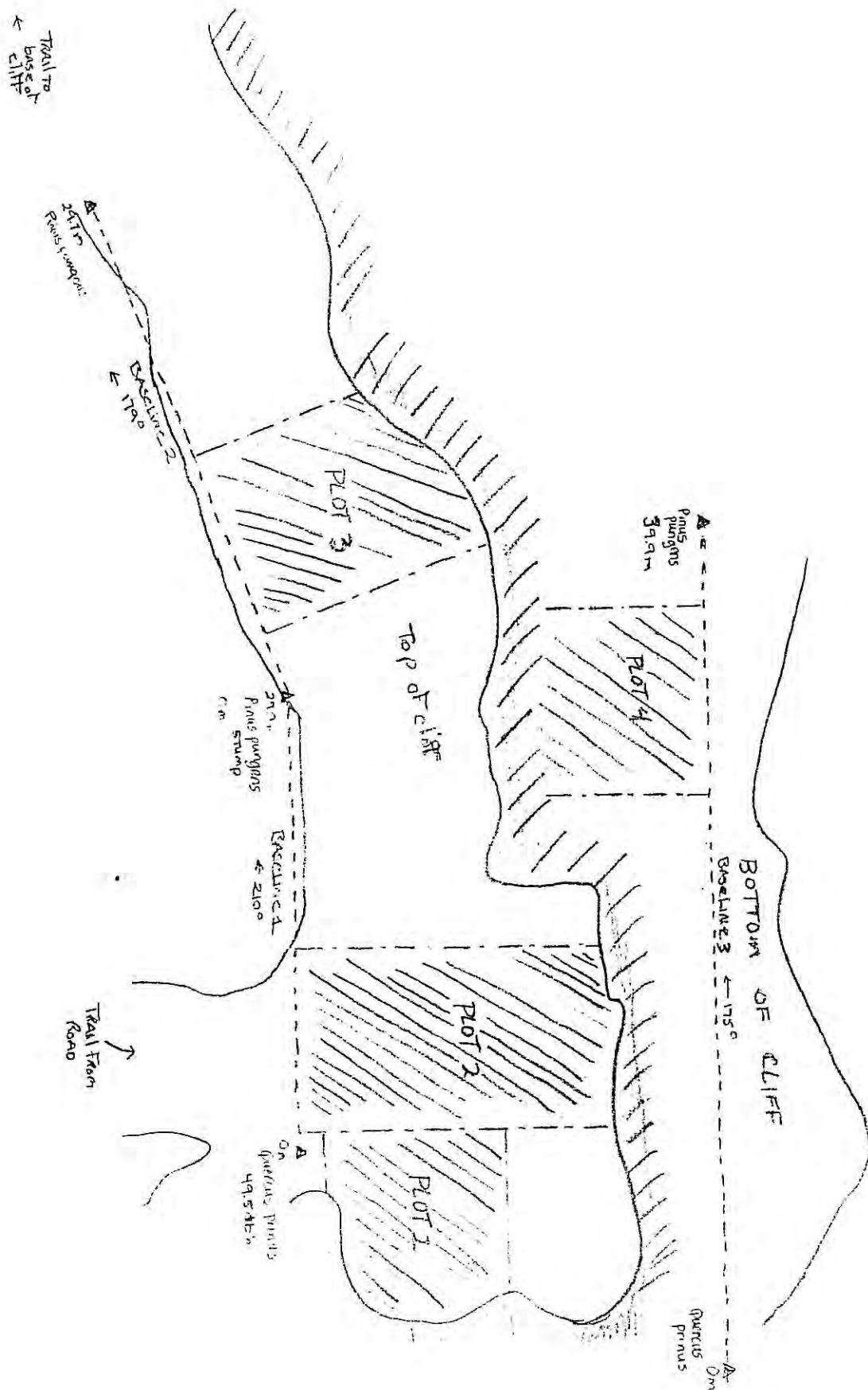
All monitoring methods are tied to baseline transects established above and below Sunset Rock. Two baselines were established on the top of Sunset Rock. The first has its zero point at a nail at the base of a Chestnut Oak (Quercus prinus) just to the right of the trail before it reaches the outcrop (see Table 1, Map 1). This baseline extends south, at 210 degrees, 29.9 meters from this tree, crossing the trail and paralleling the backside of the trail along the outcrop, with nails on a Table Mountain Pine (Pinus pungens) (12.4 meters along baseline), to a stump of Table Mountain Pine (29.9 meters). The second baseline begins at the stump of Table Mountain Pine and extends south, at 179 degrees, 29.7 meters, ending at a Table Mountain Pine (see Table 1, Map 1). The baseline at the base of Sunset Rock has its zero point north of the overhanging cliff face at a nail on a Chestnut Oak just below the trail, and extends south, at 175 degrees, to nails on a Chestnut Oak (26.1 meters) and ending at a Table Mountain Pine (39.9 meters) (see Table 1, Map 1).

All photopoints are taken from specific points along the baseline, the mapping uses the baseline as the point from which to measure the coordinates of major biological and physical elements, and one edge of each cover plot is located along the baseline.

TABLE 1. Summary of Baseline Measurements

Meters along Baseline	Meters from last Landmark	Species of Landmark	Compass Direction
A. Area above cliff face			
First Baseline			
0	0	Chestnut Oak	210
12.4	12.4	Table Mt Pine	210
29.9	17.5	stump of Table Mt Pine	210
Second Baseline			
0	0	stump of Table Mt Pine	179
29.7	29.7	Table Mt Pine	179
B. Area below cliff face			
0	0	Chestnut Oak	175
26.1	26.1	Chestnut Oak	175
39.9	13.8	Table Mt Pine	175

MAP 1. Location of Baseline Transects and Plots at Sunset Rock



Photopoints

Photopoints are a qualitative to semi-quantitative method to visually document changes in appearance and condition of populations, vegetation, and landscapes. They are used in geography, geology, botany, and history to quantify the rate, nature, and direction of change in observed features and evaluate the underlying causes of the perceived changes. Photopoints are efficient (inexpensive, rapid), aesthetically unobtrusive, permanent, and can have multiple uses. Photopoints are an option for baseline studies when one does not know specifically what to measure or where to measure it.

Photopoints were taken from specific locations along each baseline transect (Table 2) to obtain a continuous photographic record of the upper and lower areas of Sunset Rock. The camera used was a 35mm Nikon F2 with a 28mm wide angle lens. The film was Fugichrome 100. The camera was mounted on a tripod and the bottom of the lens was set 60cm above the ground. Most photographs were taken at right angles to the baseline, either toward the cliff edge or the cliff base. Some photographs were taken of the baseline transect. Data sheets for the photopoints on each baseline are included in Appendix A.

The photopoints took a half day to shoot with only one roll of 36 exposure film. The best time of day to take photopoints is between 10 am and 2 pm, when there is enough light but early enough that one is not shooting directly into a late afternoon sun.

Mapping

Mapping is a more quantitative, repeatable method that can detect large changes in a site. The precision of mapping is limited by the level of detail of the map. It is best used for objects with discrete edges (tree trunks, stems, rocks, edge of cliff) and can only detect presence/absence or changes in horizontal dimensions.

Maps were produced for specific sections of the area above and below Sunset Rock. All measurements were taken from the baseline transects. Coordinates were obtained for major physical and biological elements. These included stems of all trees and shrubs, the diameter at breast height (dbh) for larger trees, the cliff edge (but not the bottom of the rock face), distinct rock/soil interfaces, the location and edges of islands of shrubs and herbs, and trees that have evidence of being used as anchors for climbing. Also included were the depth of exposed roots from a location on the trunk determined to be the original soil level.

TABLE 2. Location of Photopoints

Photo- point Number	Meters along Baseline	Meters from last Photopoint	Direction from baseline /Notes on Photopoint
Baseline 1. Northern Section above Cliff-face			
1-1	1	0	300 W
1-2	4	3	300 W
1-3	6	2	210 S, tape on left of frame
1-4	8	2	300 W
1-5	12	4	300 W
1-6	12.4	.4	210 S, tape on left of frame
1-7	20	7.6	300 W
1-8	24	4	300 W
1-9	28	4	300 W
1-10	29.4	1.4	30 N, tape on right of frame

Baseline 2. Southern Section above Cliff-face

2-1	3	0	260 W
2-2	8	5	260 W
2-3	11	3	260 W
2-4	17	6	260 W
2-5	28	11	260 W

Baseline 3. Area below Cliff-face

3-1	3	0	175 S, tape on right of frame
3-2	3	0	175 S, tape on left of frame
3-3	6	3	265 W
3-4	12	6	265 W
3-5	17	5	265 W
3-6	28	11	175 S
3-7	28	0	85 E
3-8	31	3	85 E
3-9	34	3	85 E
3-10	34	0	175 S, tape on left of frame
3-11	34	0	355 N, tape in middle of frame

It took one day to map selected areas immediately above and below Sunset Rock. Remapping the site is done by determining the coordinates of the physical and biological elements and matching the location and information on previous maps of the site.

Quantitative Data on Cover

Four plots of varying sizes were established on top (3) and below (1) Sunset Rock to quantitatively assess the ground cover of biological and physical characteristics (see Map 1 and Appendix C for locations). These plots were subjectively selected to measure the impact of trampling at specific locations. Plot 1 was an area above the cliff-face not used extensively by climbers, thus has characteristics of undisturbed rock outcrops. Plot 2 is probably the most impacted site on top of Sunset Rock. Plot 3 was placed in an area above the cliff-face that has moderate climbing use and still retains islands of native vegetation. Plot 4 is located at the base of the cliff-face where climbing damage is extensive.

A single sampling method, point intercept, was used to assess the condition of the ground cover. Temporary transects were randomly chosen within each 1 meter length of the plot baseline, perpendicular to the baseline. The plot baseline was the same as the primary baselines used for photopoints and mapping, with the exception of Plot 1, which used a secondary baseline originating at the 1 meter location along the first primary baseline at the top of Sunset Rocks. Cover data was collected at regular 10 cm distances along each temporary transect, from the baseline to the edge of the cliff. Cover data was obtained for the following categories: 1) rock, 2) gravel, 3) soil, 4) litter 5) lichens/mosses, 6) grasses/forbs, 7) roots, and 8) woody species.

Future data collection can be done by locating the plots, randomly placing transects within each 1 meter section of the plot baseline, and sampling each transect at 10 cm distances. Blank data sheets are included in Appendix E.

Inventory for Rare Plant Species

Several rare plant species have been found on Lookout Mountain. These include Scutellaria montana (mountain skullcap), a federally threatened plant species, Epigea repens (trailing arbutus), Lonicera flava (yellow honeysuckle), Silene rotundifolia (roundleaf catchfly), Trillium luteum (yellow trillium), Rhododendron canescens (wild azalea), and Euonymus americanus (strawberry bush). The area immediately surrounding Sunset Rocks was inventoried for these species, with special attention for the mountain skullcap.

RESULTS

Photopoints

Twenty-six photopoints were taken along the upper and lower levels of Sunset Rock. These photopoints provide a continuous picture of conditions across sections of the top and bottom of Sunset Rock. The slides from the photopoints in 1993 are located in Appendix B. Each slide is numbered, with the year, the baseline, the location above or below the cliff-face, the location on the baseline, and the bearing of the photopoint.

The slides show the extent of human impact at Sunset Rock. These include extensive areas of bare ground, areas of shrub vegetation, exposed tree roots, and eroded soil. A range pole should be used in the future to provide a measure of scale in the photopoints.

Mapping

Maps of the areas along the upper and lower levels of Sunset Rock are in Appendix C. They provide the location for the major physical and biological elements at the site.

Both the photopoints and mapping show that the reduction of vegetative cover and soil erosion has been extensive along the top and bottom of Sunset Rock (Figures 5 and 6).

The amount of soil loss from this site can be estimated from assessing the trunks of the Table Mountain Pines that grow along the upper edge and lower sections of the cliff face. The historic ground level can be determined from trunk characteristics (bark, diameter) and first roots (Figure 5). Forty-one (33 above, 8 below) Table Mountain Pines were mapped and measured above and below the cliff face. Of these 9, or 27% had evidence that soil has been eroded from their base. The estimated amount of soil that has been eroded away ranged from a quarter to a full meter (10 to 39 inches). The location of the trees with the greatest erosion are nearest the cliff edge or base. This loss of soil will make the trees unstable, reduce the moisture and nutrients available to the trees, and eventually reduce the vigor of the trees.

The trees above and below the rock face showed other signs of damage. Fourteen of the upper 33 Table Mountain Pines exhibited evidence of being used as anchors for climbing ropes. One tree at the base of the rock face had several holes carved out of its trunk approximately 1.5 meters (4.5 feet) above the ground (Figure 7).

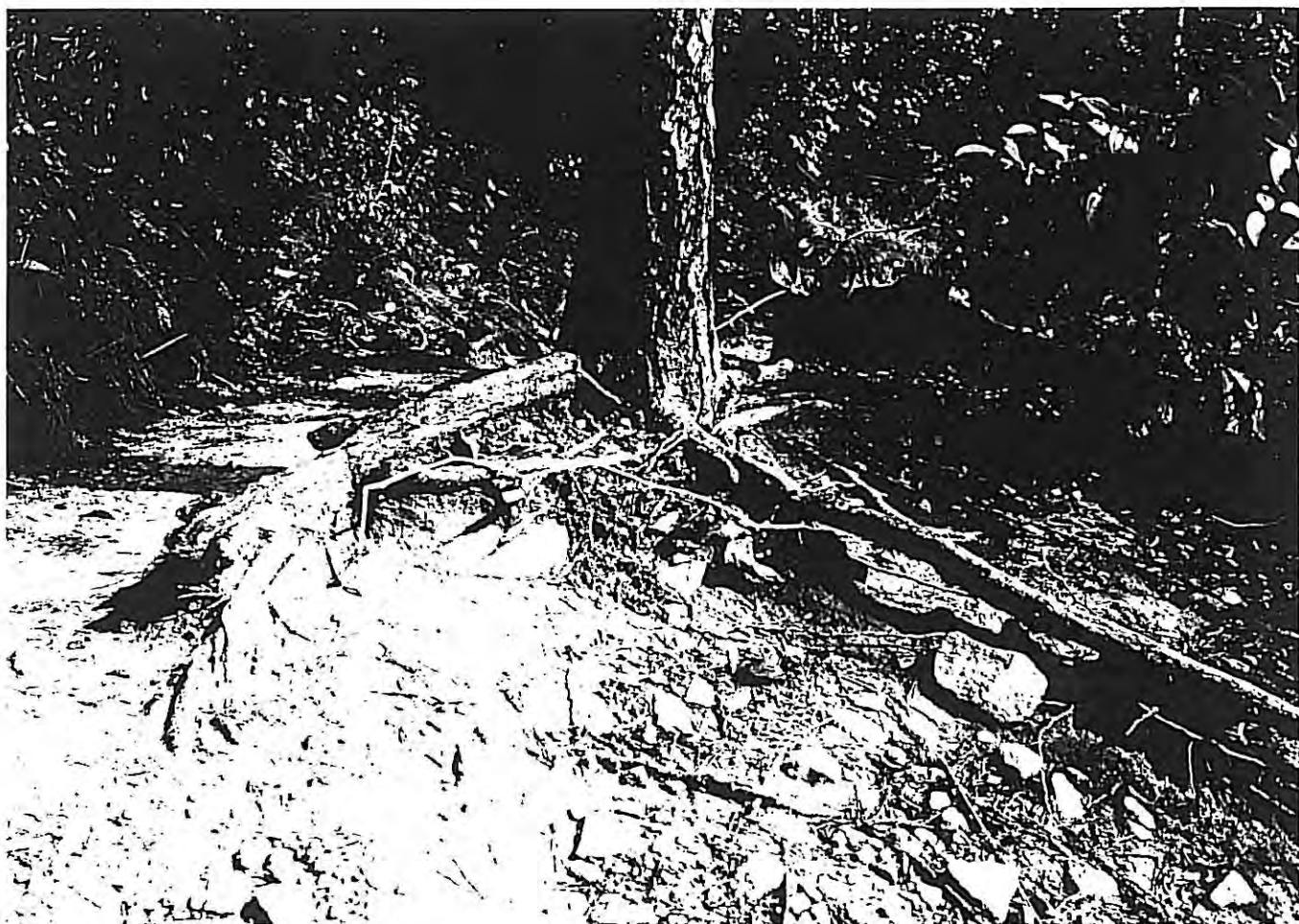


Figure 5. Soil erosion at base of Table Mountain Pine.



Figure 6. Soil Erosion at base of Sunset Rock.



Figure 7. Damage to a Table Mountain Pine at base of Sunset Rock.

Quantitative Data on Cover of Vegetation

Four plots were established on top (3) and below (1) Sunset Rock. Summary of the data is found in Tables 3 and 4. Using the point intercept method, at 10 cm intervals, cover data was obtained for the following categories: 1) rock, 2) gravel, 3) soil, 4) litter, 5) lichens/mosses, 6) grass/forbs, 7) roots, and 8) woody species.

Rocks, gravel, and soil made up the greatest percentage of cover in most transects and plots. Lichens and mosses were most abundant in Plot 1, a plot with little climbing impact. Gravel and soil were less abundant in Plot 1, although this could be the result of the extent of the area covered by rock. Plot 2 had high percentages of gravel and soil, reflecting the extensive trampling that takes place at this section of the rock outcrop. Grasses and forbs were most common in Plot 3, where there were several grass/forb islands. This plot is located in an area that appears to have less climbing pressure than Plots 2 and 4. Woody roots and woody stems had very little cover in any plot.

These data can be analyzed to determine the amount of change in percent cover that can be detected over time. This amount of change is known as the MDE, or minimal detectable effect. The analysis requires the choice of a test alpha (the probability of saying there is a change when there is none) and power (the inverse of beta, the probability of saying there is no change when there is change) level. An alpha of 0.1 (10%) and a power of 0.9 (90%) have been chosen for this analysis.

The results are shown in Table 5. These results are valid only if the amount of variation in the data is not significantly different among sampling periods. Also, the actual MDEs for an overall analysis that incorporated all of these variables would be different, since the alpha for multiple t-tests will be higher than the desired value of 0.1. For most of the variables, the sampling design and method can detect relatively small changes in percent cover. For example, in plot 1, an 11 percent change in gravel cover or a 20 percent change in soil cover would be considered a significant change. Rock cover, however, due to its variation among transects, would have to change greater than 45 percent before it was considered statistically significant. Detecting smaller changes in rock cover is possible in the other plots. We recommend that a biostatistician be consulted when analyzing future data.

Inventory

No rare plant species were found in the vicinity of Sunset Rock.

Table 3. Raw data for four vegetation plots.

Plot	Transect	Baseline		Bearing (degrees)	Length (M)	Total		Rock	Gravel	Soil	Litter	Lichens/ Mosses		Grasses/ Forbs	Roots	Woody
		Pos. (M)	Pos. (M)			Points	Points									
1	1	3.13		39	8.5	85	20	10	20	17	13	3	0	0	0	0
1	2	4.38		39	10.5	105	43	0	7	15	35	6	0	0	0	0
1	3	5.17		39	10.4	104	42	1	5	22	31	2	0	0	0	0
1	4	6.51		39	11.5	115	74	0	0	8	26	4	0	0	6	1
1	5	7.49		39	11.7	117	93	0	0	3	21	3	0	0	1	0
2	1	2.44		309	12.5	125	62	6	24	14	13	5	1	0	0	0
2	2	3.59		309	12.2	123	37	49	18	11	7	1	0	0	0	0
2	3	4.59		309	11.8	117	28	54	20	12	2	1	0	0	0	0
2	4	5		309	12	118	24	49	21	17	5	1	1	0	0	0
2	5	6.8		309	11.3	114	57	34	13	5	4	0	1	0	0	0
2	6	7.08		309	11.5	111	41	30	23	5	10	0	2	0	0	0
2	7	8.86		309	11.5	121	64	18	19	12	4	2	2	0	0	0
2	8	9.21		309	11.6	117	60	19	20	12	1	1	4	0	0	0
3	1	2.65		269	8	80	1	23	32	9	0	3	2	0	0	0
3	2	3.68		269	8.5	85	7	19	18	19	0	19	2	1	0	1
3	3	4.44		269	8.5	85	8	13	17	7	0	45	2	0	0	0
3	4	5.28		269	8.9	89	5	22	21	10	1	24	0	5	0	0
3	5	6.73		269	9.4	94	24	36	17	10	0	0	3	0	0	0
3	6	7.84		269	8.8	88	26	16	26	11	0	0	6	3	0	0
3	7	8.81		269	8.2	82	22	1	14	23	1	6	4	6	0	0
3	8	9.72		269	8	80	51	1	4	17	1	24	0	1	0	0
3	9	10.01		269	7.8	78	34	1	10	12	4	15	0	2	0	0
3	10	11.67		269	7.2	72	24	1	6	15	4	20	0	0	0	0
4	1	1.43		85	7.7	77	23	18	25	3	0	0	8	0	0	0
4	2	2.17		85	9.6	96	61	20	14	0	0	0	1	0	0	0
4	3	3.27		85	8.1	81	32	18	26	6	0	0	0	0	0	0
4	4	4.8		85	6.7	67	12	14	36	3	0	2	0	0	0	0
4	5	5.11		85	7.1	71	24	9	29	12	1	6	0	1	0	0
4	6	6.85		85	6.96	69	4	1	30	14	0	12	0	6	0	0
4	7	7		85	7.1	71	3	8	24	23	0	11	1	3	0	0
4	8	8.78		85	5.37	53	6	4	32	5	2	2	1	1	0	0

Table 4. Summary of % ground cover data for Sunset Rock.

Plot	Number of Transects	Lichens & Mosses					Grasses & Forbs		Woody Roots Vegetation	
		Rock	Gravel	Soil	Litter	Mosses	Forbs	Roots	Vegetation	
1	5	Mean	49.7	2.5	7.0	13.0	23.8	3.4	0.0	1.2
		SE	9.87	2.31	4.34	3.62	3.43	0.64	0.00	1.01
2	8	Mean	39.4	27.5	16.7	9.2	4.8	1.1	1.2	0.0
		SE	4.70	5.18	1.01	1.19	1.19	0.45	0.40	0.00
3	10	Mean	24.7	15.3	19.6	16.2	1.4	19.0	2.2	2.9
		SE	6.15	4.27	3.21	2.06	0.68	5.29	0.74	0.94
4	8	Mean	25.7	15.0	38.9	11.9	0.6	6.0	1.8	2.0
		SE	7.11	2.83	5.02	3.79	0.48	2.49	1.25	1.09

Table 5. Minimum detectable effects for a two sample t-test with alpha of .1 and a power of .9 for each test (see text).

Plot	Number of Transects	Lichens & Mosses					Grasses & Forbs		Woody Roots Vegetation	
		Rock	Gravel	Soil	Litter	Mosses	Forbs	Roots	Vegetation	
1	5	45	11	20	17	16	3	----- ¹	5	
2	8	21	23	4	5	5	2	2	----- ¹	
3	10	27	19	14	9	3	23	3	4	
4	8	31	12	22	16	2	11	5	5	

¹ No minimum detectable effect calculated due to 0 % cover in all transects.

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

The three methods used to monitor human impact at Sunset Rocks allows the National Park Service to choose an appropriate method depending on the level of efficiency and precision desired.

All methods show that human use of Sunset Rock, both current and past, has profoundly affected the vegetation and soils of the areas immediately above and below the outcropping. There has most likely been a decrease in herbaceous and shrub cover, a decrease in younger age classes of tree species, damage or death of older trees, an increased exposure of soil and rock, increased erosion, and the compaction of soil. Evidence of each of these is currently found at Sunset Rock. The photographs, mapping, and quantitative data show the extent of these disturbances. The causes of disturbance include the combination of hikers and climbers overlaid on a site that had been heavily disturbed over the last hundred years. The data on the amount of soil loss from the base of Table Mountain Pines also shows how extensive the impact has been. The estimated amount of soil that has been eroded away ranged from a quarter to a full meter (10 to 39 inches).

Observations of other rock outcrops in the vicinity and the quantitative sampling at Sunset Rock provide the basis for a hypothesized model of vegetation response to trampling. Undisturbed rock outcrops are characterized by: 1) rocks covered with lichens (Figure 8); 2) soil, litter, and vegetation in small crevices and depressions on the rock surface (Figure 9); 3) a mostly unbroken cover of herbaceous, forbs, and shrubs near the cliff edge; and 4) a mixed canopy of pine and oak growing from deeper soils and crevices with no exposed roots. Moderate trampling creates trails through the vegetation to the cliff edge, removes lichen cover from exposed rocks and soil, litter, and vegetation from crevices and depressions. Heavy trampling further removes lichens from exposed rocks and soil, litter, and vegetation from crevices and depressions, and widens and deepens trails to the cliff edge. These trails become a mix of soil and exposed rock that are conduits for water movement, enhancing erosion and exposing the shallow roots of shrubs and the deeper roots of trees. Extreme trampling completely removes lichen cover from exposed rocks except where protected by trees or the slope of the rock, completely removes soil, litter and vegetation from crevices and depressions, eliminates most grass, forb, and shrub species adjacent from the rock face, resulting in the area being a mix of soil, gravel, and exposed rock. It also kills small trees and exposes the roots of the remaining larger trees and compacts and removes substantial amounts of soil.

Moderately trampled areas can be restored to relatively undisturbed conditions by eliminating the trampling by closure. Heavily trampled areas need some active restoration, but can probably be restored to undisturbed conditions. Extremely trampled areas,



Figure 8. Rock surface near cliff in area not used for climbing.



Figure 9. Crevice on rock face in area not used for climbing.

however, may not be able to be restored to undisturbed conditions. The extreme loss of soil and changes in the topography would take thousands of years to naturally restore and substantial restoration efforts to return to a relatively undisturbed appearance.

Recommendation 1. Dedicated Areas for Climbing.

It is the recommendation of this report that the National Park Service maintain some areas for climbing and hiking, other areas only for hiking, and selected areas that would be closed to hiking and climbing. These latter sites would be protected to maintain representative sites of the undisturbed cliff community. In areas chosen for hikers and climbers, there needs to be an active and continual restoration effort to ensure that the site does not become extensively degraded.

We suggest that climbing be limited to specific rock faces. The heavy impact of climbing permanently impacts the vegetation and soils of a rock outcrop. Thus, it is probably better to allow climbing at some sites that are continually managed and restored and leave the currently undisturbed/minimally disturbed sites in their current condition. Rotating sites among rock outcrops for climbing would only distribute this extensive damage over all outcrops. In a rotated site scenario there may not be the time for sites to restore themselves or the funding to maintain a restoration project over many outcrops.

Recommendation 2. Conservation and Restoration Efforts.

At sites designated for climbing, there needs to be a continuous restoration effort. This restoration effort would require the addition of soil to sites, the planting of native vegetation, the use of a temporary soil holding material (geotextile), and the protection of these restored sites from trampling. Since it is probably impossible to restore the site to a relatively natural condition, the restoration design would have to determine which areas should be restored with soil and plants and where and how (fences, barriers, rock walls) foot and climbing traffic would be directed. Additional concern must be given to the use of trees as anchors for climbing (Figure 10).

Any restoration effort would need to include some long-term monitoring. Monitoring would be needed for two specific reasons: 1) to assess the success of the restoration efforts, and 2) to determine when the next round of restoration action will need to begin. With as much trampling as this area gets, restoration will need to be continuous. Monitoring would need to be reflected in any restoration plan and in its planning schedule and budget.

Recommendation 3. Frequency of Monitoring.

It is recommended that the photopoints be repeated annually, and the mapping and quantitative data collection be conducted every two years. This frequency will allow for detection of major changes (storm damage, erosion), as well as slowly occurring trends (succession, changes in vegetation). The frequency of sampling should be increased if any restoration actions are initiated.

Recommendation 4. Analysis of Data after Resampling.

The photopoints are visually assessed for changes. The mapping is assessed by comparing the location of major biological and physical elements to determine change. The quantitative data on the cover of physical conditions and vegetation cover can be analyzed by descriptive and graphical techniques. This may provide an adequate analysis without the use of inferential statistics. Statistical tests (t-test, anovas) could be used if the data meet all the assumptions of these tests. Statistically and biologically significant trends will be most readily observed for the primary indicators of disturbance (gravel, soil) and elements that have the smallest MDE. We recommend that the assistance of a biostatistician be part of any resampling project.

Appendices

Appendix A

PERMANENT PHOTOPOINT RECORD

Photopoints Along Baseline: 1

Year: 1993

Site Name: Sunset Rock, on Lookout Mountain, Chickamauga-Chattanooga National Military Park
Site Location: West side of Lookout Mountain, Tennessee

Subject and Purpose: To monitor changes in the condition of the ground cover and vegetation in areas impacted by climbers and hikers.

Retake Frequency: annually

Camera Point Description: Photographing along a baseline, at the top of the cliff-face, mostly to the west, with a few shots of the baseline itself.

Photographer: R. Sutter, The Nature Conservancy
Camera: 35mm Nikon F2 Film: Fugichrome 100 slide ASA: 100
Date: August 1993 Time: 10 am Weather: clear

Camera Height: 60 cm Vertical Angle: 0 degrees
Lens: 28mm Filter: Haze (8Y)
Focus distance: infinity

Photopoint	Baseline Location	Bearing and Notes on Photopoint
1-1	1	300 W
1-2	4	300 W
1-3	6	210 S, tape on left of frame
1-4	8	300 W
1-5	12	300 W
1-6	12.4	210 S, tape on left of frame
1-7	20	300 W
1-8	24	300 W
1-9	28	300 W
1-10	29.4	30 N, tape on right of frame

Sketch of Reference points (location, bearings, distance to photopoint location, local landmarks)

PERMANENT PHOTOPOINT RECORD

Photopoints Along Baseline: 2

Year: 1993

Site Name: Sunset Rock, on Lookout Mountain, Chickamauga-Chattanooga National Military Park

Site Location: West side of Lookout Mountain, Tennessee

Subject and Purpose: To monitor changes in the condition of the ground cover and vegetation in areas impacted by climbers and hikers.

Retake Frequency: annually

Camera Point Description: Photographing along a baseline, at the top of the cliff-face, mostly to the west, with a few shots of the baseline itself.

Photographer: R. Sutter, The Nature Conservancy
Camera: 35mm Nikon F2 Film: Fugichrome 100 slide ASA: 100
Date: August 1993 Time: 10 am Weather: clear

Camera Height: 60 cm Vertical Angle: 0 degrees
Lens: 28mm Filter: Haze (8Y)
Focus distance: infinity

Photopoint	Baseline Location	Bearing and Notes on Photopoint
2-1	3	260 W
2-2	8	260 W
2-3	11	260 W
2-4	17	260 W
2-5	28	260 W

Sketch of Reference points (location, bearings, distance to photopoint location, local landmarks)

PERMANENT PHOTOPOINT RECORD

Photopoints Along Baseline: 3

Year: 1993

Site Name: Sunset Rock, on Lookout Mountain, Chickamauga-Chattanooga National Military Park
Site Location: West side of Lookout Mountain, Tennessee

Subject and Purpose: To monitor changes in the condition of the ground cover and vegetation in areas impacted by climbers and hikers.

Retake Frequency: annually

Camera Point Description: Photographing along a baseline, at the base of the cliff-face, to both the east and west, with a few shots of the baseline itself.

Photographer: R. Sutter, The Nature Conservancy
Camera: 35mm Nikon F2 Film: Fugichrome 100 slide ASA: 100
Date: August 1993 Time: 10 am Weather: clear

Camera Height: 60 cm Vertical Angle: 0 degrees
Lens: 28mm Filter: Haze (8Y)
Focus distance: infinity

Photopoint	Baseline Location	Bearing and Notes on Photopoint
3-1	3	175 S, tape on right of frame
3-2	3	175 S, tape on left of frame
3-3	6	265 W
3-4	12	265 W
3-5	17	265 W
3-6	28	175 S
3-7	28	85 E
3-8	31	85 E
3-9	34	85 E
3-10	34	175 S, tape on left of frame
3-11	34	355 N, tape in middle of frame

Sketch of Reference points (location, bearings, distance to photopoint location, local landmarks)

PERMANENT PHOTOPOINT RECORD

Photopoints Along Baseline:

Year:

Site Name: Sunset Rock, on Lookout Mountain, Chickamauga-Chattanooga National Military Park

Site Location: West side of Lookout Mountain, Georgia

Subject and Purpose: To monitor changes in the condition of the ground cover and vegetation in areas impacted by climbers and hikers.

Retake Frequency: annually

Camera Point Description:

Photographer:

Camera: 35mm

Film: Fugichrome 100 slide ASA: 100

Date: August

Time: am pm Weather:

Camera Height: 60 cm

Vertical Angle: 0 degrees

Lens: 28mm

Filter: Haze (8Y)

Focus distance: infinity

Photopoint

Baseline
Location

Bearing and Notes on Photopoint

Sketch of Reference points (location, bearings, distance to photopoint location, local landmarks)

PERMANENT PHOTOPOINT RECORD

Photopoints Along Baseline:

Year:

Site Name: Sunset Rock, on Lookout Mountain, Chickamauga-
Chattanooga National Military Park
Site Location: West side of Lookout Mountain, Georgia

Subject and Purpose: To monitor changes in the condition of the
ground cover and vegetation in areas impacted by climbers and
hikers.

Retake Frequency: annually

Camera Point Description:

Photographer:
Camera: 35mm Film: Fugichrome 100 slide ASA: 100
Date: August Time: am pm Weather:

Camera Height: 60 cm Vertical Angle: 0 degrees
Lens: 28mm Filter: Haze (8Y)
Focus distance: infinity

Photopoint	Baseline Location	Bearing and Notes on Photopoint
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Sketch of Reference points (location, bearings, distance to
photopoint location, local landmarks)

PERMANENT PHOTOPOINT RECORD

Photopoints Along Baseline:

Year:

Site Name: Sunset Rock, on Lookout Mountain, Chickamauga-
Chattanooga National Military Park
Site Location: West side of Lookout Mountain, Georgia

Subject and Purpose: To monitor changes in the condition of the
ground cover and vegetation in areas impacted by climbers and
hikers.

Retake Frequency: annually

Camera Point Description:

Photographer:
Camera: 35mm Film: Fugichrome 100 slide ASA: 100
Date: August Time: am pm Weather:

Camera Height: 60 cm Vertical Angle: 0 degrees
Lens: 28mm Filter: Haze (8Y)
Focus distance: infinity

Photopoint	Baseline Location	Bearing and Notes on Photopoint
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Sketch of Reference points (location, bearings, distance to
photopoint location, local landmarks)

PERMANENT PHOTOPOINT RECORD

Photopoints Along Baseline:

Year:

Site Name: Sunset Rock, on Lookout Mountain, Chickamauga-
Chattanooga National Military Park
Site Location: West side of Lookout Mountain, Georgia

Subject and Purpose: To monitor changes in the condition of the
ground cover and vegetation in areas impacted by climbers and
hikers.

Retake Frequency: annually

Camera Point Description:

Photographer:
Camera: 35mm Film: Fugichrome 100 slide ASA: 100
Date: August Time: am pm Weather:

Camera Height: 60 cm Vertical Angle: 0 degrees
Lens: 28mm Filter: Haze (8Y)
Focus distance: infinity

Photopoint	Baseline Location	Bearing and Notes on Photopoint
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Sketch of Reference points (location, bearings, distance to
photopoint location, local landmarks)

PERMANENT PHOTOPOINT RECORD

Photopoints Along Baseline:

Year:

Site Name: Sunset Rock, on Lookout Mountain, Chickamauga-
Chattanooga National Military Park
Site Location: West side of Lookout Mountain, Georgia

Subject and Purpose: To monitor changes in the condition of the
ground cover and vegetation in areas impacted by climbers and
hikers.

Retake Frequency: annually

Camera Point Description:

Photographer:
Camera: 35mm Film: Fugichrome 100 slide ASA: 100
Date: August Time: am pm Weather:

Camera Height: 60 cm Vertical Angle: 0 degrees
Lens: 28mm Filter: Haze (8Y)
Focus distance: infinity

Photopoint	Baseline Location	Bearing and Notes on Photopoint
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Sketch of Reference points (location, bearings, distance to
photopoint location, local landmarks)

Appendix B

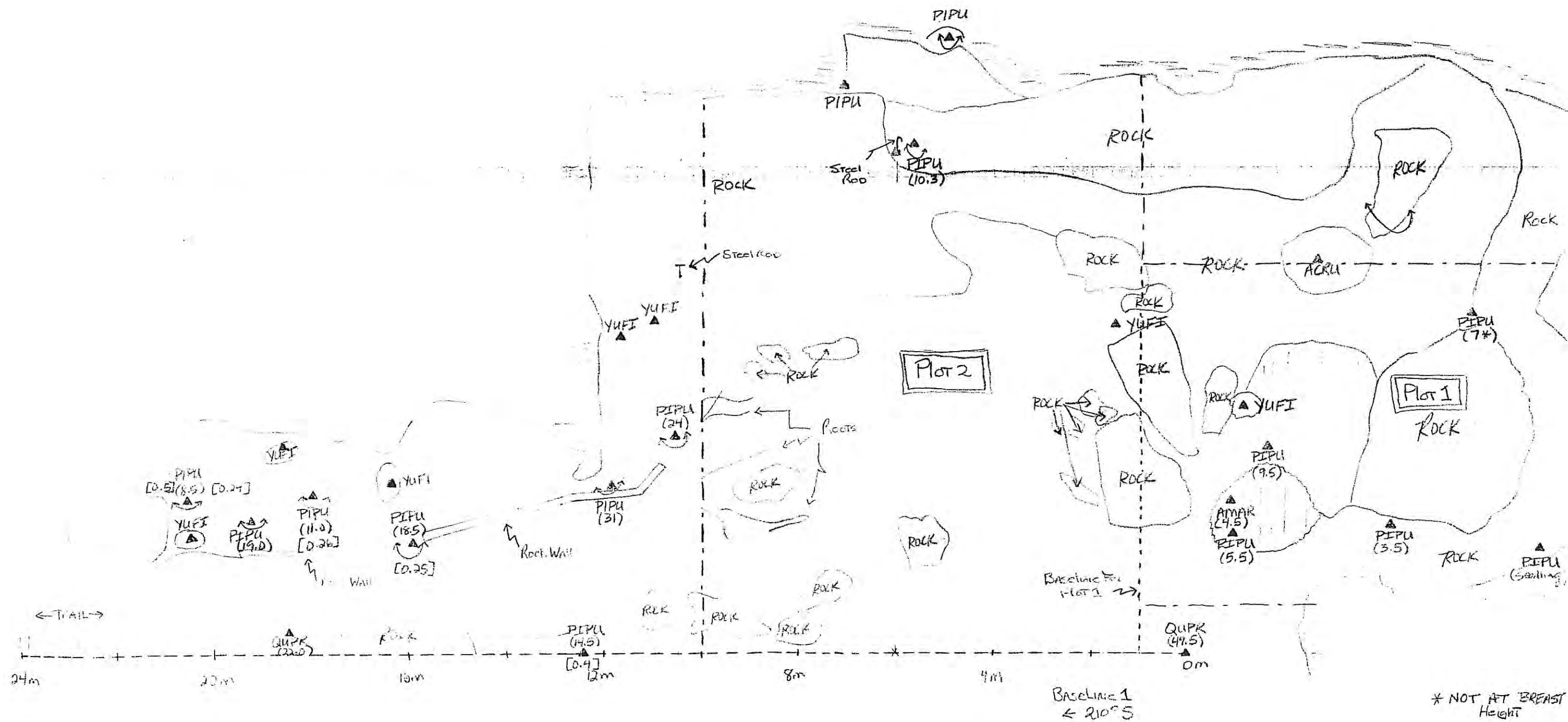
Appendix C

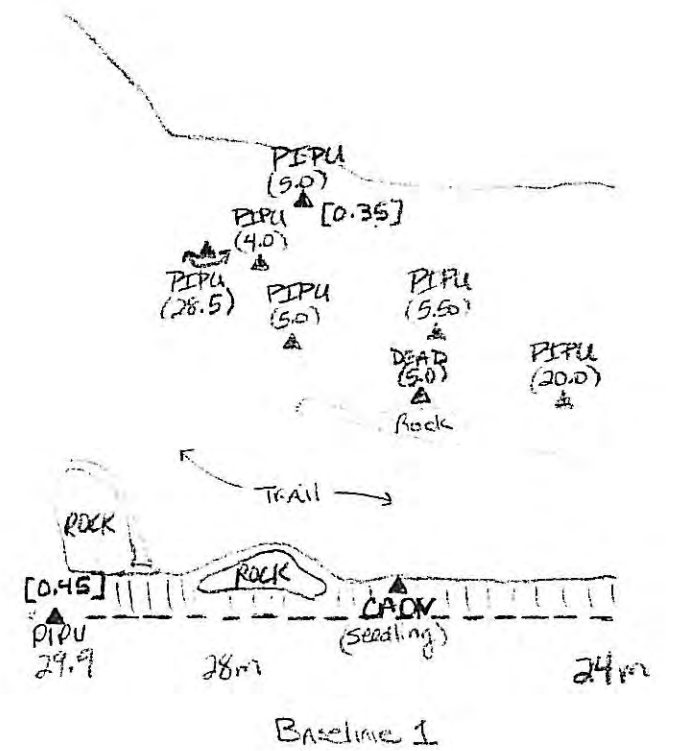
LEGEND

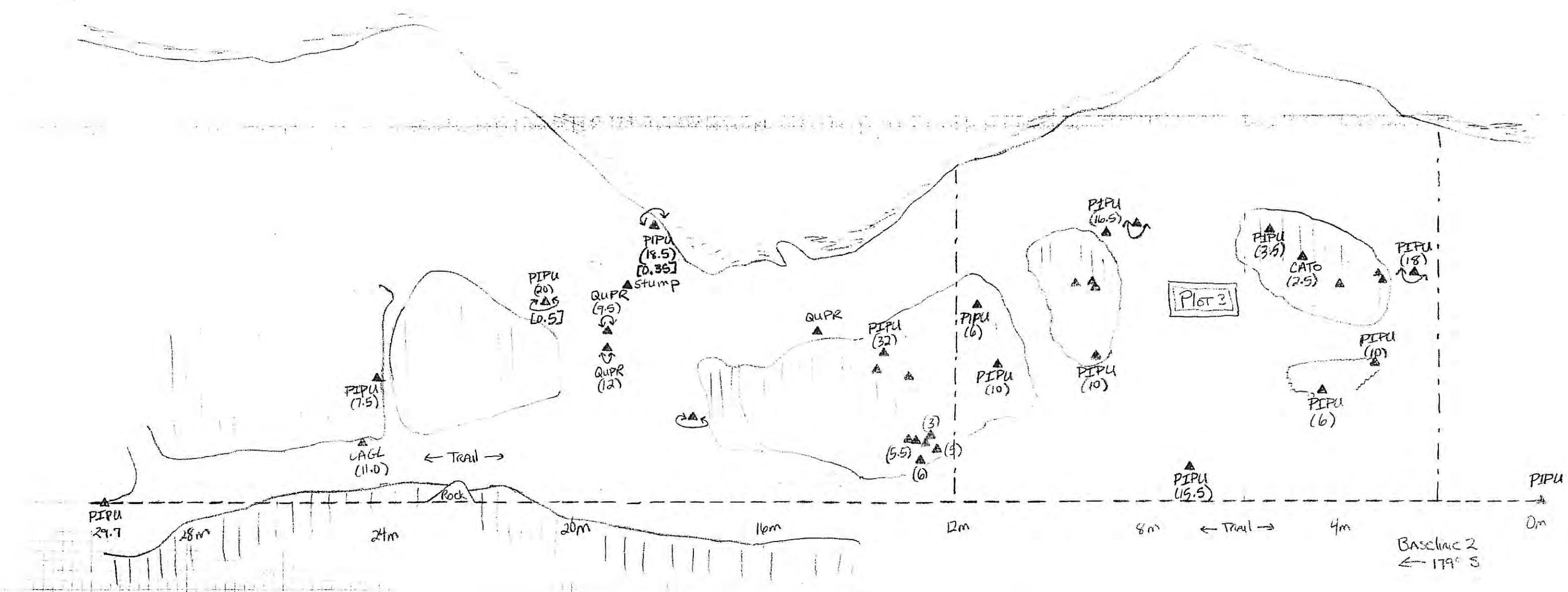
-- -- -- -- Baseline
-- -- -- -- Plot boundary
▲ Tree location
(0.5) Diameter at breast height in centimeters
[0.35] Depth of erosion in meters at base of tree
↪ Trees used as anchors for climbing ropes

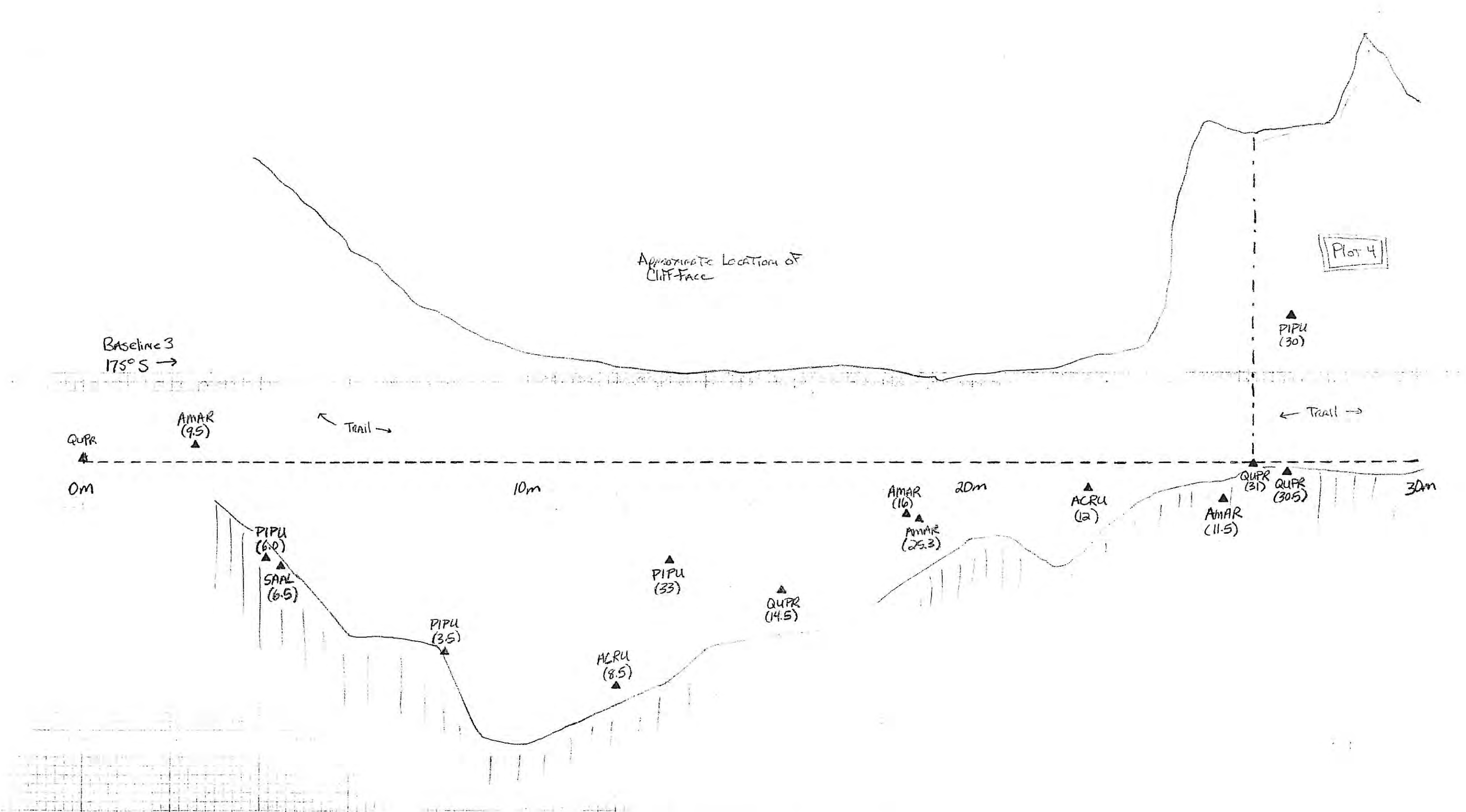
Species Names

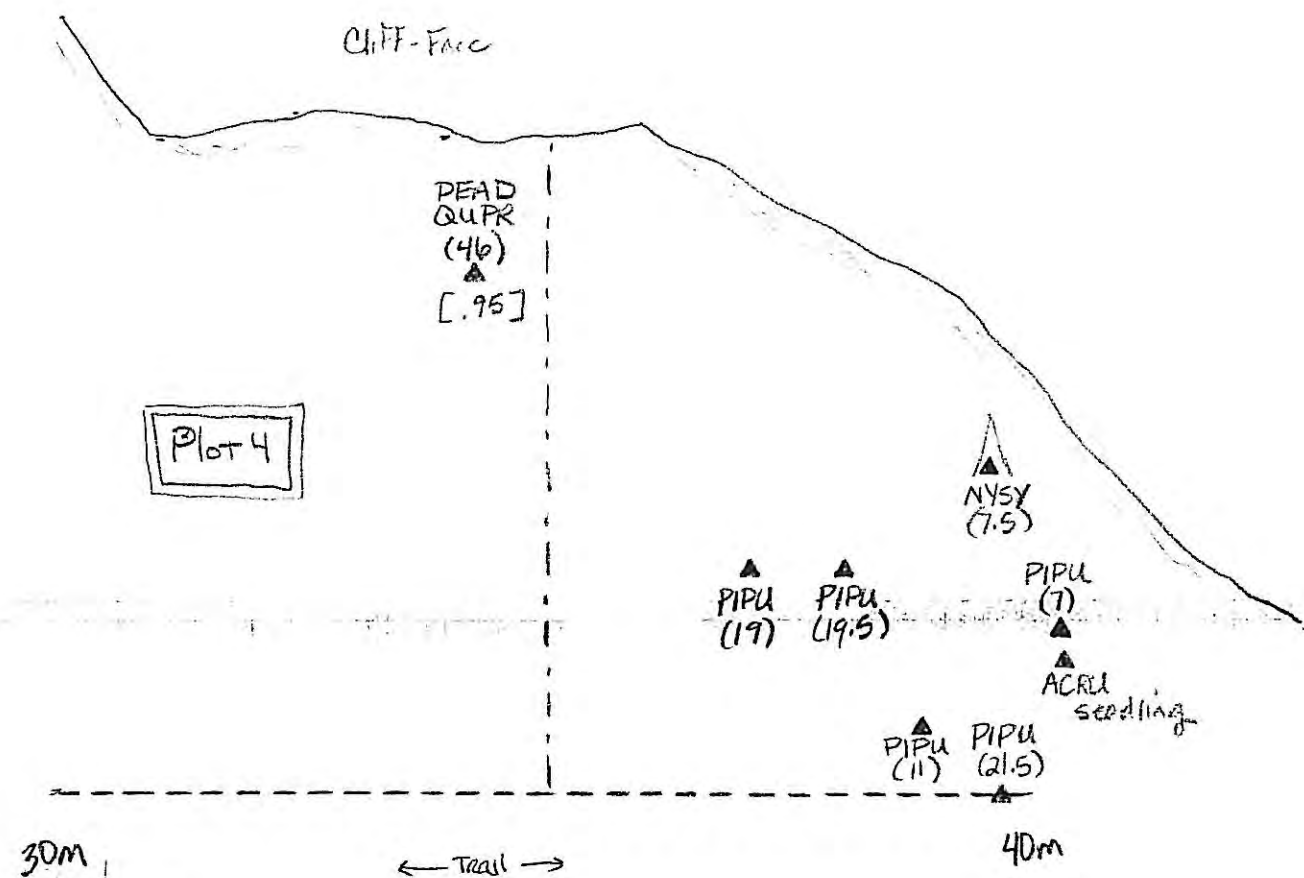
ACRU = Acer rubrum (red maple)
AMAR = Amelanchier arborea (service-berry)
CAGL = Carya glabra (pignut hickory)
CAOV = Carya ovalis (pignut hickory)
CATO = Carya tomentosa (mockernut hickory)
NYSY = Nyssa sylvatica (black gum)
PIPU = Pinus pungens (table-mountain pine)
QUPR = Quercus Prinus (Chestnut oak)
SAAL = Sassafras albidum
YUFI = Yucca filiformis











Appendix D

SUNSET ROCK/LOOKOUT MOUNTAIN MONITORING PROJECT

Point Intercept Cover Datasheet

Date: _____ Data Collectors: _____ Page _____ of _____

Outcrop: Sunset Rock Position: Above or Below Location Along Baseline: _____

Transect #: _____ Baseline Position: _____ Compass bearing: _____ Transect Length: _____

Cover Type	Number of Points	Total Points
Immovable Rocks		
Movable Rocks (> 10 cm in size)		
Gravel (< 10 cm in size)		
Soil		
Litter		
Lichen/Mosses		
Grass/Herbaceous Sp.		
Roots		
Woody Sp.		

NOTES/MAJOR CHANGES ALONG TRANSECT:

SUNSET ROCK/LOOKOUT MOUNTAIN MONITORING PROJECT

Point Intercept Cover Datasheet

Date: _____ Data Collectors: _____ Page _____ of _____
 Plot: Sunset Rock Position: Above or Below Location Along Baseline: _____
 Transect #: _____ Baseline Position: _____ Compass bearing: _____ Transect Length: _____

Cover Type	Number of Points	Total Points
Immovable Rocks		
Movable Rocks (> 10 cm in size)		
Gravel (< 10 cm in size)		
Soil		
Litter		
Lichen/Mosses		
Grass/Herbaceous Sp.		
Roots		
Woody Sp.		

NOTES/MAJOR CHANGES ALONG TRANSECT:

SUNSET ROCK/LOOKOUT MOUNTAIN MONITORING PROJECT

Point Intercept Cover Datasheet

Date: _____ Data Collectors: _____ Page _____ of _____
 Plot: Sunset Rock Position: Above or Below Location Along Baseline: _____
 Transect #: _____ Baseline Position: _____ Compass bearing: _____ Transect Length: _____

Cover Type	Number of Points	Total Points
Immovable Rocks		
Movable Rocks (> 10 cm in size)		
Gravel (< 10 cm in size)		
Soil		
Litter		
Lichen/Mosses		
Grass/Herbaceous Sp.		
Roots		
Woody Sp.		

NOTES/MAJOR CHANGES ALONG TRANSECT: