Assessment of resource changes in backcountry campsites from 1989-1996 in Rocky Mountain National Park, Colorado
by Victoria Grace Steele

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences
Montana State University
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Abstract:
One of the major contributing factors affecting wilderness resources is camping. The objectives of this study were to describe the resource changes that occur in backcountry campsites in Rocky Mountain National Park as measured by campsite area and campsite score from the Backcountry Campsite Impact Assessment and Monitoring System (BCIAMS).

Six categories, with several sub-categories each, were tested for change in area and total BCIAMS score. Categories were relative aspect, campfire, campsite type, distance from the trailhead, elevation and use. Each sub-category was analyzed independently and for each test, missing area measurements, or total scores of zero were dropped from that analysis. This produced different numbers of campsites in each test.

Most sites increased in area over time, but most sites decreased in total score over time. Sites that increased significantly in area over time were: northeast, southeast, northwest, no fire, campfire, individual, any distance from the trailhead, low or moderate in elevation and heavily used. Sites that increased significantly in total score over time were southwest and no fires. Stock sites decreased significantly over time in total score. Use was positively correlated to an increase in campsite area and total score.

Group and group/stock sites had larger areas than all other site types. Stock sites had larger areas than individual sites. Group/stock sites had higher total scores than all other site types. Campsites far from the trailhead had larger areas than sites close to the trailhead. Moderate elevation sites had higher total scores than low elevation sites.

A model of the life cycle of a campsite was adapted from Cole (1994). The decrease in BCIAMS scores, along with yearly campsite improvements has shown that impacts to campsites be reversed and allow the campsite to reach a long term steady state.

This study demonstrated the validity of assessing, monitoring and managing campsites over time. Managing campsites increases their aesthetic quality, concentrates use, and can reverse the rate of degradation. With continued management of campsites, our natural areas can be preserved for future generations.

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of

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in

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies

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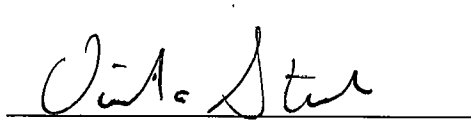
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Thou hast a voice, great Mountain, to repeal
Large codes of fraud and woe; not understood
By all, but which the wise, and great, and good
Interpret, or make felt, or deeply feel.

Percy Bysshe Shelley (1792-1822), English poet. Mont Blanc

This thesis is dedicated to:
Clarence 'Zumi' Zumwalt (1912-1996), Long's Peak Ranger
Larry 'Dean' Bowyer (1948-1996), Rocky Mountain Rescue Group
Homer Rouse (1936-1996), Superintendent, Rocky Mountain National Park (1993-1995)

These three men had a passion for the mountains that brought joy and meaning into the lives of everyone around them. Hopefully the results of this study will help preserve the mountains that they loved.

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TABLE OF CONTENTS

Page

1. INTRODUCTION 1

Objectives 1
Previous Studies and Secondary Hypotheses 6
Aspect 7
Campfire 8
Campsite Type 8
Distance from the Trailhead 10
Elevation 11
Use 11
Study Area 12
Location 12
Visitation 15
Vegetation 17
Backcountry Campsites 19

2. METHODS 22

BCIAMS Data Collection 22
BCIAMS Method One Two 26
Field Studies in 1996 30
Measure of Error Study 30
Spherical Densiometer Study 32
Mathematical Manipulations to the Data 33
Conversion of Method One to Method Two 33
Development of Backcountry Campsite User Data 35
Weighting of Data for Time Analysis 39

3. RESULTS and DISCUSSION 43

Field Studies in 1996 43
Measure of Error Study 43
Results 43
Discussion 43
Spherical Densiometer Study 44
Results 44
Discussion 44
BCIAMS Data 45
Descriptive Statistics 45

Results 45
Discussion 45
Changes Over Time Within Each Sub-category 45
Results 45
Discussion 67
Changes Over Time Within Each Category 67
Results 67
Discussion 68
Differences Between Sub-categories 68
Results 68
Discussion 71
Ordering of Sub-categories 71
Results 71
Discussion 74
Method Two Analysis 75
Results 75
Discussion 81
Second Test of Method Two 83
Results 83
Discussion 83
Correlation of Use with Area and Total Score Over Time 85
Results 85
Discussion 87
Change Over Time for Use 87
Results 87
Discussion 87
Changes Over Time on Each Campsite 88
Results 88
Discussion 91

4. CONCLUSIONS AND RECOMMENDATIONS 93

Conclusions 93
Recommendations for Further Studies 96
Management Intervention 96
High Elevation Sites 98
Stock Sites 98
Spring Melt Out 99
Recommendations for the Management of Backcountry Campsites 100
Recommendations for the BCIAMS Study 102

REFERENCES CITED 105

APPENDICES 111

Appendix A - Backcountry Campsites 111
List of Backcountry Campsites in Rocky Mountain National Park 113
Appendix B - Correlations for Method Two 115
Correlations Between Sub-categories for Method Two 116
Correlations Between Sub-categories for Method Two Excluding Vegetative Cover, Root and Shrub damage 117
Appendix C - Cart Decision Tree Analysis 119
Decision Tree for the Log Area of Campsites 122
Appendix D - Data Sheets for Method One 123
Data Sheet 124
Rating Summary 126
Rating Key 127
Appendix E - Data Sheets for Method Two 133
Impact Rating 134
Campsite Inventory Form 135
Appendix F - Data Sheets For 1996 Field Studies 136
Instructions for Spherical Densiometer Study 137
Data Sheet for Spherical Densiometer 138
Letter 139
BCIAMS Study Instructions 140
Data Sheet for Evaluation Number 1 141
Impact Rating 142

LIST OF TABLES

Table Page

1. The original hypothesis for each category and sub-category. 7

2. Annual visitation, backcountry use, and percent of visitors who camped in the backcountry to Rocky Mountain National Park from 1960-1996 (White, 1997). 15

3. Method one and two questions which were scored by field rangers. This example shows the results of the conversion from method one to method two. 27

4. Description of the six categories (independent variables) and their sub-categories. 28

5. Campsites evaluated in each year the data was collected for BCIAMS. 29

6. Campsites evaluated during the 1996 field study. 31

7. List of campsites for the spherical densiometer study. 32

8. Ranges of scores for method one rating questions and their conversion to the range of scores used in method two Method two questions were all scored the same (poor = 0, fair = 1, good = 2, excellent = 3). 34

9. Sources of backcountry campsite use data and percentage of the data that was available. 36

10. Data used in the normalization of backcountry user data. Rows A, B, E, and F are numbers of backcountry campers. Rows C, D, and G are percentages. 38

11. New range of scores for analysis for area (std. = standard deviation). The minimum and maximum are the lowest and highest values for the sub-category through time. The mean and std. are averaged over time for the sub-category. 40

12. New range of scores for analysis for total score (std = standard deviation). The minimum and maximum are the lowest and highest values for the sub-category through time. The mean and std are averaged over time for the sub-category. 41

13. Changes in campsite area (1989 through 1996) for each sub-category. * Significant ($\alpha = 0.05$) 49

14. Changes in campsite total score (1989 through 1996) for each Sub-category. * Significant ($\alpha = 0.05$) 58

15. Campsites sub-category characteristics that changed in area from 1989 through 1996. *Significant ($\alpha = 0.05$) p-value for area and total score for categories. 68

16. Significant ($\alpha = 0.05$) differences between sub-categories within each category for campsite area and total score. 69

17. Significant ($\alpha = 0.05$) differences between sub-category means within each category for campsite area and total score. 70

18. The original hypotheses for the means of each category and sub-category and the actual outcomes for area and total score. 73

19. Statistical summary of changes for method two variables over time. There are 1017 degrees of freedom. A negative correlation shows a decrease in score, while a positive correlation shows an increase in score. 76

20. Significant ($\alpha = 0.05$) changes (increase = I, decrease = D) between sub-categories within each category over time for method two variables. The overall trend for all scores was significant. 77

21. Significant changes in total score over time for campsites (page 1 of 4). A negative correlation shows a decrease in score, while a positive correlation shows an increase in score. 78

22. Significant ($\alpha = 0.05$) changes (increase = I, decrease = D) between sub-categories within each category over time for method two variables excluding vegetative cover, shrub and root damage. 84

23. Correlation of use with area and total score 86

24. Change in use over time for sub-categories 88

25. Campsites that showed a significant ($\alpha = 0.05$) change in campsite area over time. A negative correlation shows a decrease in area, while positive correlations show an increase in area. 89

26. Campsites that showed a significant ($\alpha = 0.05$) change in campsite total score over time. 90

27. Campsites that showed a significant ($\alpha = 0.05$) change in use over time 92

28. Recommendations for types of data to collect for BCIAMS study. 102

LIST OF FIGURES

Figure Page

1. Life cycle of a campsite based on predictions of Cole (1992 and 1994). 3
2. Fern Lake group site, 1976, the first year the site was established (Thompson River files, 1996). 4
3. Fern Lake group site, 1977 (Thompson River files, 1996). 4
4. Fern Lake group site, 1979 (Thompson River files, 1996). 5
5. Glacier Gorge campsite, 1978 (Thompson River files, 1996). 13
6. Glacier Gorge campsite, 1996 (Thompson River files, 1996). 13
7. Rocky Mountain National Park location map 14
8. Visitation in Rocky Mountain National Park (Metz, 1995, White, 1997). 16
9. Backcountry overnight use in Rocky Mountain National Park (Sweet, 1997). 16
10. Monthly use in backcountry campsites (Sweet, 1997). 17
11. Rocky Mountain National Park district map (Sweet, 1997). 24
12. Rocky Mountain National Park campsite map (Steele, 1998, Thomas, 1996) 25
13. Scatter plots residuals of aspect, distance, elevation, and use for area. 46
14. Scatter plots residuals of aspect, distance, elevation, and use for total score. 47
15. Mean campsite area from 1989-1996 for aspect. 50
16. Mean campsite area from 1989-1996 for campfires. 51

17. Mean campsite area from 1989-1996 for campsite type. 52

18. Mean campsite area from 1989-1996 for distance. 53

19. Mean campsite area from 1989-1996 for elevation. 54

20. Mean campsite area from 1989-1996 for use. 55

21. Trends in the change in area over time for all categories. 56

22. Mean total score from 1989-1996 for aspect. 59

23. Mean total score from 1989-1996 for campfires 60

24. Mean total score from 1989-1996 for campsite type. 61

25. Mean total score from 1989-1996 for distance. 62

26. Mean total score from 1989-1996 for elevation. 63

27. Mean total score from 1989-1996 for use. 64

28. Trends in the change in area over time for all categories. 65

29. Differences between sub-categories for area. 72

30. Differences between sub-categories for total score. 72

31. Life cycle of a campsite modified to reflect management intervention. 85

32. Upper Wind River, 1993 (Thompson River files, 1996). 97

33. Upper Wind River, 1996 (Thompson River files, 1996). 97

ABSTRACT

One of the major contributing factors affecting wilderness resources is camping. The objectives of this study were to describe the resource changes that occur in backcountry campsites in Rocky Mountain National Park as measured by campsite area and campsite score from the Backcountry Campsite Impact Assessment and Monitoring System (BCIAMS).

Six categories, with several sub-categories each, were tested for change in area and total BCIAMS score. Categories were relative aspect, campfire, campsite type, distance from the trailhead, elevation and use. Each sub-category was analyzed independently and for each test, missing area measurements, or total scores of zero were dropped from that analysis. This produced different numbers of campsites in each test.

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A model of the life cycle of a campsite was adapted from Cole (1994). The decrease in BCIAMS scores, along with yearly campsite improvements has shown that impacts to campsites be reversed and allow the campsite to reach a long term steady state.

This study demonstrated the validity of assessing, monitoring and managing campsites over time. Managing campsites increases their aesthetic quality, concentrates use, and can reverse the rate of degradation. With continued management of campsites, our natural areas can be preserved for future generations.

CHAPTER 1

INTRODUCTION

Objectives

The goals of the United States National Park Service include protecting the natural resources of the parks while at the same time managing them for the peoples' enjoyment and use. To effectively manage the parks' natural resources, it is important to understand how the resources are used by wildlife and people, what the major contributing factors are to changes in the resources over time, and how the resources respond to these different factors. One of the major contributing factors to change in backcountry resources is camping. The objective of this study were to describe the resource changes that occur in backcountry campsites in Rocky Mountain National Park as measured by the area of the campsite and as scored by the Backcountry Campsite Impact Assessment and Monitoring System (BCIAMS).

The Organic Act (1916) (16 United States Code (USC) 1) states that the National Park Service is responsible for:

> "...conserving the scenery and the natural and historic objects and wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations."

In partial fulfillment of the Organic Act, Rocky Mountain National Park initiated the Backcountry Campsite Impact Assessment and Monitoring System in 1989 (Thompson, 1988).

The purpose of BCIAMS was to inventory, assess, and monitor impacts to backcountry campsites resulting from overnight use. Analysis of data collected from BCIAMS gives park managers information about the changing conditions of backcountry campsites due to repetitive and increased visitor use. This data can then be used in developing standards that would help determine group size limitations, campsite closures or relocations, wood fire use limitations, and rerouting and maintenance of trails around campsites (Connors and Konz, 1989).

Backcountry overnight use by campers began to increase in Rocky Mountain National Park in the 1960's and peaked in 1977 (Sweet, 1997). Backcountry camping in the park is now less than it was in 1977, but more than in the 1960's.

Cole (1992 and 1994) found that degradation to vegetation and soils in campsites increases rapidly during the first 2-5 years of use (the development phase). Campsites do not grow in size indefinitely and they eventually reach a spatial limit (Cole, 1992). Cole (1994) predicted that after 3-5 years, campsites reach a state where resource damage increases as a slow rate, which he refers to as the dynamic equilibrium phase, and we will refer to as the mature phase (Figure 1).

Cole predicted that campsites in the mature phase of dynamic equilibrium (older than 3-5 years) fluctuate in the state of their degradation by 10-20% per year indefinitely,



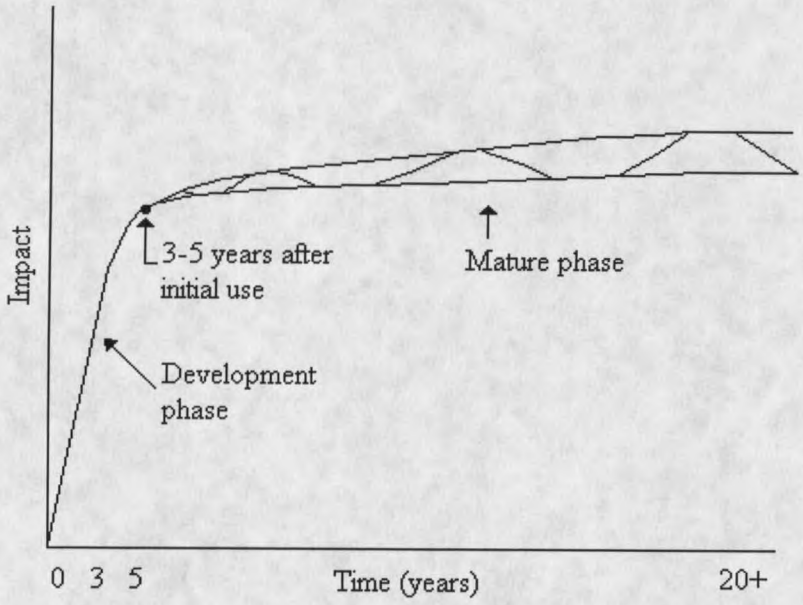


Figure 1. Life cycle of a campsite based on predictions of Cole (1992 and 1994).

if use characteristics remain the same (Cole, 1994). Campsites in the park appear to have degraded significantly in the first 3-5 years, followed by continuing resource damage of 10-20% in subsequent years (Figures 2, 3 and 4). In this study we will determine if campsites in Rocky Mountain National Park follow Cole's model, or if the resources in campsites are changing in a different manner.

The main objective of this study was to find out how increased visitor use and the geographical characteristics of campsites interact to cause changes in campsite area and in the condition backcountry campsite resources over time. The following main



Figure 2. Fern Lake group site, 1976, the first year the site was established (Thompson River files, 1996)



Figure 3. Fern Lake group site, 1977 (Thompson River files, 1996)



Figure 4. Fern Lake group site, 1979 (Thompson River files, 1996)

hypotheses will be addressed: 1) have campsites increased in area and has their total Backcountry Campsite Impact Assessment and Monitoring System (BCIAMS) score increased in the eight years (1989 through 1996), and 2) are user numbers positively correlated to area and total BCIAMS score?

Previous Studies and Secondary Hypotheses

The relationships between use, type of use and environmental factors are the important factors in determining the cause of campsite impacts (Cole and Marion, 1988). According to Cole (1994) there are four main ways to measure the intensity of impact on a campsite. The four categories proposed by Cole have been determined by studies on campsites in different areas of the country over the last few decades. The categories proposed by Cole are: 1) frequency of use (called in this study the "category use"), 2) type and behavior of use (categories: campsite type and campfire), 3) season of use (summer), and 4) environmental conditions (categories: relative aspect, elevation, and distance from trailhead). From this information, six categories were developed for the BCIAMS study to further analyze the data. The six categories to study campsite impacts used in this study are: relative "aspect", "campfire" sites, "campsite type", "distance from the trailhead", "elevation", and amount of overnight "use" per year.

Changes in area and total BCIAMS score over time were tested across the six categories of different environmental factors, type and amount of use. The following are secondary questions (Table 1): 1) Do campsites of relative aspect southeast (SE) and northwest (NW) have a larger area and total BCIAMS score than those that face from

northeast (NE) or southwest (SW)? 2) Do campsites that allow campfires have a bigger area and total score than campsites that do not allow campfires? 3) Are campsites of the type "group/stock" larger in area and total score than all other site types? 4) Are

Table 1. The original hypothesis for each category and sub-category.

Category	Expected results
Aspect	SW and NW > SE and NE
Campfire	CF > NF
Campsite type	G/S > G > S > I > L
Distance	close >far> middle
Elevation	high > low > moderate
Use	heavy > light > feather

campsites of the type "group" larger in area and total score than individual, stock, and llama sites? 5) Do campsites closer to the trailhead have a larger area and total score than those far from the trailhead, and are sites that are at middle distances have the smallest area and total score? 6) Are campsites at higher elevations larger in area and higher in total score than those at lower or moderate elevations? 7) Are the heaviest used campsites larger in area and higher in total score than the lighter used sites?

Aspect

Campsites at different aspects receive different amounts of insolation, resulting in differences in vegetation, soil moisture, and period of snow cover. Sites at northwest aspects are shaded and are covered with snow for longer periods of time than sites at other aspects. Campsites facing southwest are the drier than sites facing in other aspects (Cole and Fichtler, 1983). Campsites that face northwest, have wetter soils in the spring,

are more vulnerable to trampling, compaction and erosion at this time (Cole, 1994). In the spring plants were more fragile and more easily damaged by trampling, which leads to larger impacts from camping (Cole, 1994). Strand (1979) found that vegetation impacts by horses were greater and lasted longer in wet meadows versus dry meadows.

All campsites in Rocky Mountain have a grade of 5% or less, so that they are flat enough to camp on. Therefore, none of the campsites are completely affected by the effects of aspect. It was expected that if there are any differences in campsites due to aspect, campsites of aspects SW and NW will be more highly impacted than sites from SE and NE in this study.

Campfire

Campers who cook over wood fires cause more impact to campsites and the fires sterilize the soil which inhibits plant growth (Cole, 1992). Where campfires are allowed, vegetation is removed by campers searching for firewood, and this speeds degradation of campsites and limits rejuvenation (Cole, 1989b). It was therefore expected in this study that sites that allow campfires will show more impacts than sites that do not allow campfires.

Campsite Type

Campsite type is usually defined as what type of campers use a site. Common "types" of campsites are sites used by groups (in Rocky Mountain National Park, a group is 7-20 people), sites used by groups with horses, and sites used by small groups of people (in Rocky Mountain National Park, a small group, called an individual site, is 1-6

people).

Cole (1990) proposed that users not in groups and without horses cause less impact to campsites than others. Taylor (1997) found that there were different amounts of impacts on saplings outside the campsite depending on the amount of use the site received. Cole (1988) found that campsites in the New River Gorge that had been used by large groups of commercial rafting outfitters were larger and more de-vegetated than sites used by small groups of local fishermen. Cole (1987, 1988) found that the use of pack stock significantly increased the area of disturbance within a campsite.

Cole and Hall (1992) completed a study of trends in campsite conditions in the Bob Marshall Wilderness in Montana. The study area included both lower elevation mountain campsites with low use and high use campsites by stock parties over nine years. They found that sites used by stock had 11 times the damage to trees, more severely compacted soils, more loss of organic soil horizons and more exotic plants than non-stock sites and low use sites. It was found that campsites for smaller, non-stock groups were much less severally impacted than stock campsites.

In studies of experimental trampling by 1000 horses, it has been shown that trails trampled by horses are 2-3 times as wide and 1.5-7 times as deep as similar trails produced by 1000 hiker passes (Weaver and Dale, 1978). Campsites used by horses can be 10 times as large as those used by hikers (Frissel, 1973). Additionally, it has been found that horses destroy vegetation through trampling four to eight times as fast as hikers (Nagy and Scooter, 1974). Shod hooves tend to loosen soil which leads to more impacts (McQuaid-Cook, 1978).

In this study it was expected that highest impacts will be found in the group/stock campsites. It was expected that impacts will be seen in the following order based on campsite type (largest to lowest impacts): group/stock, group, stock, individual, and llama. It was expected that llama sites will be the smallest because llama use in the park is low.

Distance from the Trailhead

From personal experience I have noticed that most backpackers seem to prefer to camp close to the trailhead. All trail heads in the park are lower than any campsite on that trail. Distance was correlated with elevation of campsites in the park. Campsites farther from the trailhead are more severely impacted than those close to the trailhead (Cole and Hall, 1992). It was expected that sites farthest from the trailhead will receive fewer users per year because they are harder to get to, and will then be less impacted than sites close to the trailhead.

However, campsites at moderate distances from the trailhead are mostly in thicker sub-alpine forests, which have the thickest organic layers of soils (Cole, 1994).
It was expected that sites at middle distances will be impacted the least because the thick soil is less readily compacted and eroded. Based on personal experience, sites 0-2.0 miles (0 - 3.3 km) from the trailhead were defined as close, those 2.1-5.5 miles (3.4 - 9.2 km) from the trailhead as middle distance, and those farther than 5.6 miles (9.3 km) from the trailhead.

Elevation

As campsites increase in elevation, the vegetation changes from montane to sub-alpine and alpine. Cole (1993b) studied campsites on the east side of the Colorado Rocky Mountains at two elevations and three vegetation types: forested and open meadow at 8692 feet (2,650 m), and above treeline at 11,316 feet (3,450 m). He found that alpine vegetation types were more resistant to trampling than sub-alpine and lower elevation sites. Areas above tree line are notoriously difficult to rehabilitate (Stevens, 1976, Cole and Marion, 1988).

Cole (1987, 1995) found that fragile areas (such as high elevation area) can be severely impacted by only one night of camping. It was expected that high elevation sites will show more impacts than low elevation campsites because they do not recover from heavy use. Sites from 8000-9600 feet (2439-2926 m) were defined as low, from 9601-11,000 feet (2927-3354 m) as moderate elevation, and those above 11,001 feet (3355) as high elevation sites.

Use

The amount of use a campsite receives affects the amount of resource damage the site receives (Cole, 1994). There is an increasing curvilinear relationship between the amount of use a campsite receives and the percentage of vegetative cover loss (Cole, 1985). There is an increasing curvilinear relationship between frequency of use and intensity of impact on a campsite (Cole, 1994). As use increases, vegetative cover decreases, and intensity of impact increases.

Cole (1987, 1988, Cole and Marion, 1988) found that high use sites are 2-3 times

as large, have more tree damage, have more ground cover alteration bur less groundcover regeneration, and had more compacted soils than low use sites. Cole (1987, 1988, 1995) found that vegetation loss on high use sites was 20% greater than on low use sites. Cole and Hall found that medium and low use campsites were relatively stable, but high use campsites deteriorated over time (1992).

In a study camping of impacts on vegetation, just one night of camping was sufficient to cause an increase in impacts to campsites in both resistant (how well the vegetation tolerates trampling) (Cole, 1992), and non-resistant vegetation types (Cole, 1995). Additionally, as the soil is compacted due to trampling, rocks emerge and cause campers to seek other sites in which to lay their tents (Figure 5 and 6). This, in turn, causes the campsites to increase in size (Cole, 1987). It was therefore expected that high use sites will show more impact than low use sites.

Based on categorizations used by Cole (1986) in a study in the Grand Canyon, low use sites (in this study called "feather" sites) were defined as those which received 1-20 campers per year, lightly used sites received 21-50 campers per year, and heavily used sites received 51-900 campers per year.

Study Area

Location

Rocky Mountain National Park straddles the continental divide in northwest Colorado (Figure 7). There are three towns near the park, Estes Park and Allenspark on



Figure 5. Glacier Gorge campsite, 1978 (Thompson River files, 1996)



Figure 6. Glacier Gorge campsite, 1996 (Thompson River files, 1996)

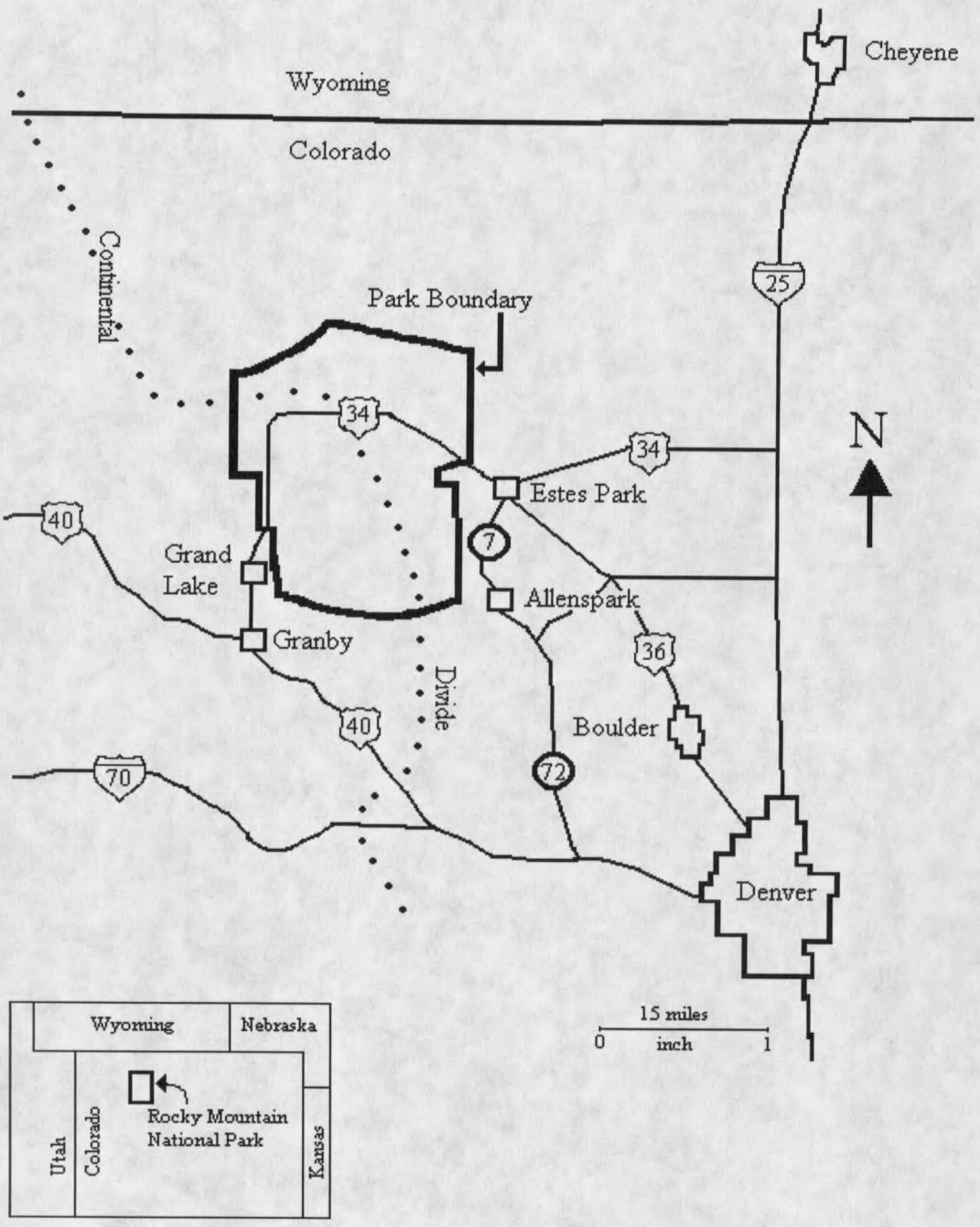


Figure 7. Rocky Mountain National Park location map.

the east side, Grand Lake on the west side. The park encompasses 265,727 acres (107539 hectares) of coniferous forest, subalpine, and tundra ecosystems. One third of the park is above tree line (11,500 ft/3500 m) (Nelson, 1979). The west side has gentler slopes, larger, moister coniferous forests, and receives more snow and rain than the east side (Nelson, 1979).

Visitation

There are 356 miles (573 km) of trails with 227 established backcountry campsites in the park (Sweet, 1997). Trails begin at 7,000 feet (2100 m) to 8,000 feet (2400 m) and lead to some of the highest points in the state at more than 14,000 feet (4300 m). Annually, about 3.1 million people visit the park, about 38,000 people camp overnight in the backcountry each year, and these numbers are increasing (Figures 8 and 9) (White, 1997). The ratio of park visitors who camp has increased through 1977, then decreased to current levels (Table 2).

Table 2. Annual visitation, backcountry use, and percent of visitors who camped in the backcountry to Rocky Mountain National Park from 1960-1996 (White, 1997).

Year	Annual visitation	Backcountry visitation	Backcountry visitation: percentage of annual visitation
1960	1,532,489	3,711	0.2%
1970	2,357,909	21,058	0.9%
1977	2,894,994	62,708	2.7%
1996	3,115,785	42,625	1.4%

Most of parks' visitors (80%) arrive between Memorial day and Labor day (Metz, 1995). Likewise, most of the use of backcountry campsites (93%) is between the months

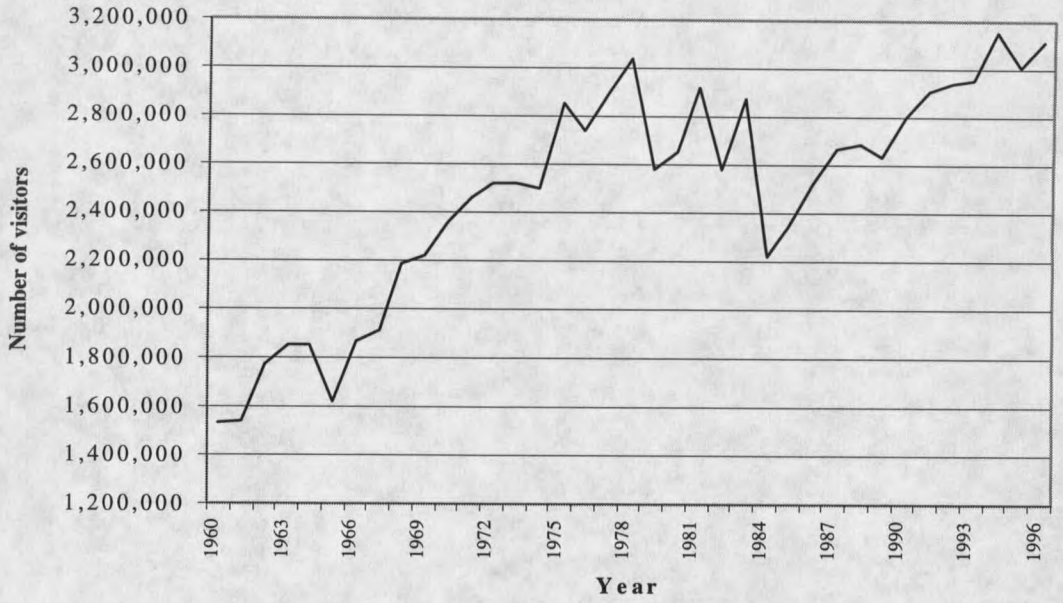


Figure 8. Visitation in Rocky Mountain National Park (Metz, 1995, White, 1997).

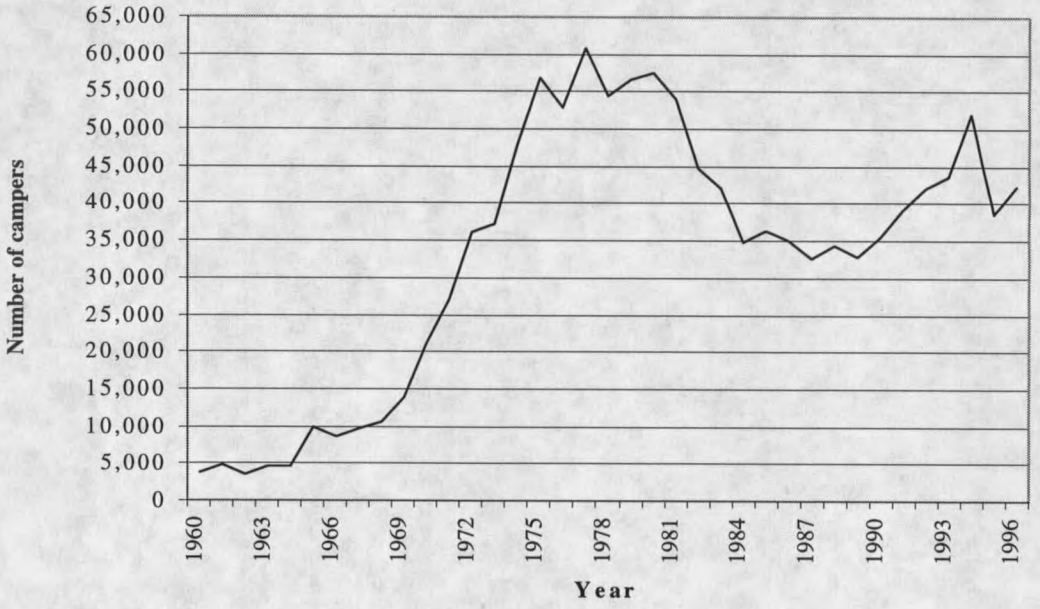


Figure 9. Backcountry overnight use in Rocky Mountain National Park (Sweet, 1997).

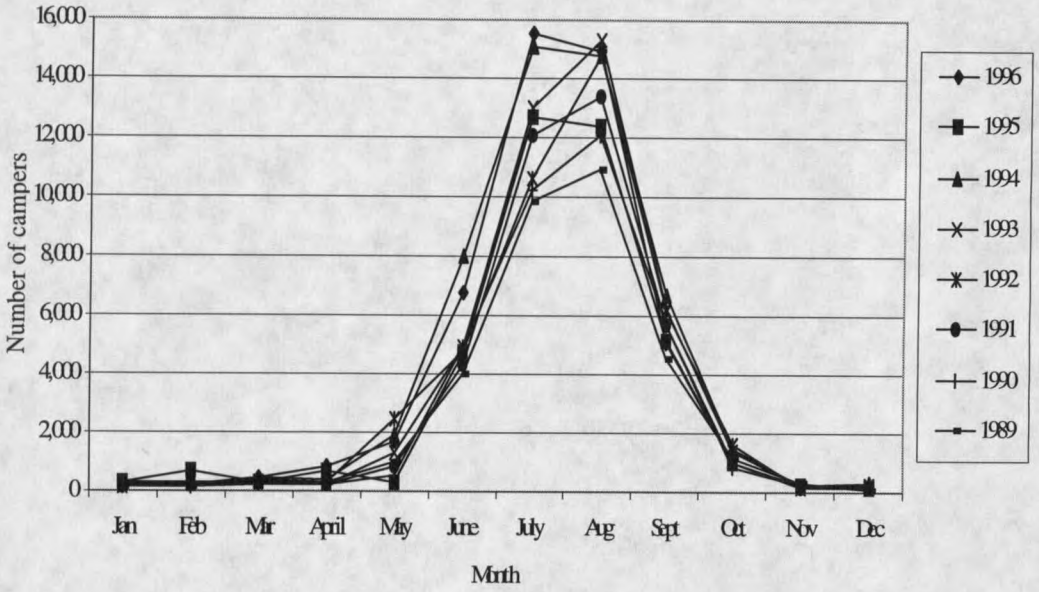


Figure 10. Monthly use in backcountry campsites (Sweet, 1997).

of May and September, with most of those visitors in July and August (Figure 10) (Sweet, 1997).

Vegetation

The park encompasses montane (7,000 feet to 10,500 feet, (2100 m to 3200 m)), subalpine (10,500 feet to 11,500 feet (3200 m to 3500 m)), and alpine zones (greater than 11,500 feet (3500 m) (Nelson, 1979). Ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*) dominate the lower boundary of the montane zone. Ponderosa pine is more abundant on the dry, east side while Douglas fir is more abundant on the west side (U.S. Department of Agriculture, 1971). Limber pine (*Pinus flexilis*) occurs on barren ridges and rock outcrops with dry soil and forms a forest with close-growing trees. Aspen (*Populus tremuloides*) is found in moister soils, avalanche chutes and gorges

(Nelson, 1979). Balsam poplar (*Populus balsamifera*), alder (*Alnus tenuifolia*), and stream-bank birch (*Betula sp.*) is found along streams and large open meadows are interspersed with the forest.

The upper boundary of the montane forest consists of aspen and lodgepole pine (*Pinus contorta*) and sometimes these species extend into the subalpine zone. Both species are often the first to colonize an area after a forest fire. Large open meadows are interspersed with forest. Perennial wild flowers include sedum (*Crassulaceae sp.*), saxifrage (*Saxifragaceae sp.*), geranium (*Geraniaceae sp.*), cinquefoil (*Potentilla sp.*), and penstemon (*Penstemon sp.*).

The subalpine forest includes Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). The soils are covered by forest litter and include a thicker organic layer (Chronic, 1984). Plants found on the forest floor include fairy slipper (*Calypso bulbosa*), and twin flower (*Linnaea borealis)* (Chronic, 1984).

The upper boundary of the subalpine zone is denoted by timberline and is dominated by an environmentally-dwarfed tree form called krummholz. The krummholz form is found in a variety of conifer tree species (limber pine, subalpine fir, and Engelmann spruce) and is found growing in the marginal and harsh climate at timberline. On the southeast-facing and southwest-facing slopes and in shaded valleys, treeline extends higher than on the north and northwest-facing exposures and windswept ridges (Nelson, 1979).

The alpine zone is dominated by short, sedge turf, and short-stemmed flowering plants (Chronic, 1984). The growing season is short and limits the ability of the plant to

grow seeds to maturity. Because most plants are perennials, often they rely on asexual reproduction. Small mounds or depressions in tundra environments offer protection from wind, sun, and extreme cold (Kemp, 1990). Flowering plant species include rose (*Rosaceae sp.*), mustard (*Cruciferae sp.*), saxifrage (*Saxifragaceae sp.*), and asters (*Aster sp.*) families.

Backcountry Campsites

Throughout the park there are seven types of backcountry campsites as described in the following paragraphs. Five of these types of campsites are 'established' meaning they are designated and maintained campsites in a specific mapped location along maintained trails in the backcountry. The other two categories of campsites are not established and are found in particular drainages (cross-country or winter zones) or cliff areas (bivy sites). To more effectively manage the parks' backcountry resources, a reservation system for backcountry overnight use was started in 1974. The reservation system encourages compliance with backcountry camping regulations in established campsites throughout the park.

A campsite is a location that will accommodate one party per night. A party is a group of people who are staying in the same backcountry campsite. Campers must camp in established sites in the summer, but can camp on snow near campsites in the winter. The summer is the period between approximately April 1st and October 31st, depending on snow conditions. The rest of the year is considered winter. All campsites are located at least 100 feet from streams, lakes, and trails.

Only the five categories of established campsites were analyzed in this study

because data for cross-country and bivy sites was not sufficient for analysis. The five types of campsites that will be described here are: group, group/stock, individual campsites, stock, and llama campsites. Appendix A describes the location, number, classification, distance from the trailhead and elevation of campsites in the park.

Campers in group campsites are limited to parties of 8-12 for up to three nights, campfires are not allowed except in specially designated campsites, and tents must be placed within the established camping area. The established camping area in some locations consists of tent pads built using logs, in other cases the tent campsites may be recognized as a denuded area within 10 feet of the metal arrowhead. Group campsites are large enough to accommodate 5-7 tents.

Group/stock campsites are group campsites where up to 20 stock animals are allowed to be tethered overnight at a hitch rack within 100 feet of the campsite. Campers follow the same rules as those at group campsites.

Campers at individual campsites are limited to parties of 1-7, must move after three nights, cannot have campfires except in designated campsites, and must camp within the established camping area. At many campsite locations tent pads have been built, in other cases the campsite is recognized as a denuded area with a metal arrowhead in the center. The campsites are large enough to accommodate 1-2 tents.

At stock campsites campers may bring up to five horses, llamas, or mules. Campers follow the same rules as those at individual sites. Animals are kept at a hitch rack that is within approximately 100 feet of the stock campsite.

Llama campsites are individual campsites that allow backcountry campers to bring

up to five llamas as pack animals. Horses and mules cannot be taken into llama campsites. Campers follow the same rules as those at individual sites. Animals are kept at a hitch rack that is within approximately 100 feet of the llama campsite. From these description of campsites and camping, the methodology of the BCIAMS study will now be discussed.

CHAPTER 2

METHODS

From Cole's (1983) studies on assessing campsite impacts, techniques for monitoring and assessing backcountry campsites have been developed (Kitchell and Connor, 1984; Cole, 1989b; Grover, 1990; Kuss, 1990; Curecanti N. P., 1991; Marion, 1991b; Landres, Cole and Watson, 1994; Landres, 1995). Some of the most common methods for collecting data are summarized by Marion (1991a).

There were two parts to this study. The first was the BCIAMS collection of data from 1989 through 1996. Data were recorded by field personnel, along with comments on evaluation sheets, and photographs were taken. The second part of the study was a series of field studies conducted in 1996 designed to gain information about the amount of variance in the BCIAMS database.

BCIAMS Data Collection

In the BCIAMS study, campsites were organized by location to determine the years in which they would be assessed. First, the park's campsites were divided into two groups based on the side (east and west) of the continental divide where they occurred. The east side is divided into five districts (Wild Basin, Long's Peak, Thompson River, North Fork and Fall River). The west side is considered as one district. Thus, there are

six districts (the west side is the sixth district) in the park and their boundaries have not changed during the study (Figure 11).

There are 227 backcountry campsites in the park between 8,100 feet (2469 m) and 12,760 feet (3889 m) (Figure 12). Several backcountry campsites are often located in close proximity to one another and are called "camp areas". For example, at Fern Lake camp area there are four individual campsites and one group campsite, while there is only one individual campsite at Upper Ouzel Creek. Therefore, on any night there may be five permits issued for Fern Lake with a maximum of 40 people, but only one permit may be issued with a maximum of seven people at Upper Ouzel Creek.

In 1974 the park adopted a backcountry camping permit system and officially established most campsites in the park by placing metal arrowhead markers in the center of the campsites. All but one backcountry campsite in this study are at least 18 years old (Betts, personal communication, 1996). Renegade campsite on the west side was established in 1992 (Rouse, 1992, Devine, personal communication, 1996). Fern Lake individual campsites were established in 1982 (Magnuson, 1982). Some campsites may be significantly older than 18 years, and some may have been in use for more than 100 years (Betts, personal communication, 1996). Mosquito Creek campsite is the only campsite closed since the beginning of the study (1994) (Rouse, 1994, Devine, personal communication, 1996).

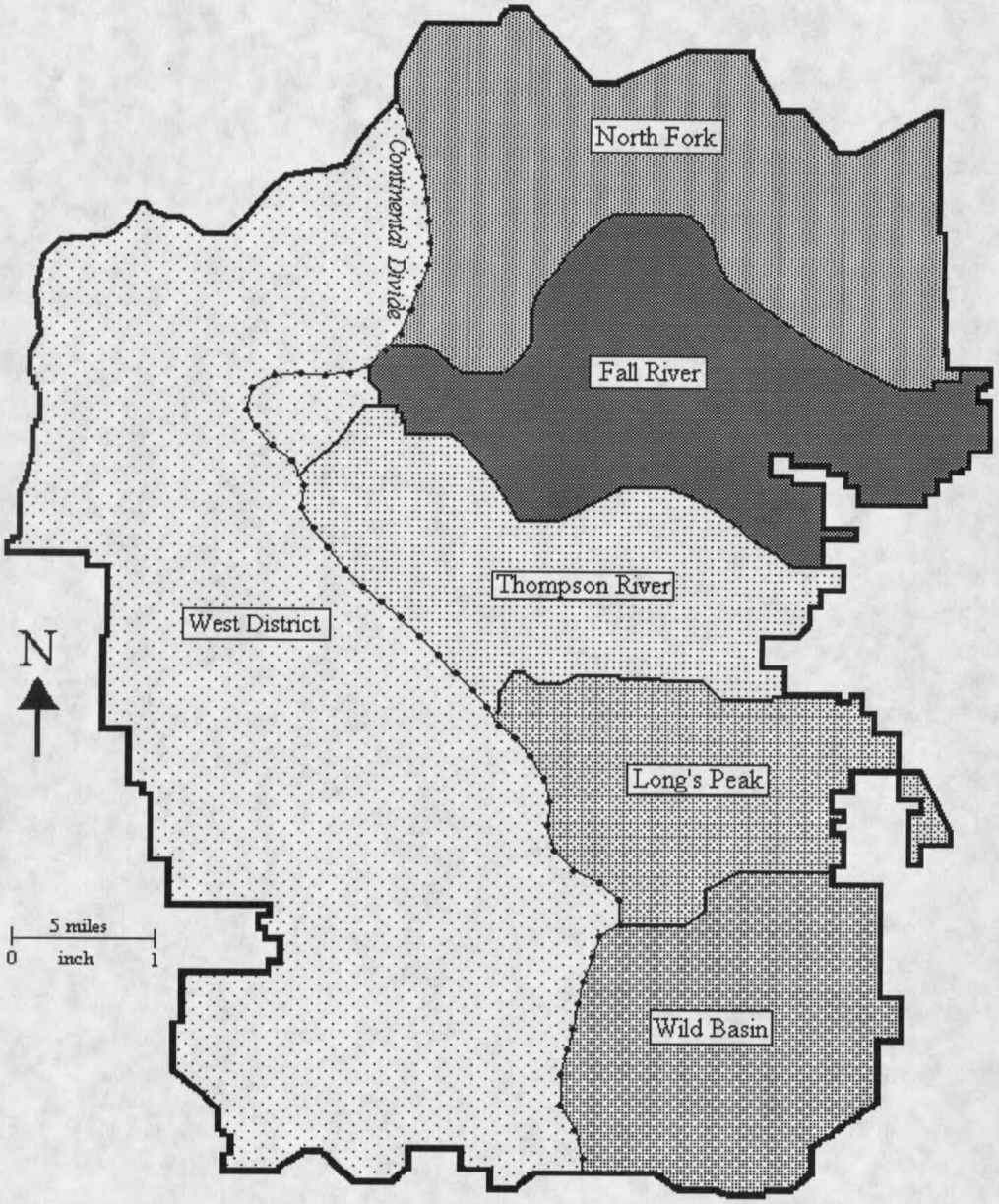


Figure 11. Rocky Mountain National Park district map.

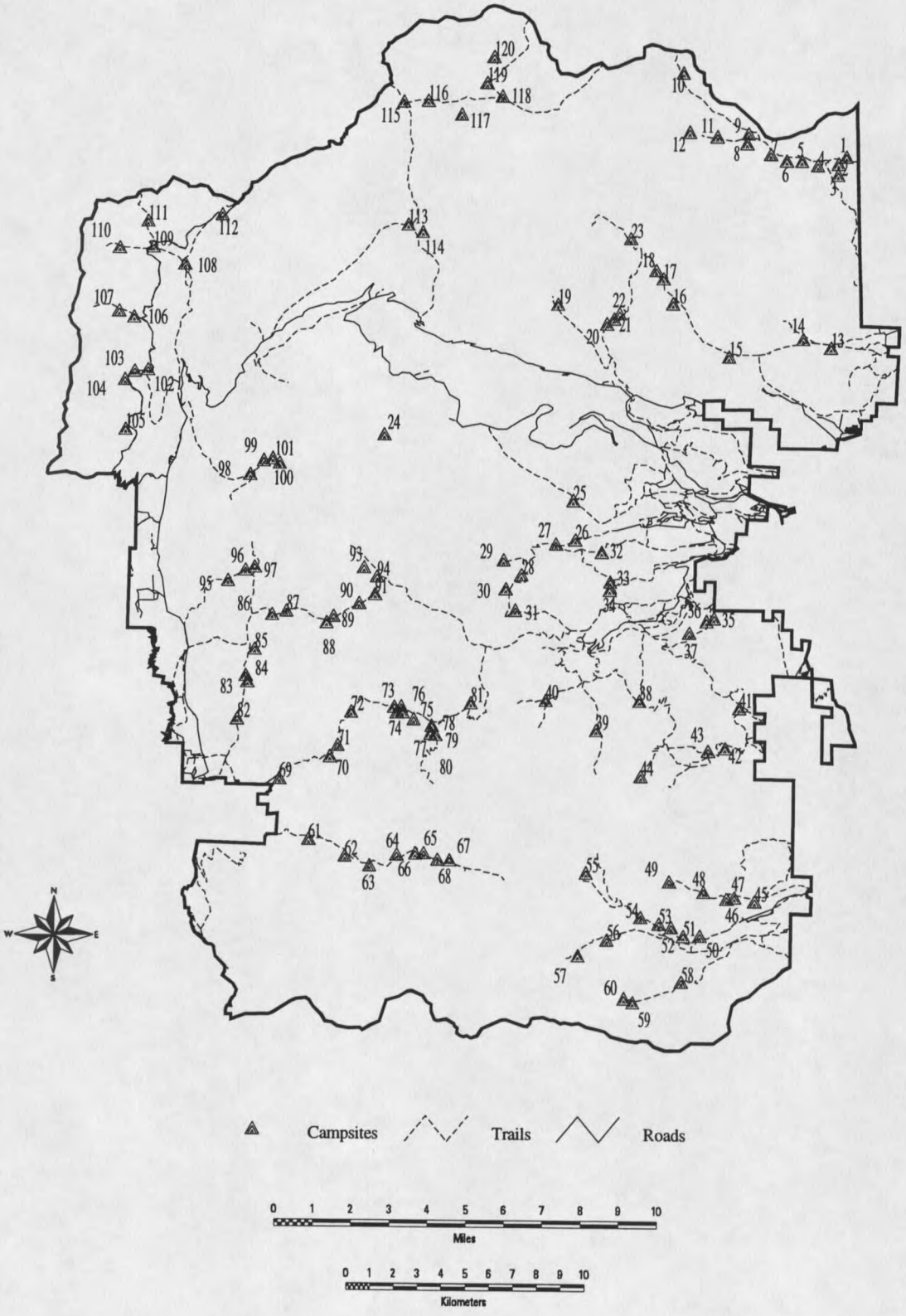


Figure 12. Rocky Mountain National Park campsite map (Steele, 1998, Thomas, 1996)

BCIAMS Methods One and Two

Two different methods were followed (Appendix D and E). The first (method one) was used from 1989 through 1994. The second (method two), a revised and consolidated version of method one, was started in 1995, and is still in use. Both methods required a ranger to visit the campsite during July or August of each year. The ranger used the scoring sheets shown in Appendices D and E to score campsites based on the rating questions. Scores ranged from 0 to 6 for method one and 0 to 4 for method two. Scores were then recorded along with estimates of the campsites area and campsite sketches and photos.

Method one was revised because rangers who completed the scores for the rating sheet in the field suggested that the scores were subject to wide variations depending on differences between individuals who scored the campsite. During the years of 1992 through 1994 a revised method was developed and then it was implemented in 1995.

There were fourteen general indicators, sub-divided into thirty-one scores of campsite degradation in method one (Appendix D). These 14 general indicators were combined into eight scores in method two (Table 3).

The two dependent variables in this study were the total core area and the total BCIAMS score. The area of a campsite was measured by pacing or visually estimating the length and width of the campsite at its widest points and then multiplying these values for the total area. The total BCIAMS score is the sum of the scores of the eight indicators in method two.

Table 3. Method one and two questions which were scored by field rangers. This example shows the results of the conversion from method one to method two.

Method one	Indicators of Method one	match	Indicators of Method 2	Method two
1. Vegetation cover	1a, 1b, 1c, 3a, 3b, 3c		1	1. Vegetation/ground cover
a. percent overstory				2. Tree/shrub damage (limbs broken, carved on, scarred, felled)
b. percent under story				
c. distribution				3. Root exposure
2. Tend pad				4. Social trails (non-designated)
a. erosion				5. Access trails/tread condition
b. excavations and trenches				6. Illegal satellite sites
3. Vegetative litter				7. Cleanliness (number of illegal fire rings/ scars, feces, etc.)
a. % cover				
b. distribution of what is				8. Barren core/camp area (sq. ft)
c. present in the campsite				
d. condition				
4. Access trails				
a. number				
b. width				
c. depth				
d. profile				
5. Side trails				
a. number	7a, 8a		2	
b. width				
c. depth	2a, 7b, 8b		3	
6. Satellite sites				
a. number	5a, 5b, 5c		4	
b. condition				
7. Shrub damage: in and adjacent to the campsite	4a, 4b, 4c, 4d		5	
a. percent damaged, reduce vigor				
b. root exposure	6a, 6b		6	
8. Tree damage: in and adjacent to the campsite				
a. broken limbs, gashes, etc.	9a, 9b, 10a, 10b, 10c, 11		7	
b. root exposure				
9. Human waste	14		8	
a. toilet paper				
b. fecal matter				
10. Fire pits				
a. number				
b. rock scaring				
c. charcoal and ash				
11. Trash				
12. Land form and shape				
13. Elevation				
14. Core area				

Six categories reflecting different environmental factors, type and amount of use were tested against the two dependent variables (area and total score over time). These six independent variables were divided into several sub-categories and include aspect, campfires, campsite type, distance from trailhead, elevation, and amount of overnight use (Table 4).

Table 4. Description of the six categories (independent variables) and their sub-categories.

Category	Sub-category name	Sub-category description	Number of campsites per sub-category
Aspect	NE	1-90 degrees	195
	SE	91-180 degrees	437
	SW	181-270 degrees	245
	NW	271-360 degrees	168
Campfire	no fires allowed	no fires (NF)	904
	fires permitted	campfire (CF)	141
Campsite type	group	G (8-12 people/night)	65
	group/stock	G/S (20 animals/night)	41
	individual	I (1-7 people/night)	910
	llama	L (1-5 llama/night)	19
	stock	S (1-5 animals/night)	9
Distance from trailhead	close	0-2 mi.	166
	middle	2.1-5.5 mi.	468
	far	5.6-11.5 mi.	379
Elevation	low	8000-9600 ft	140
	moderate	9601-11000 ft	416
	high	11001-12800 ft	464
Use	feather	0-20 people/yr.	58
	light	21-50 people/yr.	189
	heavy	51-900 people/yr.	575

Campsite use data was collected by backcountry office personnel and included: the number of times a campsite was at capacity per month, the number of nights the campsite was used per month, and the number of total campers per month for each year. Photographs were taken, sketches were made and the date and name of the ranger who collected the data were recorded.

In 1989, 1990 and 1991, all 227 individual, group, and stock sites were evaluated each year. Because evaluation of 227 campsites per year was so time consuming, the campsites were randomly divided into three groups (in each of 6 districts) to reduce the number of campsites that had to be evaluated each year. After this division, each campsite was visited once every three years (Table 5). More time between evaluations was considered too long to accurately detect change and cause of the change.

Table 5. Campsites evaluated in each year the data was collected for BCIAMS.

Year	Number of campsites evaluated	Method of Data collection	Rotation
1989	all campsites	method one	baseline data
1990	all campsites	method one	baseline data
1991	all campsites	method one	baseline data
1992	1/3 of campsites	method one	first rotation
1993	1/3 of campsites	method one	first rotation
1994	1/3 of campsites	method one	first rotation
1995	1/3 of campsites	method two	second rotation
1996	1/3 of campsites	method two	second rotation
1997*	1/3 of campsites	method two	second rotation

* completed in 1997 and not included in this analysis

Field Studies in 1996

Field studies completed in 1996 were designed to 1) interpret the variance of data collected by different individuals, 2) compare methods one and two used in the BCIAMS study from 1989-1996, and 3) compare quantitative measurements with qualitative measurements of vegetative cover (Appendix F). Two studies were designed to facilitate this: 1) a measure of error study to address questions 1 and 2 above, and 2) a study using a device to quantitatively measure amount of overstory (spherical densiometer) addressed question 3 above. Nine east-side campsites were chosen for the 1996 field study based on the following criteria: 1) the campsites were evaluated in 1995, 2) campsites were on the east-side for ease of access to 46 volunteers, 3) at least two campsites were within 2.0 miles (3.3 km) of the trailhead to accommodate volunteers who could not hike very far, 4) there was at least one campsite in each of six vegetation categories as classified by the park (meadow, lodgepole pine, mixed spruce/fir, aspen, sub-alpine fir, other), 5) at least one campsite was from each of the 5 east side districts, and 6) there was at least one campsite in each of the following elevation categories: 8,000 to 8,900 feet (2438 to 2713 m), 9,000 to 9,900 feet (2743 to 3018 m), 10,000 to 10,900 feet (3048 to 3322 m), and greater than 11,000 feet (3353 m).

Measure of Error Study

Ten campsites (Table 6) were evaluated by at least 6 people each. Each person evaluated two campsites, using both methods on each campsite. Method order was

Table 6. Campsites evaluated during the 1996 field study.

Campsite	Miles from trailhead (mi.)	Elevation (feet)	Vegetation type	District
Arch Rocks	1.6	8,240	Lodgepole pine	Thompson River
Boulderfield	6.0	12,760	Other	Long's Peak
Goblin's Forest	1.2	10,120	Spruce/Fir	Long's Peak
Golden Banner	2.6	9,600	Aspen, Spruce/Fir	North Fork
Odessa Lake	4.8	12,020	Spruce/Fir	Thompson River
Old Forest Inn	1.7	8,400	Lodgepole pine	Thompson River
Pine Ridge	1.4	8,880	Lodgepole pine	Wild Basin
Thunder Lake	6.8	10,574	Spruce/Fir	Wild Basin
Upper Ouzel Creek	6.0	10,600	Spruce/Fir	Wild Basin
Ute Meadows	2.2	10,000	Spruce/Fir	Fall River

counterbalanced between campsites using a block counterbalance design. This design allows each campsite to be visited by two different people, who use method one and method two in different orders. Each method was used the same amount of times, by the same amount of people but in different orders. The block counterbalance design reduces the chances of confounding errors which can occur if the order of measurements was always the same. Volunteers were assigned the method order according to the counterbalance design generated for those campsites.

Volunteers were given detailed instructions for completing the evaluations, along with maps of the campsites. Evaluations were completed on all campsites during the three-week period between June 1 and June 21. This schedule ensured that the campsites were snow free and that over-story and under-story conditions were not changing during the study.

Spherical Densiometer Study

To compare quantitative measurements compared with the quantitative measures used in BCIAMS two volunteers (Dan and Lisa) collected quantitative (spherical densiometer) and qualitative (visual estimate) data using method one and two scores of over-story canopy on the eight campsites. They took quantitative and qualitative measures once in the spring (June 1-June 21) and on the same campsites once in the fall (August 15-Sept 7) (Table 7).

Table 7. List of campsites for the spherical densiometer study.

	Order of evaluations		Season measurements were completed		
Campsite	method one	method two	spring	fall	Evaluator
Arch Rocks	2	1	Yes	Yes	Dan
Arch Rocks	1	2	Yes	Yes	Lisa
Goblins Forest	1	1	Yes	Yes	Dan
Goblins Forest	2	2	Yes	Yes	Lisa
Golden Banner	1	2	Yes	Yes	Dan
Golden Banner	2	1	Yes	Yes	Lisa
Odessa Lake	2	1	No	Yes	Dan
Odessa Lake	1	2	Yes	Yes	Lisa
Pine Ridge	1	2	Yes	Yes	Dan
Pine Ridge	2	1	No	No	Lisa
Thunder Lake	1	2	Yes	Yes	Dan
Thunder Lake	2	1	No	No	Lisa
Upper Ouzel	2	2	Yes	Yes	Dan
Upper Ouzel	1	1	Yes	Yes	Lisa
Ute Meadow	2	1	Yes	Yes	Dan
Ute Meadow	1	2	Yes	Yes	Lisa

Spherical densiometer measurements were taken while standing at the metal arrowhead campsite marker on the campsite. The spherical densiometer was used by counting the number of squares on a small (~2") concave mirror that reflect the overstory. Four measurements were taken by holding the mirror flat and then turning to face north, south, east, and west.

Mathematical Manipulations of the Data

Conversion of Method One to Method Two

To analyze the data from the methods one and two, converting scores from method one to method two was necessary. The conversion from method one to method two was facilitated by asking eight individuals to attempt to match questions from method one with those in method two. The overall result of this test was used to convert from method one to method two.

Scores for each campsite and each question from 1989 through 1994 using method one were converted to a score that closely approximated what would have resulted had the data been collected by method two. For example, for method two question one, the matching method one questions were 1a, 1b, 1c, 3a, 3b, and 3c. Scores for these six method one questions were then averaged to produce a single score for question one, method two. Method one questions 12 and 13 were not used because there was no match for them in method two.

Finally, the range of the scores from method one were converted to the same range as those in method two (Table 8). If the average score for 1989-1994 was from 0.0

Table 8. Ranges of scores for method one rating questions and their conversion to the range of scores used in method two. Method two questions were all scored the same (poor = 0, fair = 1, good = 2, excellent = 3).

Method one question		Method one score choices			
		poor	fair	good	excellent
1	a	0.5	1.0	1.5	2.0
	b	1.0	2.0	3.0	3.5
	c	1.0	2.0	3.0	4.5
2	a	1.5	3.0	4.5	6.0
	b	1.5	3.0	4.5	6.0
3	a	1.0	2.0	3.0	4.0
	b	1.0	2.0	3.0	4.0
	c	1.0	2.0	3.0	4.0
4	a	0.5	1.0	1.5	2.0
	b	0.5	1.0	1.5	2.0
	c	0.5	1.0	1.5	2.0
	d	0.5	1.0	1.5	2.0
5	a	1.5	3.0	4.0	5.0
	b	1.0	2.0	3.0	4.0
	c	1.0	2.0	3.0	4.0
6	a	1.0	2.0	3.0	4.5
	b	1.0	2.0	3.0	4.0
7	a	1.5	3.0	4.5	6.0
	b	1.5	3.0	4.5	6.0
8	a	1.0	2.0	3.0	4.0
	b	1.0	2.0	3.0	4.0
9	a	1.0	2.0	3.0	4.0
	b	1.0	2.0	3.0	4.0
10	a	1.0	2.0	3.0	4.0
	b	0.5	2.0	3.0	4.0
	c	0.5	2.0	3.0	4.0
11	a	1.0	2.0	3.0	4.0
Conversion to method 2		0	1	2	3

and 0.9, it was converted to a 0, if the score was from 1.0 to 1.9, it was converted to a 1, if the score was from 2.0 to 2.9, it was converted to a 2, and the score was from 3.0 to 3.9, it was converted to a 3.

Development of Backcountry Campsite User Data

Due to unforeseen difficulties, much of the backcountry campsite user data, recorded from backcountry permit information, was lost. It was therefore necessary to piece together what data were available and interpolate the missing user data from this information. Computer record keeping was initiated in the backcountry office in 1994 and user data were complete for the years of 1994, 1995, and 1996. For the years of 1989 through 1993, partial numbers were available (Table 9).

User data for 1989 through 1993 were compiled from several sources. The sources of information were: copies of the original 35,000 backcountry permits from the backcountry office, a campsite user study performed on the west side by Wintermute and Williams (1990, 1991, 1992, 1993), and data collected by myself and another ranger in 1989 and 1991. Data from the backcountry permits was obtained by a group of 4 volunteers who wrote down essential information from each permit. The total number of permits issued each year, and number of campers per year that stayed in group, individual, stock, cross-country, bivy, and winter campsites was obtained from the backcountry office. Data from cross-country, bivy, and winter campsites was necessary to interpolate missing data. The percentages of data that were available are shown in Table 9.

Table 9. Sources of backcountry campsite use data and percentage of the data that was available.

Year	Percentage of all campsites or backcountry permits	Source of backcountry use data	Number of campsites or backcountry permits counted
1989	13% campsites	Thompson River district (Hayes, 1989)	29 campsites
1990	13% campsites	Thompson River district (Steele, 1990)	29 campsites
	29% campsites	West district (Wintermute and Williams)	59 campsites
	50% permits	backcountry permits	4318 permits
1991	26% campsites	West district (Wintermute and Williams)	59 campsites
	97% permits	backcountry permits	7776 permits
1992	26% campsites	West district (Wintermute and Williams)	59 campsites
	99% permits	backcountry permits	10,175 permits
1993	26% campsites	West district (Wintermute and Williams)	59 campsites
	97% permits	backcountry permits	9974 permits
1994	100%	backcountry office computer permit system	227 campsites
1995	100%	backcountry office computer permit system	227 campsites
1996	100%	backcountry office computer permit system	227 campsites

Developing the remaining user data was then completed. First, the user data yearly total was calculated for all of the data that was actually available for each year. This 'observed' number was compared with the yearly total compiled by the backcountry office (BCO). The difference in these two numbers represented that amount of data that would have to be interpolated, and a percentage of data accounted for was obtained (Table 10).

Next, the percentage of data that represented cross-country, bivy, and winter camping was subtracted from the original total to yield a corrected total because they were not used in this analyses. Finally, a corrected percentage was obtained by dividing the data I had compiled by the corrected backcountry office total. This percentage was then used as a weighting factor used to normalize the user data to 100%. In 1989, the weighting factor was 22%. All user data for 1989, for each campsite was divided by 0.22. In 1994, 1995, and 1996, the weighting factors were greater than 100% because the backcountry office computer program to obtain yearly camper totals were run after December 31. Weighting factors were used for all data for all years.

It was hypothesized that although total yearly user numbers increased, the overall percentage of people camping at each site had not varied over time. For example, if 3% of visitors camp at a particular site in one year, a similar percentage of people would camp at the same site in all the years. From personal observation I have observed that people prefer the same campsites every year. For example, campers may choose a campsite based on its proximity to a certain vista, creek or trailhead. A test of this hypothesis revealed that only 2 out of 227 backcountry campsites had a significant (α =

Table 10. Data used in the normalization of backcountry user data. Rows A, B, E, and F are numbers of backcountry campers. Rows C, D, and G are percentages.

Operation	1989	1990	1991	1992	1993	1994	1995	1996
A. observed use	7213	18453	17066	24254	24617	51285	41303	41152
B. expected use	32920	31367	37557	42134	44083	52061	38668	42625
C. A / B	21.91	58.83	45.44	57.56	55.84	98.51	106.81	96.54
D. percent other	21.19	15.76	13.90	14.80	12.20	10.30	10.70	10.86
E. B * D	6975	4943	5220	6235	5378	5362	4119	4469
F. B - E	25945	26424	32337	35899	38705	46699	34549	38156
G. A / F	21.91	69.83	52.76	67.56	63.60	109.80	109.54	107.85

A. **Observed** use data: this backcountry use data was available on a campsite per month per year basis from backcountry permits and other sources

B. **Expected** user data: total backcountry use data recorded per year by the backcountry office. Yearly totals were also available, but use per site per month data was lost.

C. **Percent data available**: this is the percentage of data that was available for analysis. observed / expected

D. **Percent other**: percent of data recorded from cross-country bivy, and winter campsites based on total yearly user numbers from the backcountry office

E. **Number other**: the number of users who camped in cross-country, bivy, and winter campsites. expected * percent other

F. **Adjusted expected**: the total expected use numbers without data from cross-country, bivy, and winter campsite data. expected - number other

G. **Final use data**: This is the final percentage used as a weighting factor for normalizing backcountry user data. observed / adjusted expected

0.05) change in the percentage of use over time (Big Horn Mountain group/stock site with a $r^2 = 0.038$, $p = 0.002$, and Hitchins Gulch with a $r^2 = 0.999$, and $p = 0.028$). Thus, applying the weighting normalization across all campsites and all years was reasonable. The statistical program SAS (version 6.12) (SAS Institute, 1997) was the main tool for analyzing this data set. Minitab (release 11.12) was used to run t-tests and descriptive statistics (Minitab, Inc., 1996).

Weighting of Data for Time Analysis

Because of the high variances in the area and total score, several data manipulations were necessary before running the statistical tests. A campsite area or total score of 0 was sometimes recorded by the park in the database in lieu of data. There were no actual campsites with an area of 0 or a total score of 0, all 0's were deleted from the analysis.

The first calculation was performed after any campsite with an area or total score of 0 was removed from the database. Then, the minimum, maximum, and mean of area and total score were calculated. Next, the first standard deviation for each sub-category area and total score was added to and subtracted from each of the means for each sub-category area and total score. This produced a new set of area values and total scores within one standard deviation of the mean (Tables 11 and 12). Area values and total

Table 11. New range of scores for analysis for area (std. = standard deviation). The minimum and maximum are the lowest and highest values for the sub-category through time. The mean and std. are averaged over time for the sub-category.

Category	Sub-Category	n	min	max	mean	std	mean minus std	mean plus std
Aspect	NE	21	50	8000	1045	1033	12	2077
	SE	51	30	9680	1206	1210	-4	2417
	SW	29	80	7000	1215	934	281	2149
	NW	20	120	8400	1493	1443	50	2937
Campfire	NF	105	30	8750	1189	966	223	2155
	CF	16	242	9680	1522	1339	183	2861
Campsite type	group	7	242	8400	2967	2043	924	5010
	group/stock	5	400	9680	3229	1778	1451	5007
	individual	106	30	8300	1063	932	131	1996
	llama	3	200	2700	1051	582	470	1633
	stock	2	792	1800	1308	315	992	1623
Distance	close	19	50	8400	1035	1039	-4	2073
	middle	56	30	8300	1279	1209	70	2487
	far	43	50	9680	1333	1285	47	2618
Elevation	low	42	50	8400	1054	872	182	1926
	moderate	74	30	9680	1329	1395	-65	2724
	high	5	200	3201	1084	582	502	1666
Use	feather	37	100	9680	1084	907	177	1991
	light	29	120	7501	1062	983	79	2045
	heavy	66	30	8750	1273	1395	-122	2668

Table 12. New range of scores for analysis for total score (std = standard deviation). The minimum and maximum are the lowest and highest values for the sub-category through time. The mean and std are averaged over time for the sub-category.

Category	Sub-Category	n	min	max	mean	std	mean minus std	mean plus std
Aspect	NE	21	1	18	8	3	5	11
	SE	52	1	20	8	3	5	11
	SW	30	2	16	8	3	5	11
	N to W	20	3	20	8	3	5	10
Campfire	NF	106	1	20	8	3	5	11
	CF	17	1	16	9	3	6	11
Campsite type	group	7	1	20	9	3	6	12
	group/stock	5	2	17	11	4	7	14
	individual	108	1	20	8	3	5	11
	llama	3	3	14	7	3	4	10
	stock	2	5	13	8	1	7	9
Distance	close	18	1	18	8	3	5	11
	middle	56	1	20	8	3	5	11
	far	46	1	18	8	3	5	11
Elevation	low	43	1	20	7	2	5	10
	moderate	75	1	20	8	3	5	11
	high	6	2	16	7	2	5	10
Use	feather	39	1	14	7	2	5	9
	light	31	1	16	7	3	5	10
	heavy	66	1	20	9	3	6	12

scores greater than and less than one standard deviation from the mean were then weighted as 0.1 in the general linear model. All other area and total score values were weighted as 1.0.

Next, each campsite's area and total score was scaled by dividing the area or total score for each year by the same area or total score for 1989. This produced a relative measure of change over time rather than an absolute change over time. When the data was analyzed, any campsites with a value greater than the new maximum, or less than the new minimum was weighted in the analysis as 0.1. Finally, all area and total score values greater than 0 were included in the analysis, but the outliers (those falling outside one standard deviation of the mean) only had a 1% influence on the results.

CHAPTER 3

RESULTS AND DISCUSSION

Field Studies in 1996

Measure of Error Study

Results

Campsite area measurements from the field study for 1996 were compared to area measurement from BCIAMS method one (1989, 1990, 1991, and 1992) and BCIAMS method two (1996). The years 1993, 1994 and 1995 were not included in this sample due because the campsites in the field study were not rated in those years. Using a general linear model with repeated measures, no significant difference was detected between area scores. Bonferroni's (Keppel, 1982) test yielded no differences between any sites at the $\alpha = 0.05$ level.

Discussion

No difference was found between area scores from method one and area scores from method two. Therefore it was possible to combine all area scores in the final analysis without the necessity of developing a conversion factor for area scores between methods.

Spherical Densiometer Study

Results

The data from both of the data collectors was tested separately as well as together to determine if individual bias was affected the results. A significant difference using $\alpha = 0.05$ was found between the each of the two data collectors' quantitative measurements versus the qualitative measurements. For one data collection, the associated test's F value was 24.57, df = 7, p = 0.0049, and for the other data collector, the tests F value was 23.09, df = 14, p = 0.0003.

Bonferroni's (Keppel, 1982) test was used to test if a significant difference exists between the data collector's quantitative and qualitative measurements. A significant difference (F = 24.57, df = 38, p = 0.0001) was found between measurements for both data collectors. The difference between data collected in the spring and data collected in the fall was also tested with Bonferroni's test and no effect of season was found.

Discussion

Quantitative measurements reduce the potential for observer bias and variability between observers and are preferred to estimates (Cole, 1983). However, within the current methodology of BCIAMS, switching methods to use a spherical densiometer to measure vegetative overstory was not possible because this quantitative measure was not comparable to qualitative measurements.

BCIAMS Data

Descriptive Statistics

Results

A general linear model was used to fit a line for each of the sub-category data sets versus time. The general linear model in SAS used the method of least squares. The assumptions of the general linear model are the same as for a linear regression. The general linear model in SAS allows for missing data and unequal columns of data. The assumption of linear regression are: 1) any relationship between x and y is linear and the means of y lie on a straight line ($\mu_y = \beta_0 + \beta_1 X_1$), 2) for each value of x, y has a normal distribution centered at $\mu_y = \beta_0 + \beta_1 X_1$, 3) the variance is the same for each x and the variance does not depend on x, and 4) the sum of the residual errors is 0.

Discussion

Regression analysis is relatively robust to violations of normality or the errors. Most modest violations of normality do not effect the analysis. Scatter plots of the residuals reveal that the assumptions of linear regression were not violated (Figures 13 and 14).

Changes Over Time Within Each Sub-category

Results

A general linear model was used to test for changes in area over time for each

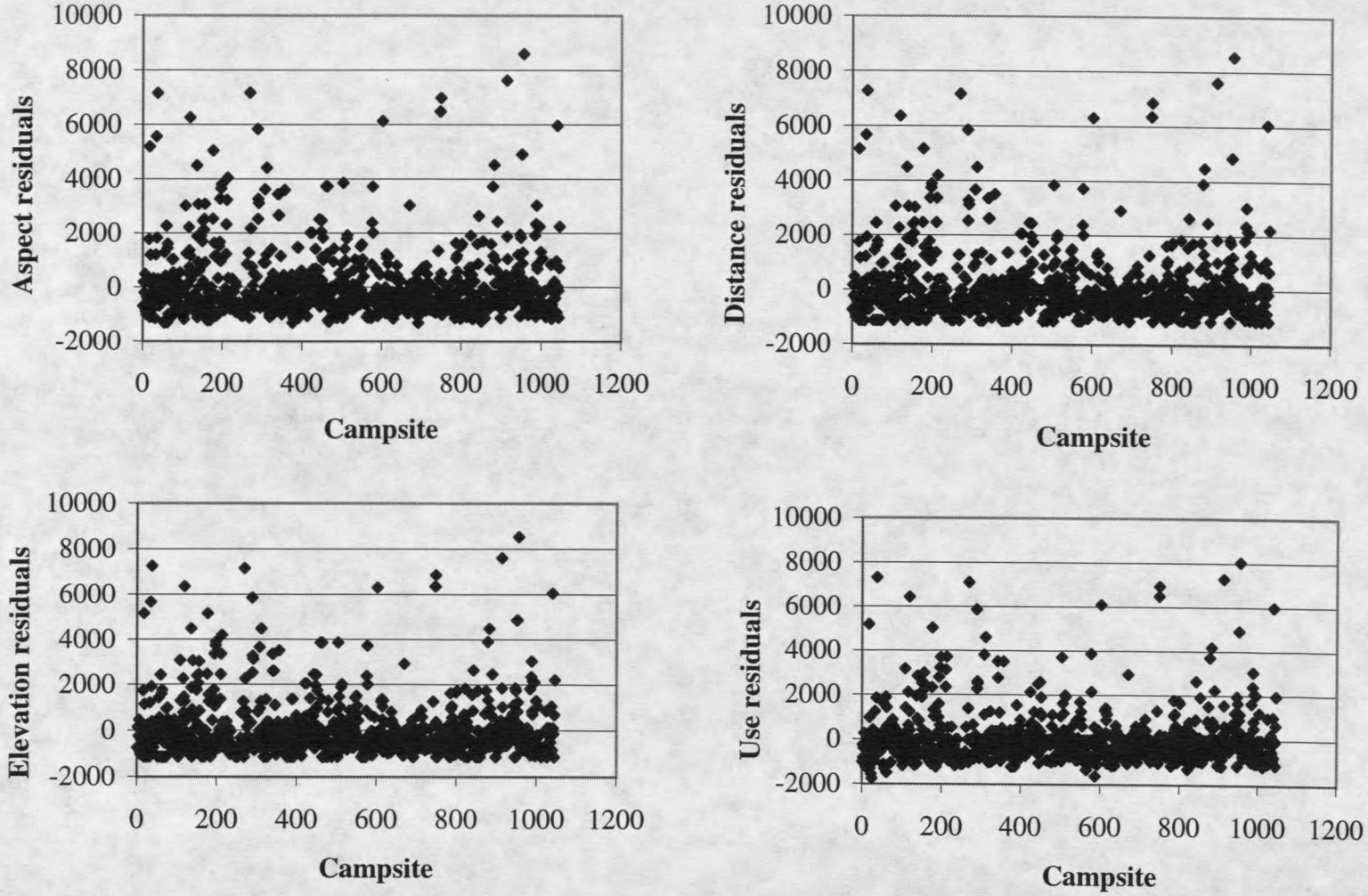


Figure 13. Scatter plots residuals of aspect, distance, elevation, and use for area.

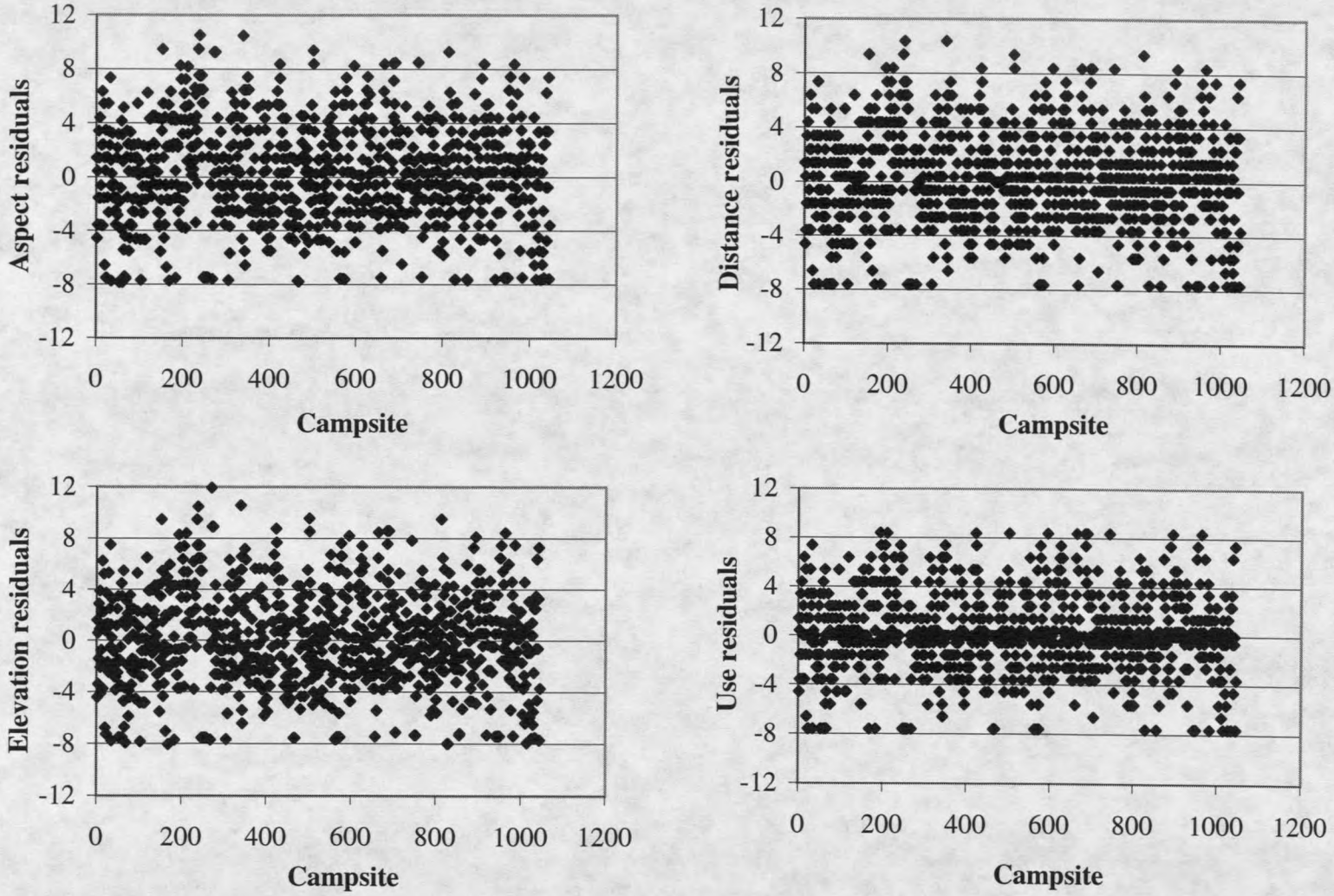


Figure 14. Scatter plots residuals of aspect, distance, elevation, and use for total score.

Sub-category. Significant increases in area over time were found in campsites within the aspect categories of (NE, SE, and NW), in campfire and no fire sites, individual campsites, campsites at all distances from the trailhead, at low and moderate elevations and in heavily used sites (Table 13). Graphs of the mean area for each sub-category for each year are plotted with the trend line in Figures 15, 16, 17, 18, 19 and 20.

To find the trend for total score over time, campsite area were scaled. The area or total score for each campsite was divided by its area or total score in 1989 to produce an value of one for 1989. This resulted in a relative change in area and total score over time. Graphs of the trend over time for area for each category are shown in Figure 21. From these graphs, it can be seen how area for each sub-category changes over time relative to the first year (1989). For example, stock sites increased in area from 1 to 1.3 over time, this reflecting a 30% change in area.

A general linear model was used to test for changes in total score over time for each sub-category. Significant increases in total score through time were found in campsites with a SW aspect and in non-campfire sites (Table 14). Stock sites showed a significant decrease in total score over time ($t = -4.07$, $p = 0.0066$). Graphs of the mean total score for each sub-category for each year are plotted with the trend line in Figures 22, 23, 24, 25, 26 and 27.

To find the trend for total score over time, total scores were scaled. The total score for each campsite was divided by the year 1989. This resulted in a relative total score starting from one. Graphs of the trend for total score over time are shown in Figure 28. From these graphs, it can be seen how total score for each sub-category

Table 13. Changes in campsite area (1989 through 1996) for each sub-category.
* Significant ($\alpha = 0.05$). Model: area = $\beta_0 + \beta 1$(year) and total score = $\beta_0 + \beta 1$(year)

AREA

Category Sub-category	Intercept	parameter estimate - year	t-value	p-value
Aspect				
NE	-349.41	0.1762	2.42	0.0167*
SE	-119.85	0.0609	3.20	0.0015*
SW	-153.26	0.0770	1.38	0.1693
NW	-228.26	0.1160	2.15	0.0330*
Campfire				
no fires allowed	-189.57	0.0959	3.92	0.0001*
fires permitted	-215.60	0.1089	4.26	0.0001*
Campsite type				
group	-10.74	0.0060	0.11	0.9149
group/stock	-270.73	0.1364	1.73	0.0958
individual	-197.65	0.0999	4.32	0.0001*
llama	-194.16	0.0977	1.68	0.1170
stock	-86.42	0.0440	1.16	0.2887
Distance				
close	-308.76	0.1572	3.40	0.0009*
middle	-143.98	0.0730	2.36	0.0189*
far	-240.73	0.1213	3.08	0.0023*
Elevation				
low	-239.41	0.1222	2.70	0.0073*
moderate	-182.81	0.0925	3.63	0.0003*
high	-72.61	0.0370	0.86	0.3952
Use				
feather	-255.34	0.1287	0.93	0.3650
light	-79.91	-0.0397	-0.54	0.5927
heavy	-294.74	0.1488	3.38	0.0008*

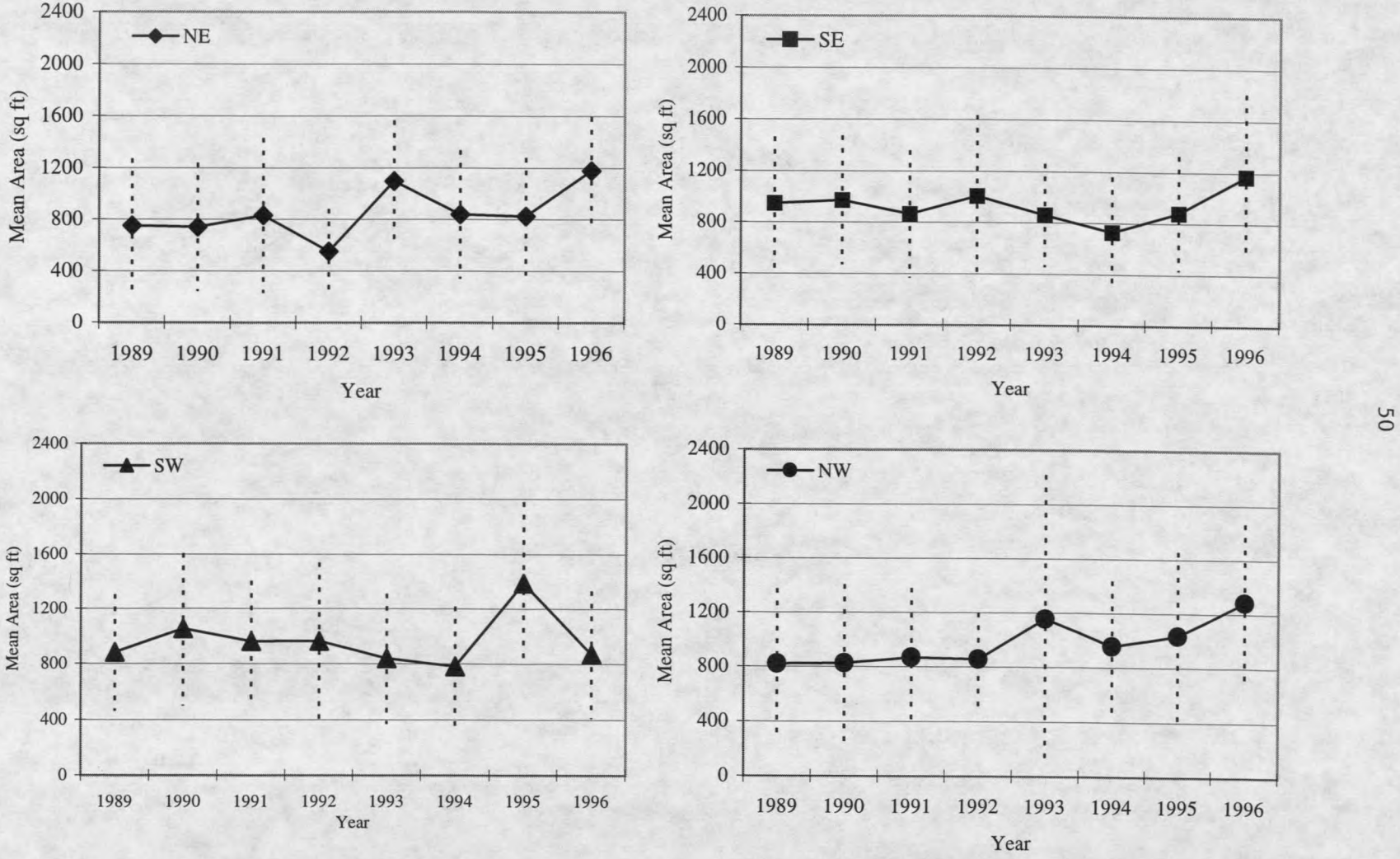


Figure 15. Mean campsite area from 1989-1996 for aspect.

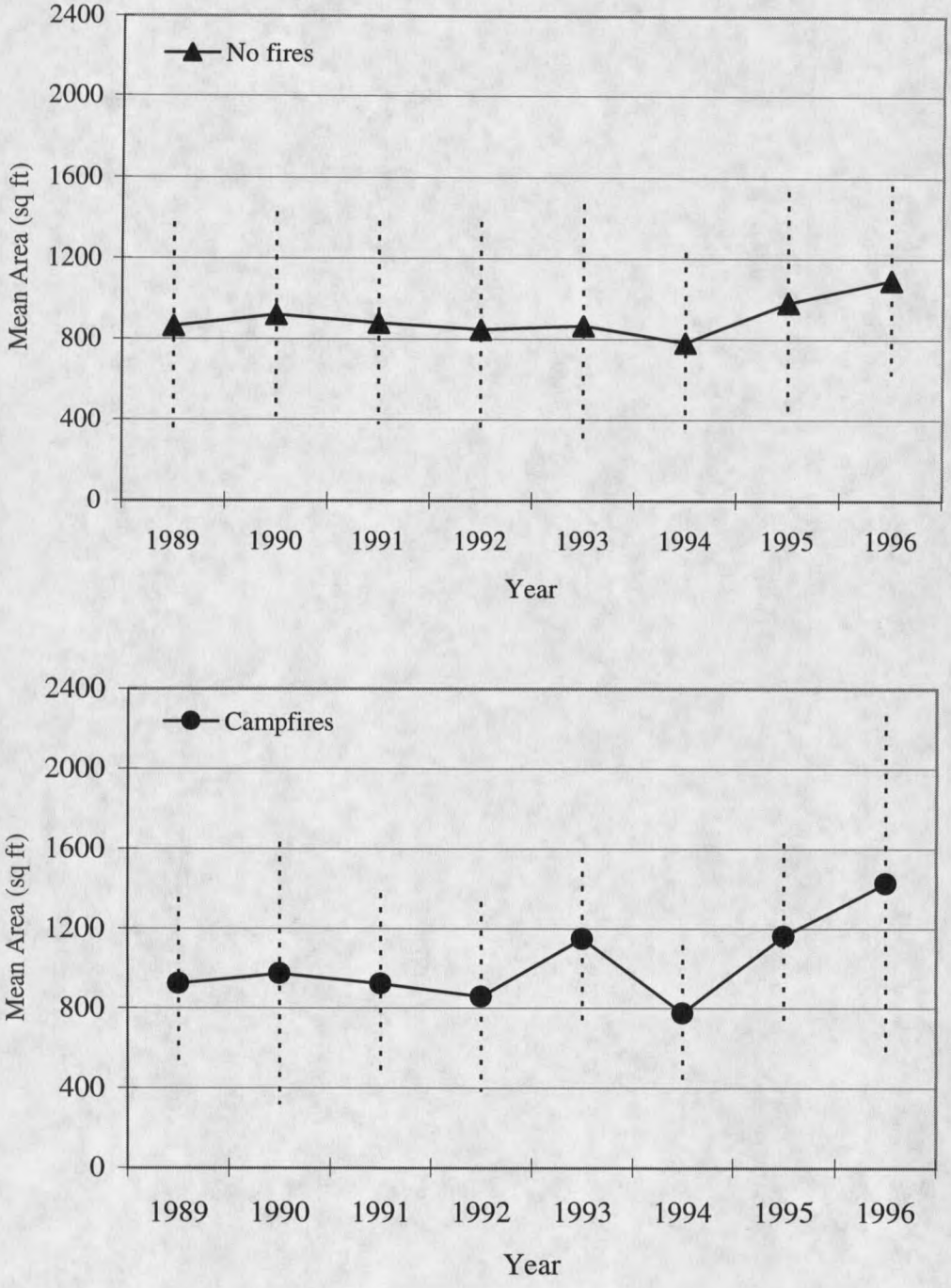
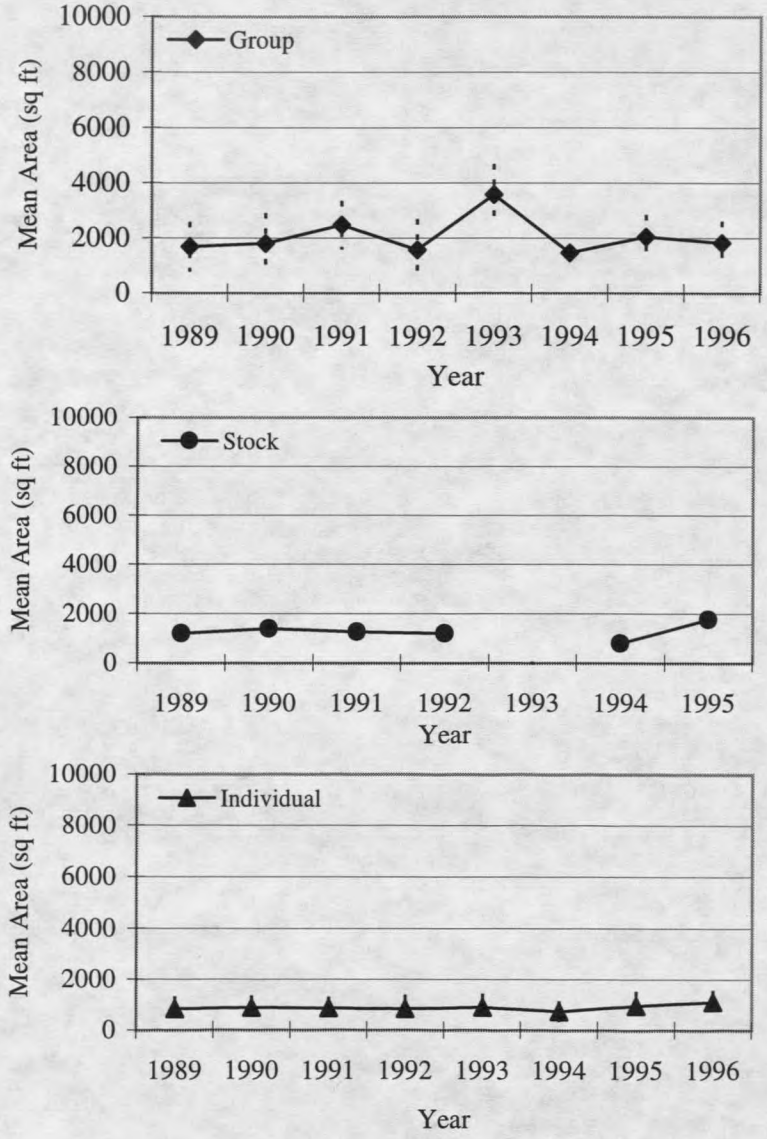


Figure 16. Mean campsite area from 1989-1996 for campfires.



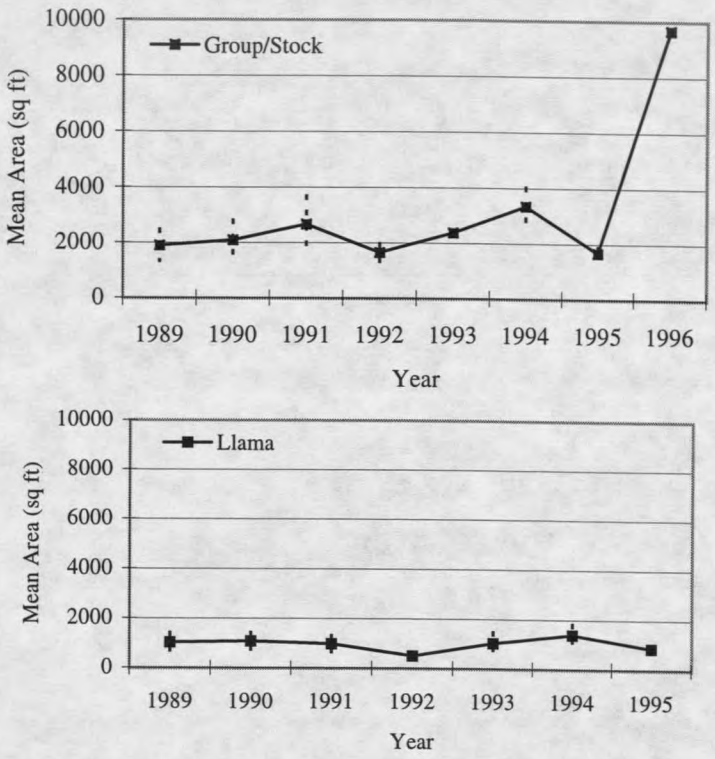
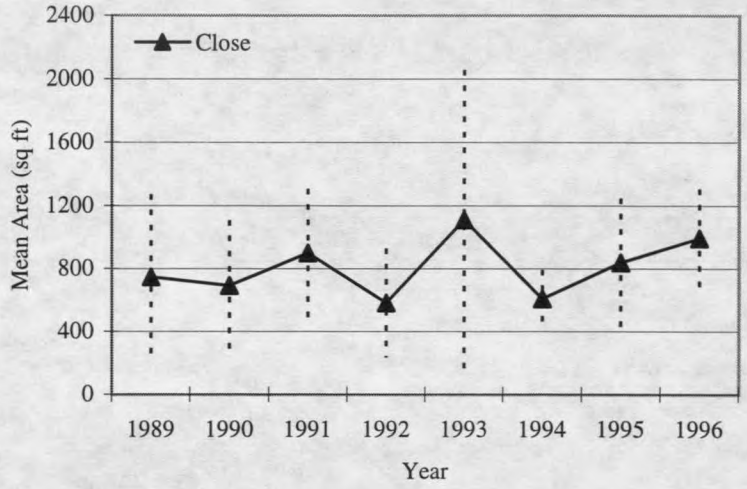
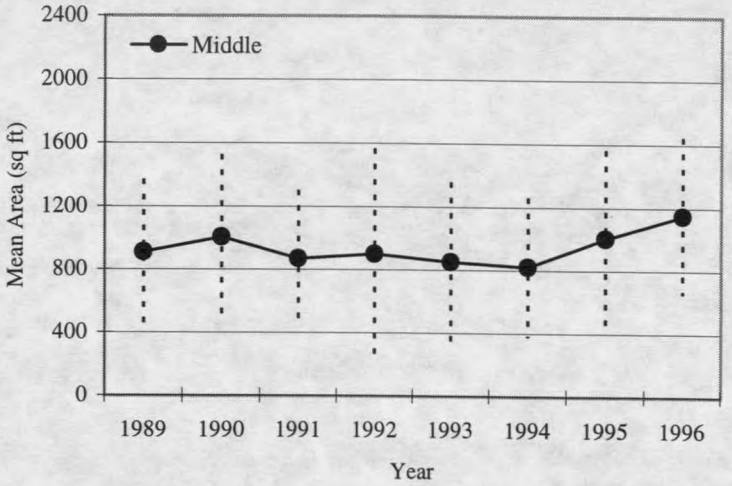


Figure 17. Mean campsite area from 1989-1996 for campsite type





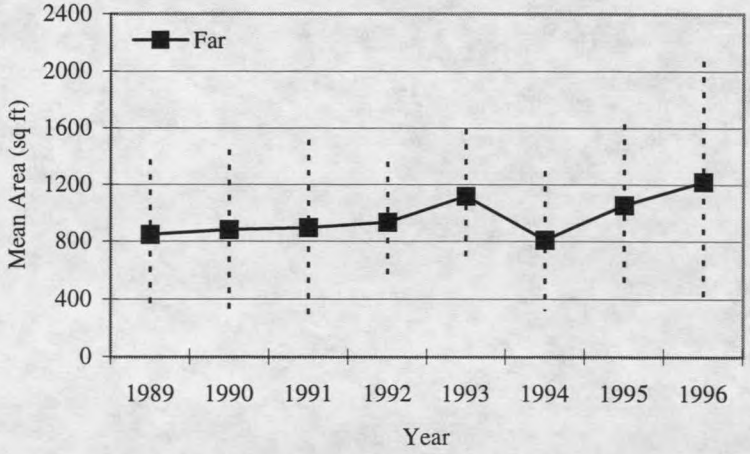
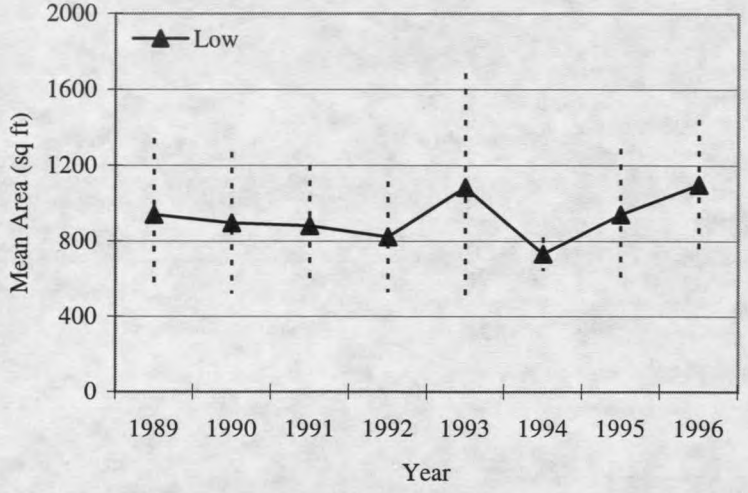
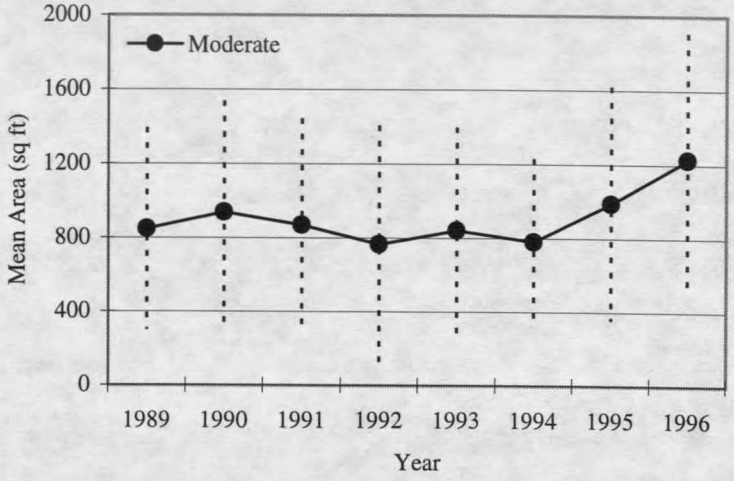


Figure 18. Mean campsite area from 1989-1996 for distance.





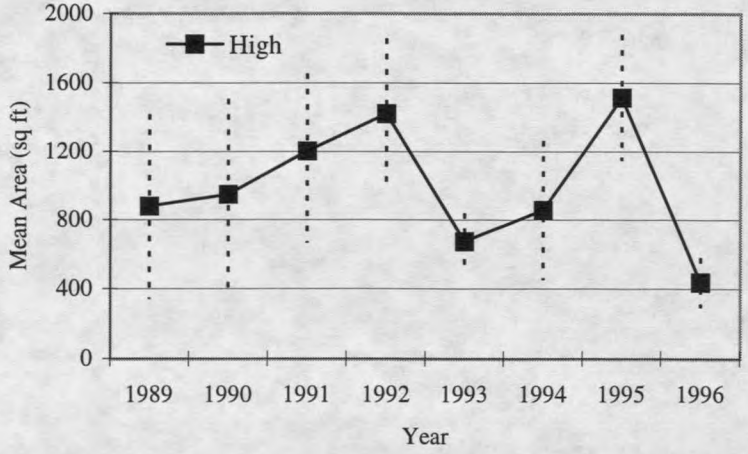
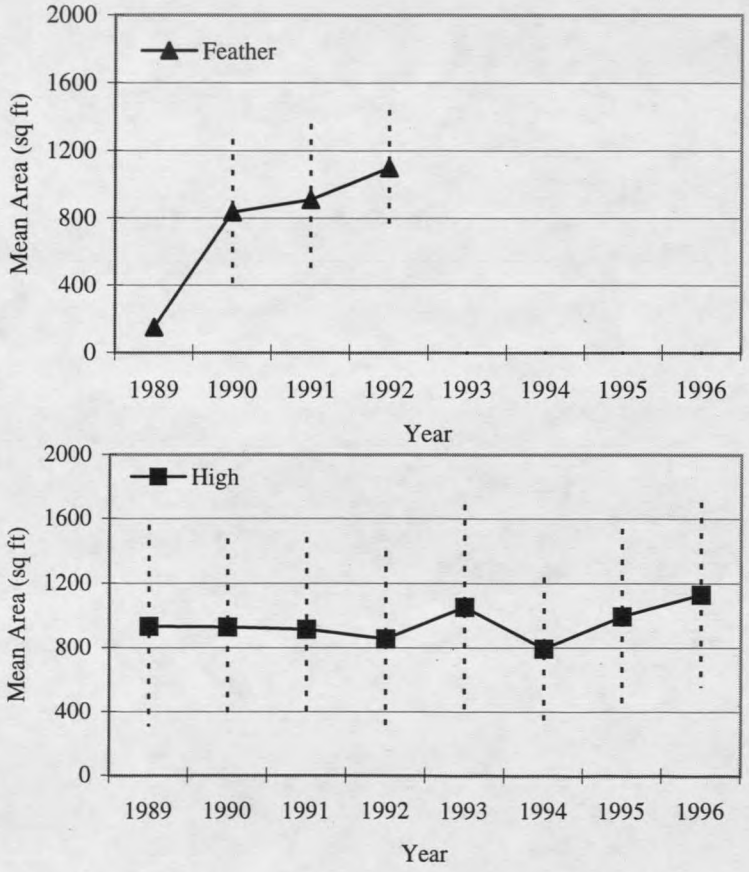


Figure 19. Mean campsite area from 1989-1996 for elevation.



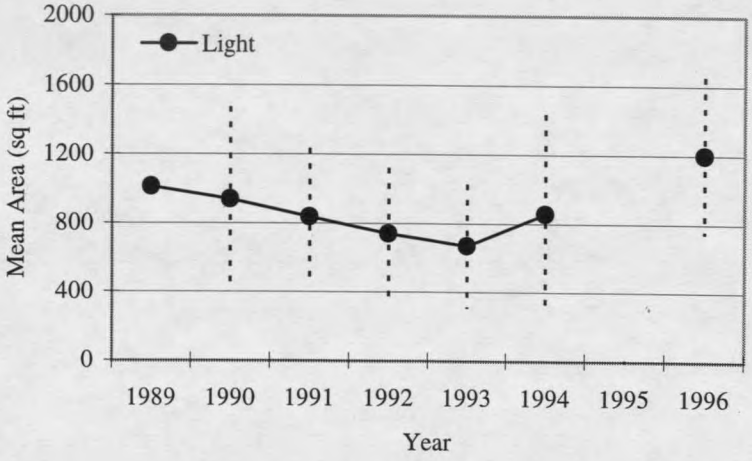


Figure 20. Mean campsite area from 1989-1996 for use.

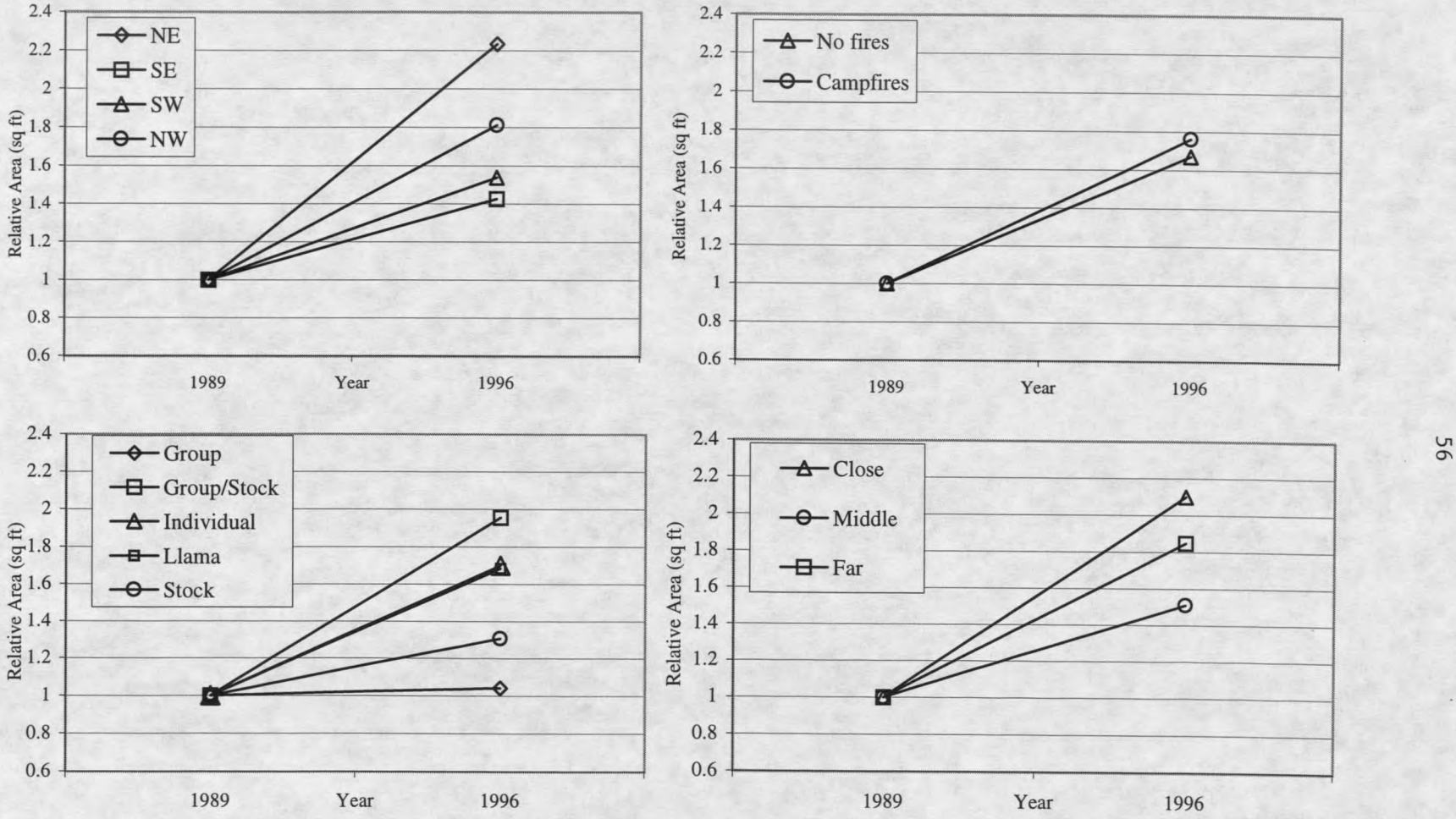


Figure 21. Trends in the change in campsite area over time for all categories

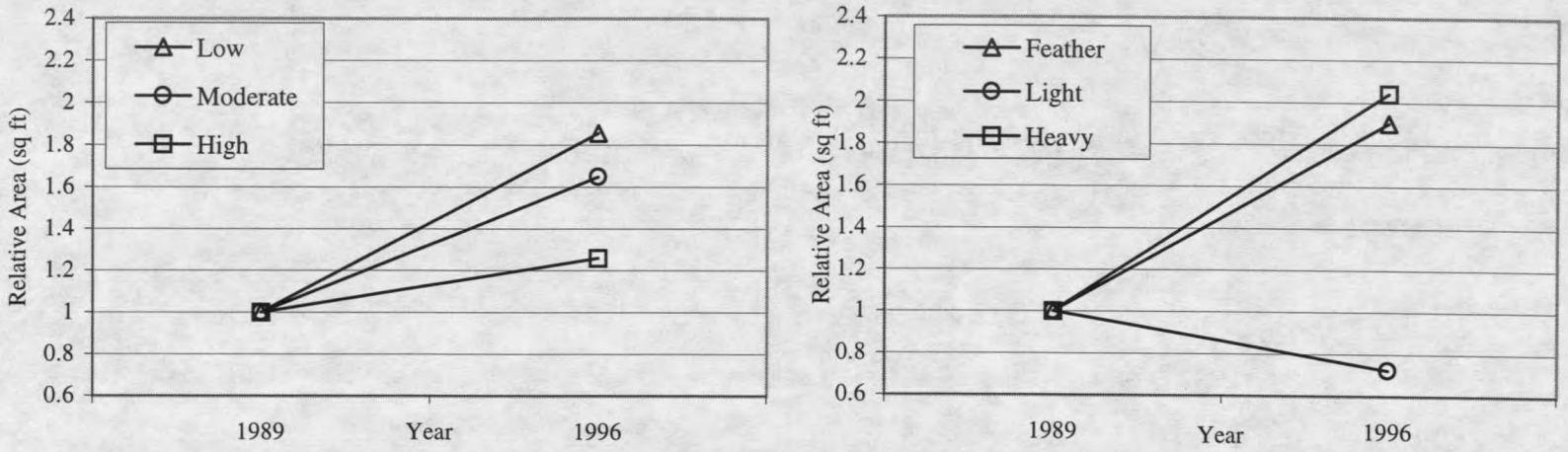


Figure 21 continued. Trends in the change in campsite area over time for all categories

Table 14. Changes in campsite total score (1989 through 1996) for each sub-category. * Significant ($\alpha = 0.05$). Model: area = $\beta_0 + \beta 1$(year) and total score = $\beta_0 + \beta 1$(year)

TOTAL SCORE

Category Sub-category	Intercept	parameter estimate - date	t-value	p-value
Aspect				
NE	-48.45	0.0265	1.13	0.2591
SE	1.27	-0.0002	-0.03	0.9795
SW	-113.52	0.0575	2.01	0.0463*
NW	-7.08	0.0041	0.45	0.6510
Campfire				
no fires allowed	12.55	0.0180	2.03	0.0426*
fires permitted	-0.0006	-0.0060	-0.63	0.5295
Campsite type				
group	-1.35	0.0011	0.08	0.9399
group/stock	-31.73	0.0163	0.89	0.3798
individual	-32.49	0.0168	1.91	0.0563
llama	1.74	-0.0004	-0.01	0.9897
stock	174.63	-0.0873	-4.07	0.0066*
Distance				
close	-103.61	0.0525	1.24	0.2184
middle	-24.54	0.0128	1.45	0.1485
far	-12.58	0.0066	0.85	0.3936
Elevation				
low	-62.68	0.0319	1.74	0.0831
moderate	-14.37	0.0077	1.00	0.3196
high	9.96	-0.0043	-0.27	0.7905
Use				
feather	239.07	-0.1194	-1.25	0.2233
light	-43.50	0.0224	0.57	0.5684
heavy	16.90	-0.0081	-1.04	0.2987

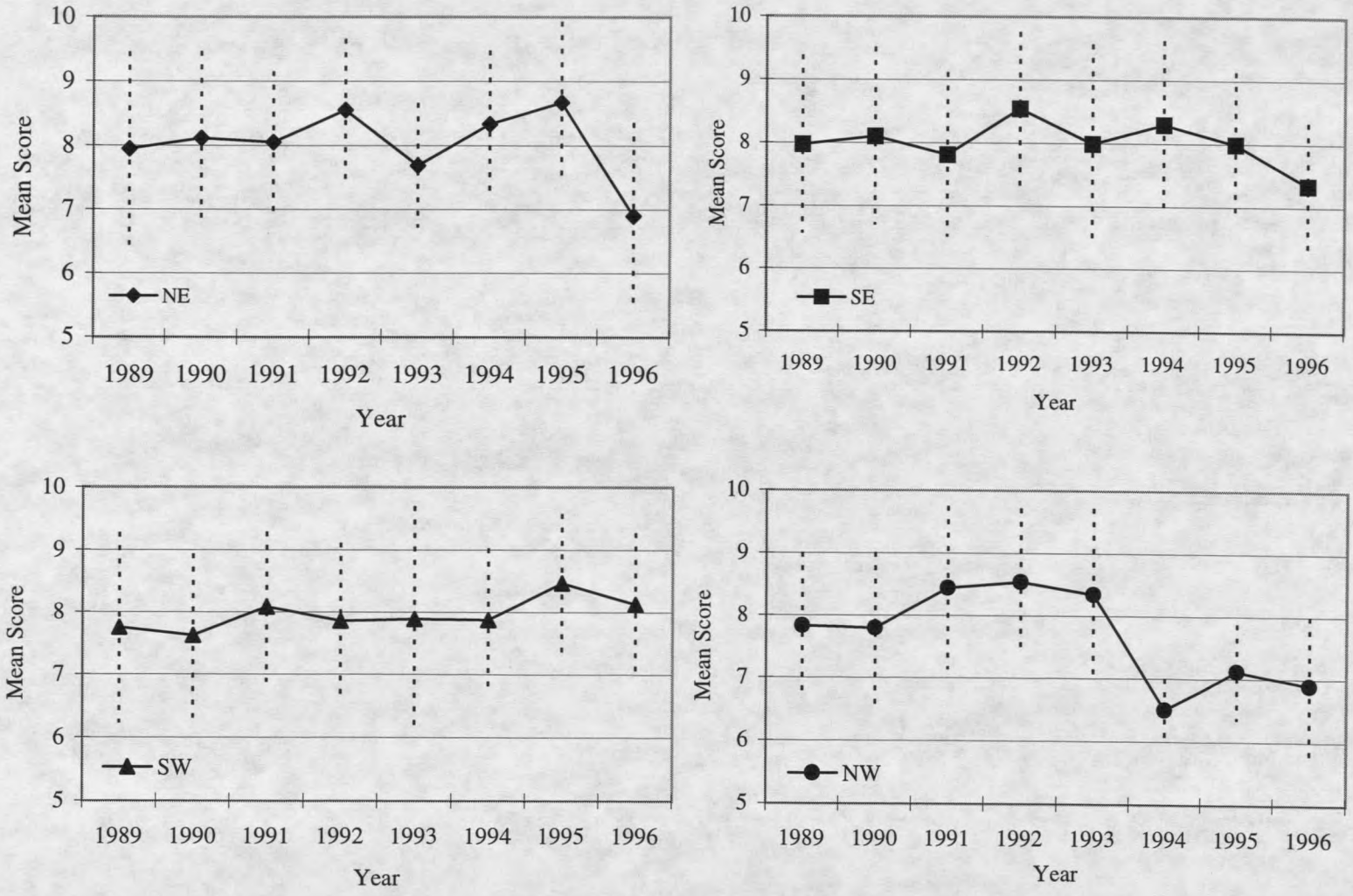
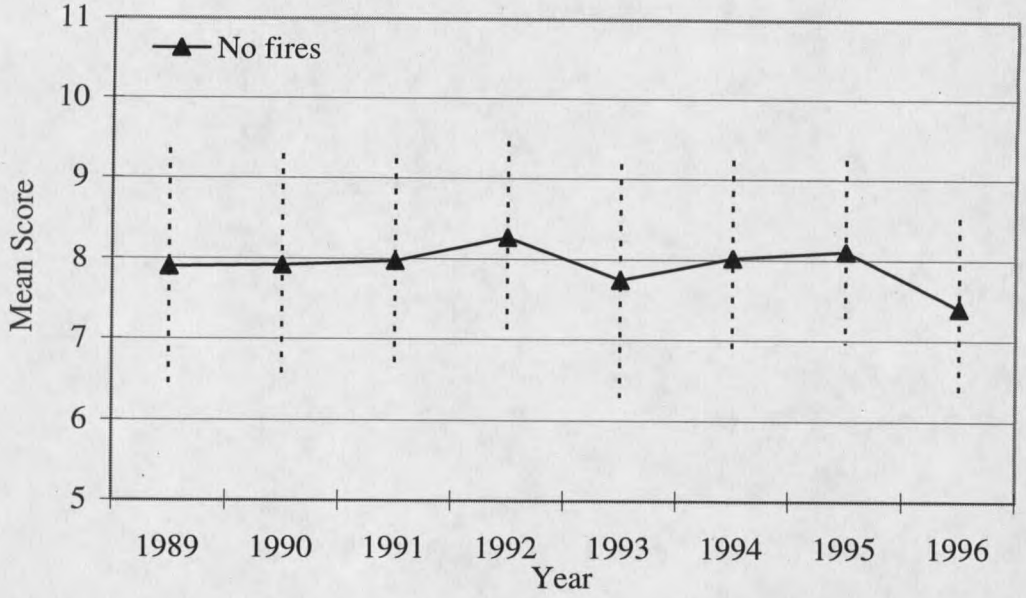


Figure 22. Mean total score from 1989-1996 for aspect.



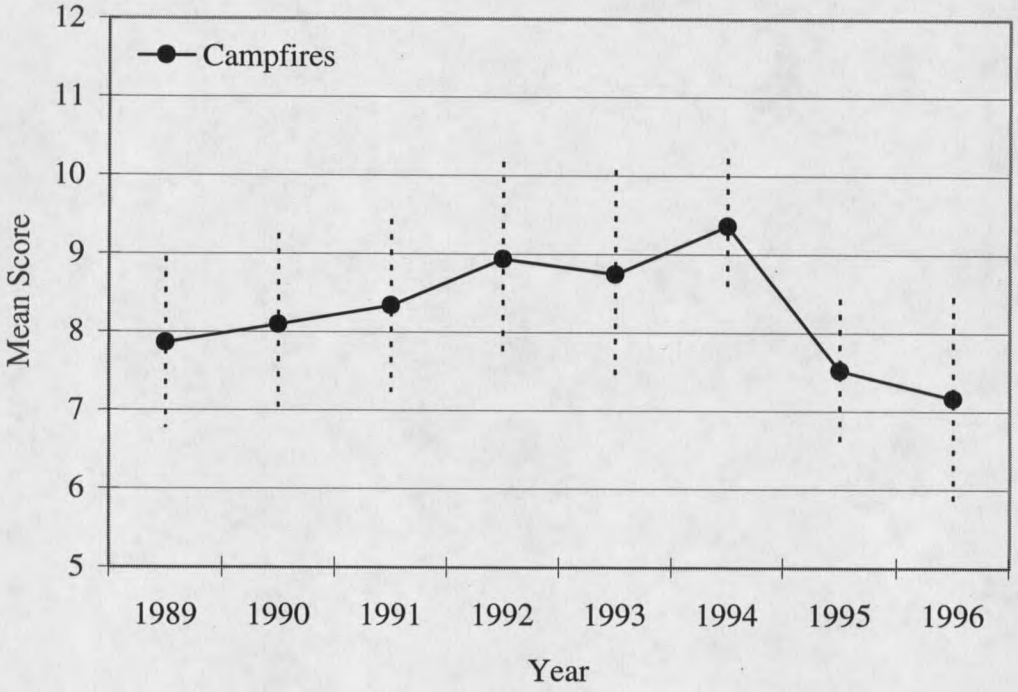
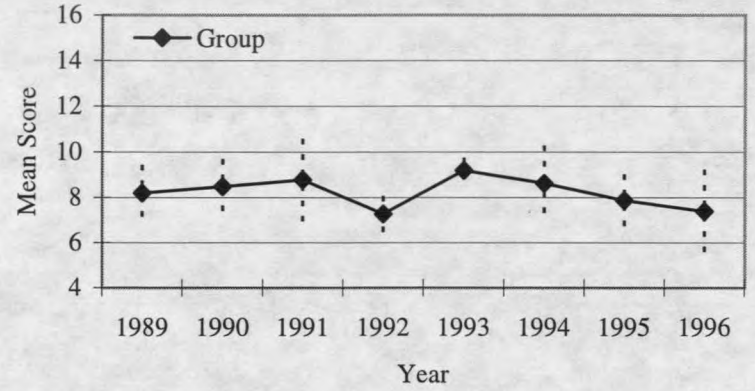
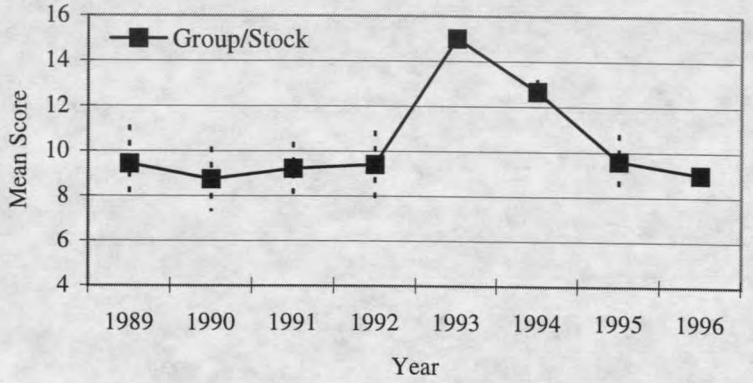
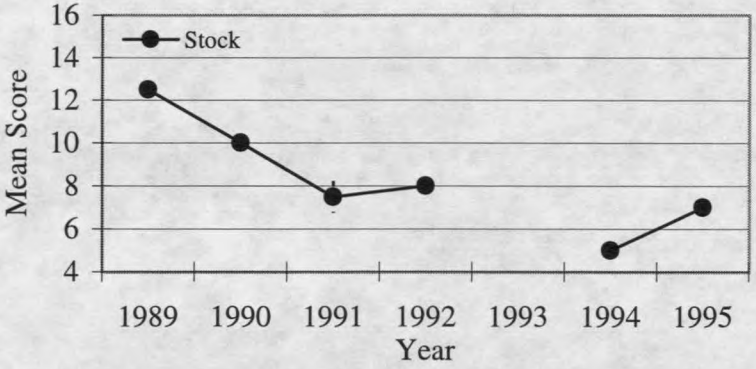
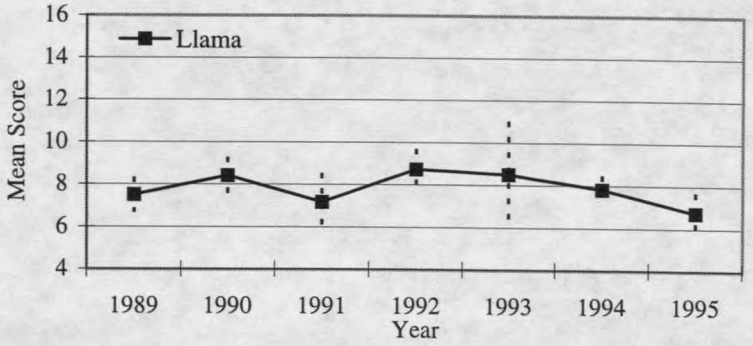


Figure 23. Mean total score from 1989-1996 for campfires.









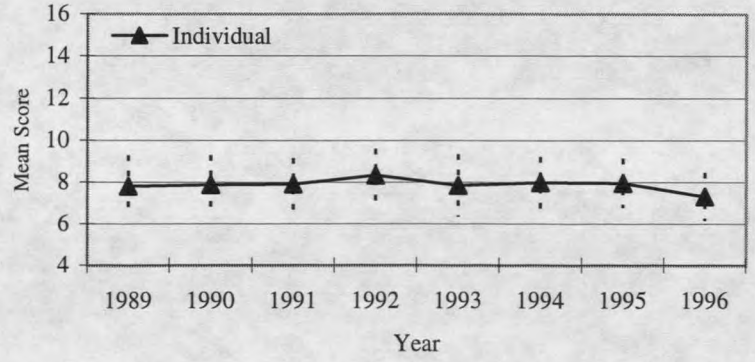
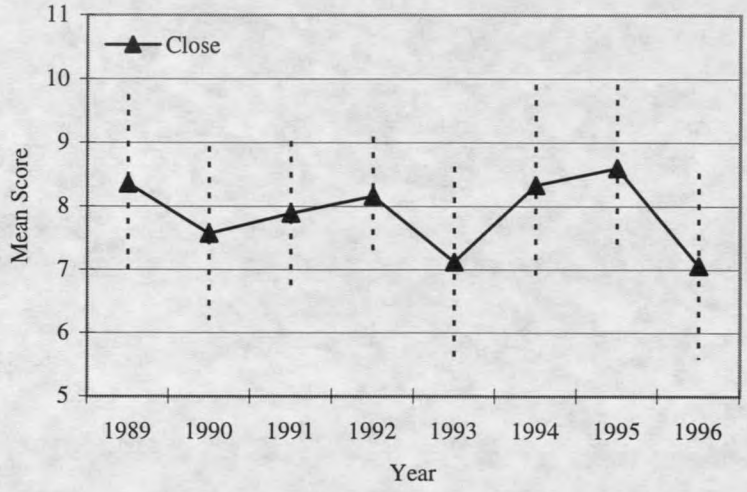
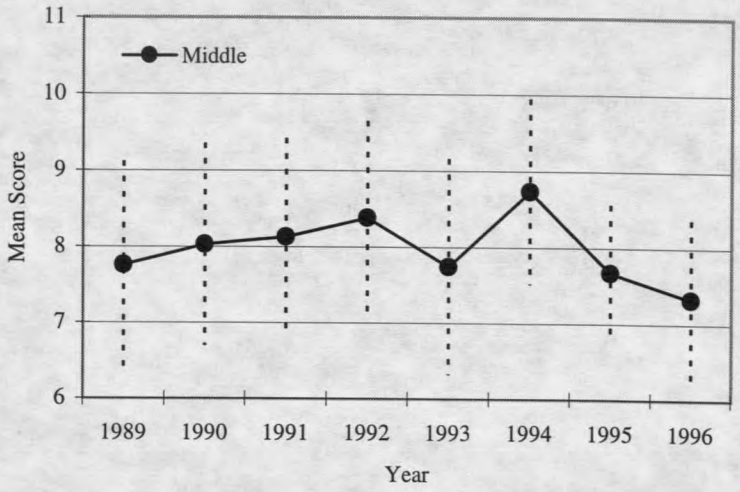


Figure 24. Mean total score from 1989-1996 for campsite type





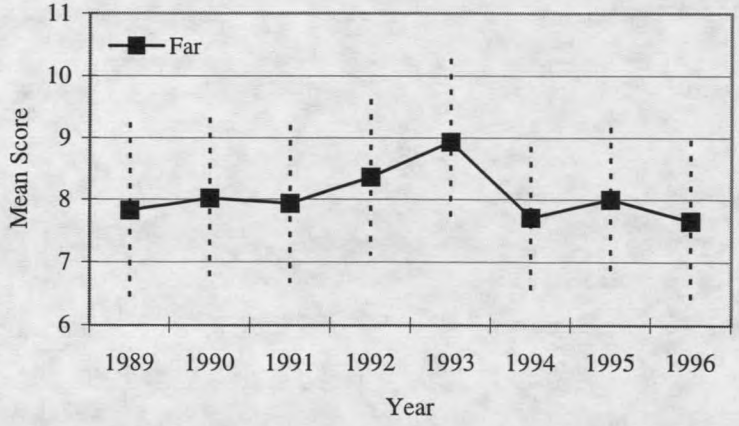
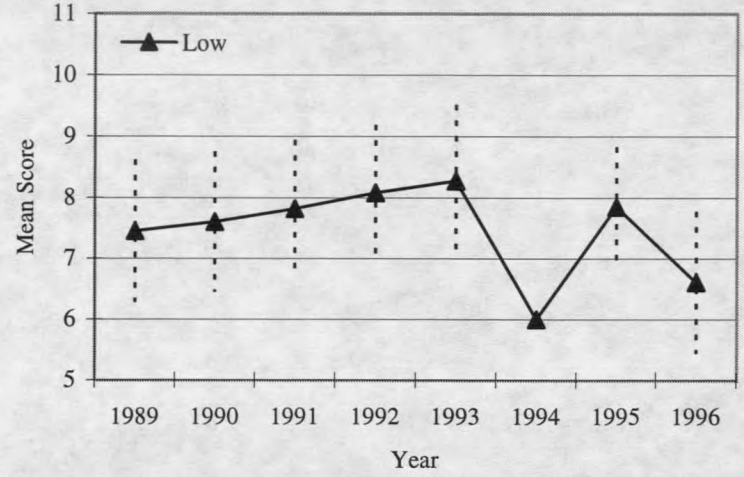
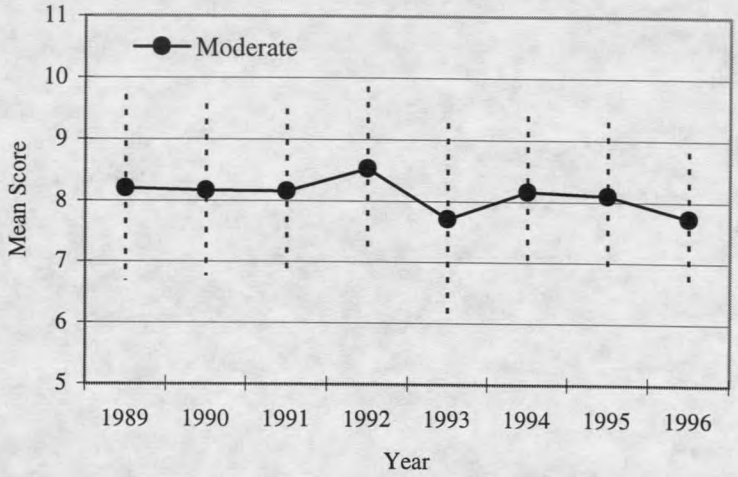


Figure 25. Mean total score from 1989-1996 for distance.





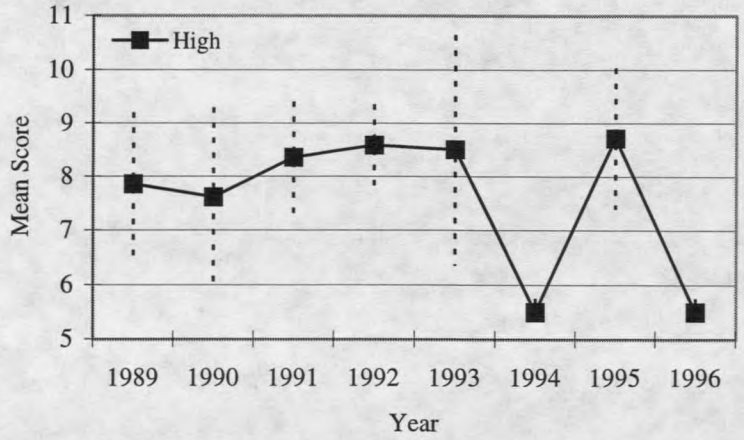
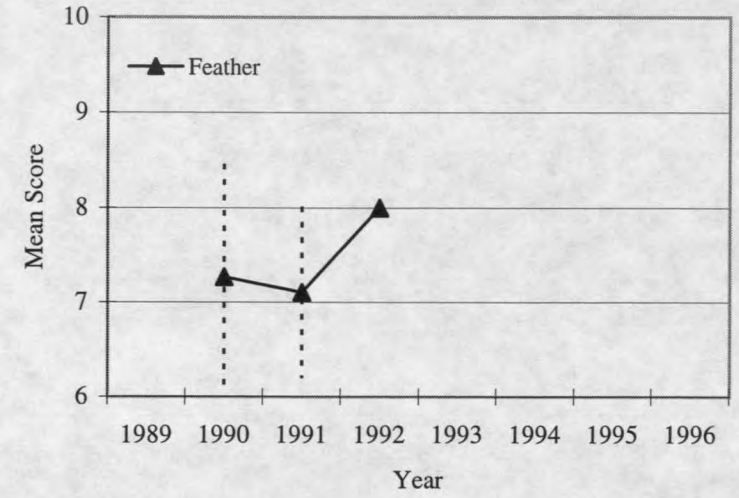
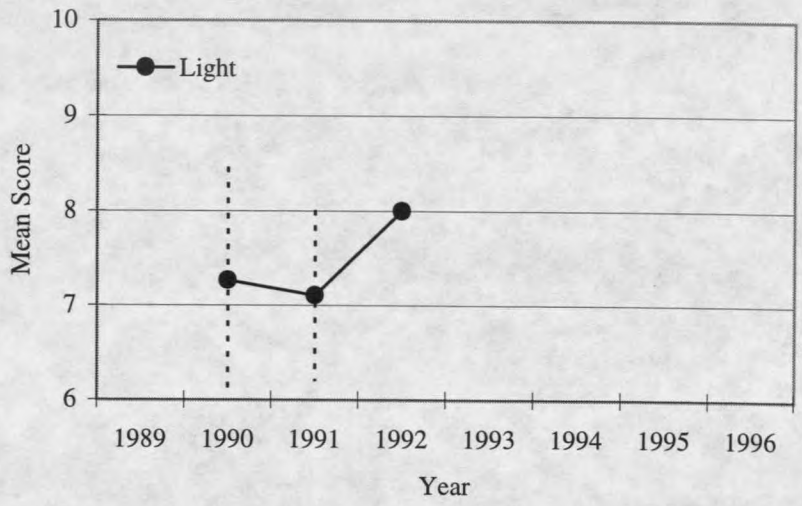


Figure 26. Mean total score from 1989-1996 for elevation.





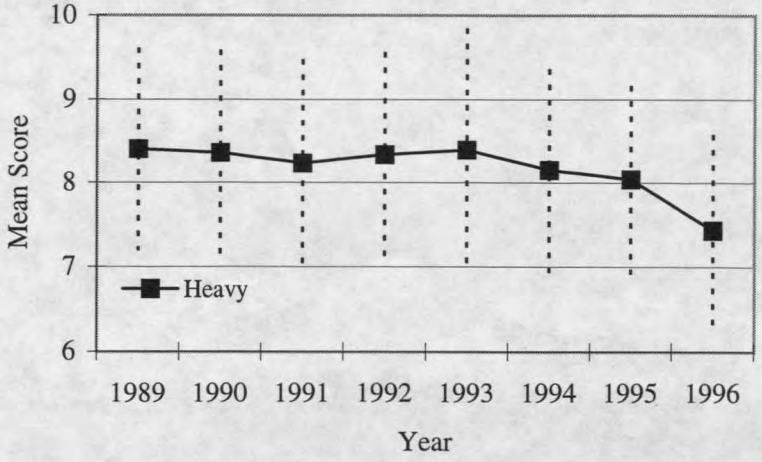


Figure 27. Mean total score from 1989-1996 for use.

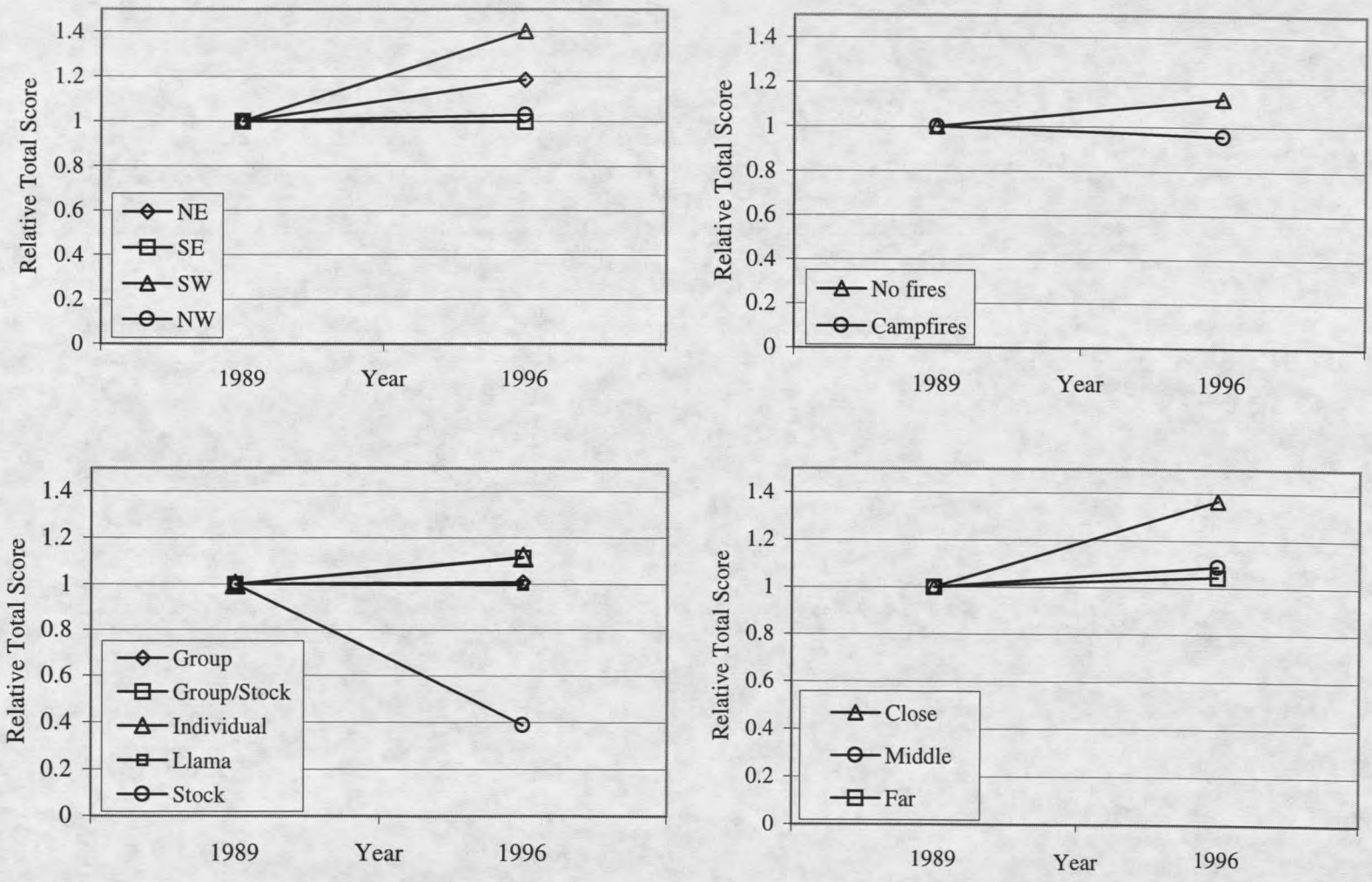
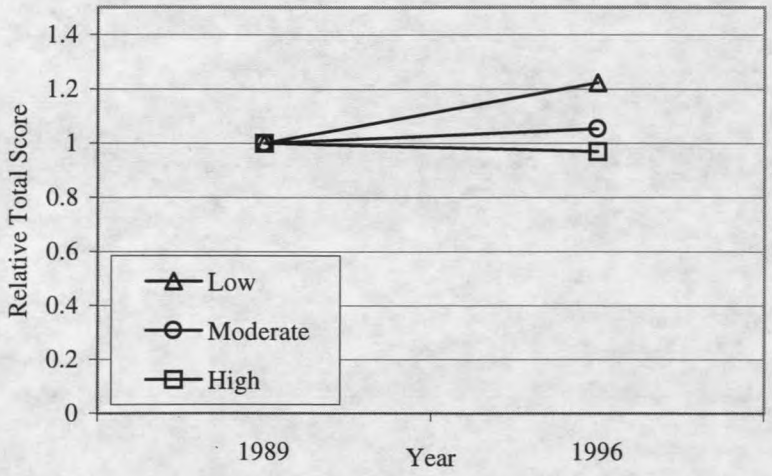


Figure 28. Trends in the change in total score over time for all categories



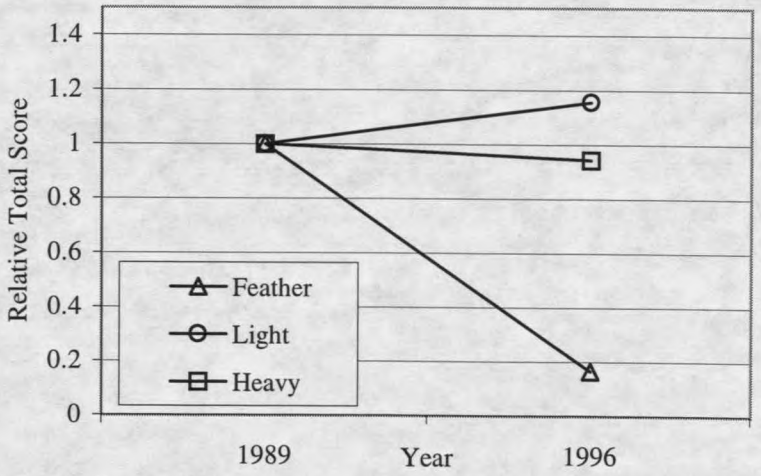


Figure 28 continued. Trends in the change in total score over time for all categories

changes over time relative to the first year (1989). For example, stock sites decreased in total score from 1 to 0.4 over time, reflecting a 60% decrease in total score.

Discussion

The general trend over time for area was an increase and for total score was a decrease. There were no sub-categories that decreased significantly in area. However, the SW facing sites and sites which did not allow fires, increased significantly in total score. It was expected that all sites, as they received more use and aged over time, would increase in total score. The SW facing sites may be the driest sites and therefore, might have increased in total score because they receive use for the longest period of time throughout the year. No-fires sites might have increased in total score because without fires, people cannot burn their trash or may not concentrate their use around the center point. Only stock sites significantly decreased in total score over time. Reasons for a decrease in total score may be due to management intervention and are discussed in method two analysis.

Changes Over Time Within Each Category

Results

A general linear model including each category was run to find changes in area over time. All categories except use showed increasing area with time, but only aspect, campfire, and distance increased significantly. None of the categories showed significant effects of time for total score. (Table 15).

Table 15. Changes in area and total score for each category (1989 through 1996). *Significant ($\alpha = 0.05$). Model: area = $\beta_0 + \beta 1$(time)

Category	**Area**			**Total Score**		
Sub-category	t-value	p-value	r^2	t-value	p-value	r^2
Aspect	4.50	0.0001*	0.0254	-0.17	0.8672	0.0139
Campfire	2.04	0.0421*	0.0158	-0.66	0.5125	0.0072
Campsite type	0.37	0.7089	0.0167	-0.25	0.8016	0.0061
Distance	3.30	0.0010*	0.0254	-1.23	0.2200	0.0068
Elevation	1.49	0.1363	0.0187	-0.64	0.5245	0.0040
Use	0.21	0.8302	0.0.42	-1.54	0.1235	0.0095

Discussion

The general linear model required to produce this data included effects of date, category, and the interaction of date and category. This model was over-paramatized as indicated by the low value of r^2 and does not describe the data well. However, this model was not mandatory as more meaningful information was derived from the models that did not include the effect of the interaction of date and category.

Differences Between Sub-categories

Results

Simple one way t-tests were run to find differences between sub-categories within each of the six categories (Table 16 and 17). For area, significant ($\alpha = 0.05$) differences were found between sub-categories in the categories of campsite type and elevation. It was found that both group/stock and group sites were significantly larger in area on average than individual, llama, and stock sites. Stock sites were significantly larger than individual sites.

Table 16. Significant ($\alpha = 0.05$) differences between sub-categories within each category for campsite area and total score.

Category			
Sub-category	Description	Campsite Area	Total Score
Aspect			
NE	1-90 deg	no difference	no difference
SE	91-180 deg		
SW	181-270 deg		
NW	271-360 deg		
Campfire			
no fires allowed	NF	no difference	no difference
fires permitted	CF		
Campsite type			
group	G	**G > I, L, and S**	**G/S > G, and I, L**
group/stock	G/S	**G/S > I, L, and S**	
individual	I	**S > I**	
llama	L		
stock	S		
Distance			
close	0-2 mi.	**far > close**	no difference
middle	2.1-5.5 mi.		
far	5.6-11.5 mi.		
Elevation			
low	8000-9600 ft	no difference	**moderate > low**
moderate	9601-11000 ft		
high	11001-12800 ft		
Use			
feather	0-20 people/yr.	no difference	no difference
light	21-50 people/yr.		
heavy	51-900 people/yr.		

Table 17. Significant ($\alpha = 0.05$) differences between sub-category means within each category for campsite area and total score.

Area			Total Score		
Category					
Sub-category	t-value	p-value	Sub-category	t-value	p-value
Aspect					
no differences between sub-category means			no differences between sub-category means		
Campfire					
no differences between sub-category means			no differences between sub-category means		
Campsite type					
G > I	4.75	0.0011			
G > L	4.06	0.0014			
G > S	2.86	0.0085			
			G/S > G	2.62	0.015
G/S > I	2.41	0.023	G/S > I	3.14	0.0082
G/S > L	2.29	0.028	G/S > L	3.03	0.0081
G/S > S	1.99	0.043			
S > I	2.83	0.018			
Distance					
far > close	1.92	0.038	no differences between sub-category means		
Elevation					
no differences between sub-category means			moderate > low	2.18	0.030
Use					
no differences between sub-category means			no differences between sub-category means		

For total score, significant ($\alpha = 0.05$) differences were found between sub-categories in the category campsite type, and distance. Group/stock sites received the highest total score compared to group, stock, individual and llama sites. Stock and group sites received about the same total score on average.

Discussion

As expected group and group/stock sites had larger areas than other site types. Stock sites were larger than individual sites indicating that even just five horses on a site was enough to significantly expand the areal size of a site compared to individual campsite where horses were not allowed. Currently, there are no places to stake out horses in group/stock campsites. Over time, as each group stakes out their horses in a different location, the campsite expands.

The total score for group/stock sites was significantly larger than all other sites except stock sites. This indicates that horses and large groups of campers not only cause an increase in area of a campsite, but they cause resource changes which were reflected in visual clues of resource damage that were scored in the BCIAMS methods.

Ordering of Sub-categories

Results

The t-tests and figures 29 and 30 show how the results of this study agree with the expected hypotheses (Table 18). The ordering of the sub-categories sometimes agrees with the expected order, but was not always significant. For significant results refer to

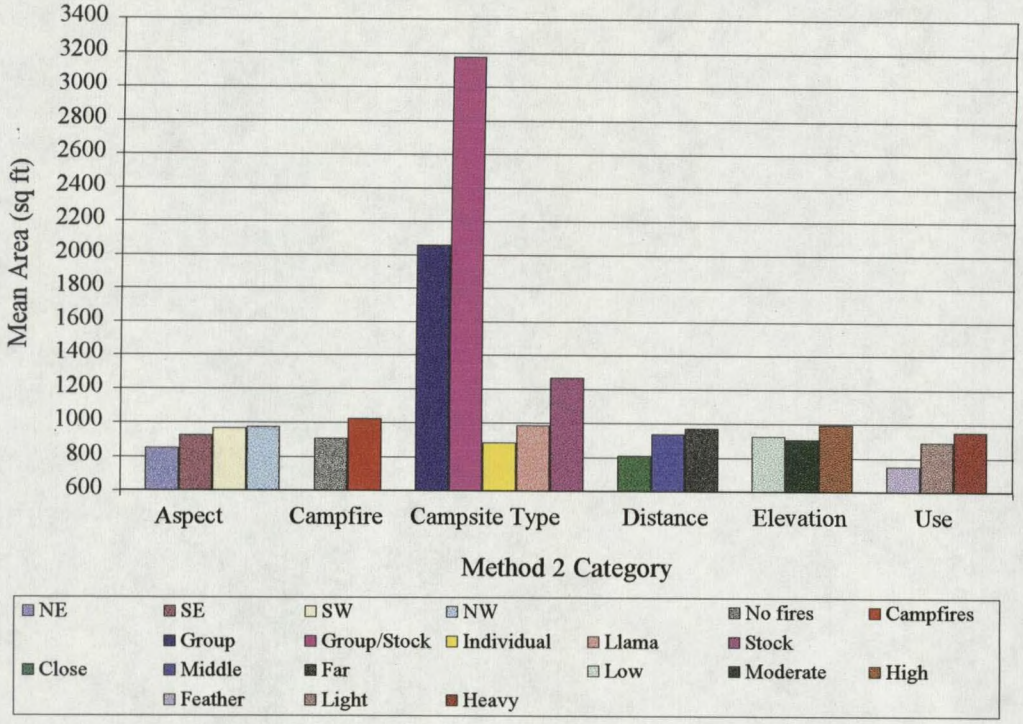


Figure 29. Differences between sub-categories for campsite area

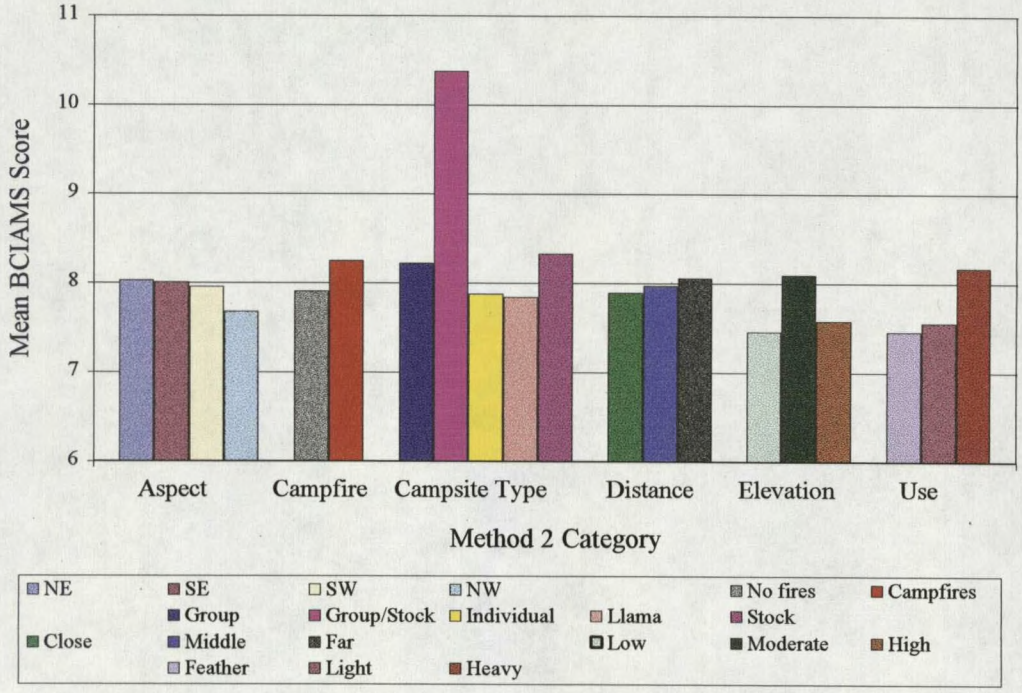


Figure 30. Differences between sub-categories for total score

Table 18. The original hypotheses for the means of each category and sub-category and the actual outcomes for area and total score. *Significant differences between sub-categories.

Category	Expected results
Aspect	SW and NW > SE and NE
Campfire	CF > NF
Campsite type	G/S > G > S > I > L
Distance	close >far > middle
Elevation	high > low > moderate
Use	heavy > light > feather

Area Category	Observed results	Agreement with expected results?
Aspect	NW > SW > SE > NE	No
Campfire	CF > NF	Yes
Campsite type	G/S > G > S > L > I	No*
Distance	far > middle > close	No*
Elevation	high > low > moderate	Yes
Use	heavy > light >feather	Yes

Total score Category	Observed results	Agreement with expected results?
Aspect	NE > SE > SW > NW	No
Campfire	CF > NF	Yes
Campsite type	G/S > S > G > I > L	No*
Distance	far > middle > close	No
Elevation	moderate> high > low	No*
Use	heavy > light > feather	Yes

the t-tests in the previous section (difference between sub-categories). The only sub-categories for area that matched to expected order were campfire, elevation, and use. For total score only use campfire and use were ordered as expected.

Discussion

The order of area and total score was important even if the results were not significant because they serve as general indicators of the state of campsites in the park. In general, sites that received larger number of visitors or stock were larger in area and had a higher total score. Although group and group/stock sites may start off larger than other sites, there is allot of overlap in the actual area of the sites. Group/stock sites ranged in areas from 400 to 9680 sq ft. Group sites ranged in area from 242 to 8400 sq ft, and individual sites ranged in area from 50 to 8300 sq ft. Llama and stock sites fell within the area ranges of individual sites. Therefore the effect of group and stock use on area of a campsite is not due to them starting off larger than all other campsite types.

Group and group/stock sites were significantly larger in campsite area than all other site types. Stock sites were also larger in area than individual sites. Therefore, the use of stock and large groups significantly affects the size of a campsite.

As the distance to a campsite increases, its area increases. Distance from the trailhead is also confounded with elevation, which is confounded with forest type. Campsites in the far distance category (5.5-11.5 miles) are in forests ranging from thick sub-alpine to above timberline. Forests with thicker canopies retain snow longer into the spring (Bachand and Steele, 1995, Skidmore, Hansen, and Quimby, 1994). Snow retention leads to increased impacts to campsites during melt-out periods. Campsites in

this category closer to 5.5 miles from the trailhead were probably more impacted by the effects of trampling during spring melt out.

Campsites at farther distances from the trailhead (closer to 11.5 miles) are close to or above timberline. The vegetation at alpine elevations is more resistant to initial trampling than vegetation at sub-alpine and lower elevations. (Cole, 1993b). But vegetation at these high elevations is not resilient and does not return readily (Stevens, 1976, Cole, 1987). Impacts to campsites farther from the trailhead were probably due to a decrease in vegetative recovery at high elevations. However, there was no significant difference in area between campsites at different elevations.

For total score, group/stock sites had significantly higher total score than individual, llama, and stock sites. Therefore, the use sites by stock and groups significantly increases the impacts to these campsites.

Moderate elevation sites had the highest total scores. These sites are in forests with thick canopies that retain snow longer into the spring. They are more susceptible to trampling during spring melt out.

Method Two Analyses

Results

For each of the method two variables, the correlation between year and score for each of the eight variables was tested to determine if they changed significantly over time. There was a significant change over time for six of the method two variables except vegetation and total score (Table 19).

Table 19. Statistical summary of changes for method two variables over time. There are 1017 degrees of freedom. A negative correlation shows a decrease in score, while a positive correlation shows an increase in score.

Method two variable	correlation	p-value
Vegetation	0.0608	0.0564
Shrub	-0.3091	0.0001*
Root	-0.2968	0.0001*
Social	0.1385	0.0001*
Access	0.2518	0.0001*
Satellite	-0.2344	0.0001*
Clean	-0.1085	0.0015*
Core	-0.0813	0.0203*
Total Score	-0.0374	0.2406

Significant ($\alpha = 0.05$) changes over time for each method two variable in each sub-category were found (Table 20). The overall trend for all scores is shown in the bottom row. An increase in score over time indicates there is more impact and resource damage, a decrease indicates an improvement.

Overall trends were as follows: vegetative cover (increase), shrub damage (decrease), root exposure (decrease), social trails (increase), access trails (increase), satellite sites (decrease), cleanliness (decrease), core area (decrease) and total score (decrease). Campsites that have increased or decreased for each of the method two variables over time were determined (Table 21). The correlations and p-values for each of the eight variables in method two for sub-categories over time for both tests of method two were calculated (Appendix B).

Table 20. Significant ($\alpha = 0.05$) changes (increase = I, decrease = D) between sub-categories within each category over time for method two variables. The overall trend for all scores was significant. (NS = not significant).

Category Sub-category	Vegetative cover	Tree/Shrub damage	Root expos	Social trails	Access trails	Satellite Sites	Clean-liness	Core area	Total score
Aspect									
NE		D	D	I	I	D	D		D
SE		D	D		I	D			D
SW		D	D	I	I	D			
NW	I	D	D	I	I	D	D		D
Campfire									
No fires		D	D	I	I	D		D	
camp fires		D	D		I	D	D		D
Campsite Type									
group		D		I			D		
group/Stock					I				
individual		D	D	I	I	D	I		
llama		D							
stock		D				D		D	D
Distance									
close		D	D	I			D		D
middle	I	D	D	I	I	D	D		D
far		D	D	I	I	D		D	D
Elevation									
low		D	D	I	I	D	D		D
moderate		D	D	I	I	D		D	D
high						D			
Use									
feather					I		D		
light	I			D	I			D	D
heavy			D	D	I	I	D	D	
Overall		D	D	I	I	D	D	D	
Trend	**NS**	**D**	**D**	**I**	**I**	**D**	**D**	**D**	**NS**

Table 21. Significant changes in total score over time for campsites (page 1 of 4). A negative correlation shows a decrease in score, while a positive correlation shows an increase in score.

Campsite	correlation	p-value	method two variable
Ditch Camp 3	0.7928	0.0189	Vegetative cover
Foot Bridge	0.6876	0.0094	Vegetative cover
Moore Park	-0.8018	0.0167	Vegetative cover
North Inlet Junction	0.6703	0.0062	Vegetative cover
Pine Martin	0.7770	0.0082	Vegetative cover
Porcupine	0.7770	0.0082	Vegetative cover
Boulder Brook (G)	0.9506	0.0494	Vegetative cover
Red Gulch (G)	0.9649	0.0351	Vegetative cover
Ditch Camp 3	0.7928	0.0189	Shrub damage
East Meadow	0.6128	0.0260	Shrub damage
Fern Lake	-0.5579	0.0106	Shrub damage
Glacier Gorge	-0.8830	0.0472	Shrub damage
Goblins Forest	-0.6675	0.0001	Shrub damage
Grouseberry	-0.7206	0.0187	Shrub damage
Hunters Creek	-0.9451	0.0044	Shrub damage
McGregor Mountain E.	-0.8882	0.0441	Shrub damage
Moore Park	-0.8018	0.0167	Shrub damage
Pear Creek	-0.6978	0.0038	Shrub damage
Pine Ridge, Upper	-0.9470	0.0145	Shrub damage
Sourdough	-0.9214	0.0261	Shrub damage
Tonahutu Meadows	-0.6682	0.0347	Shrub damage
Upper East Inlet	-0.9214	0.0261	Shrub damage
Spruce Lake (L)	-0.9605	0.0094	Shrub damage
Boulder Brook	-0.7208	0.0187	Root damage
Cache	-0.8640	0.0057	Root damage
Ditch Camp 3	0.8281	0.0111	Root damage
Fern Lake	-0.7345	0.0002	Root damage
Goblins Forest	-0.4814	0.0071	Root damage
Grand bay North	-1.0000	0.0001	Root damage
Granite Falls East	-0.9670	0.0072	Root damage
Happily Lost	-0.9476	0.0143	Root damage
Lower East Inlet	-0.7354	0.0154	Root damage
Onahu Bridge East	-0.9476	0.0143	Root damage
Paint Brush	-0.8461	0.0020	Root damage
Peregrine	-0.9670	0.0072	Root damage
Rabbit Ears	-0.9009	0.0369	Root damage

Table 21 (cont.). Significant changes in total score over time for campsites (page 2 of 4).

Campsite	correlation	p-value	method two variable
Slickrock	-0.9470	0.0145	Root damage
Summerland	0.7461	0.0084	Root damage
Aspen Meadow (G)	-0.9476	0.0143	Root damage
July (G)	0.9605	0.0094	Root damage
Cache	-0.8917	0.0029	Social trails
Cats Lair	0.5551	0.0317	Social trails
East Meadow	0.5824	0.0368	Social trails
Halfway	0.7655	0.0099	Social trails
Hunters Creek	0.8220	0.0447	Social trails
July	0.7917	0.0004	Social trails
Mirror Lake	-0.6172	0.0325	Social trails
North Inlet Falls	0.9470	0.0145	Social trails
North Inlet Junction	0.6180	0.0141	Social trails
Pine Martin	0.6854	0.0287	Social trails
Porcupine	0.9470	0.0001	Social trails
Sandbeach Lake	-0.6211	0.0102	Social trails
Summerland	0.7470	0.0082	Social trails
Valley View	0.7559	0.0300	Social trails
Big Meadows (G)	0.9476	0.0143	Social trails
Ute Meadows (L)	0.9470	0.0145	Social trails
Big Pool	0.8433	0.0022	Access trails
Boulder Brook	0.6555	0.0396	Access trails
Cache	-0.7680	0.0260	Access trails
Cats Lair	0.8107	0.0002	Access trails
Columbine Creek	-0.8660	0.0257	Access trails
East Meadow	0.6210	0.0235	Access trails
Finch Lake	0.8461	0.0020	Access trails
Grouseberry	0.8742	0.0009	Access trails
Halfway	0.8461	0.0020	Access trails
Long Draw	-0.5521	0.0266	Access trails
Lower East Inlet	0.6326	0.0497	Access trails
Mirror Lake	-0.8132	0.0013	Access trails
Moore Park	-0.8018	0.0167	Access trails
North St. Vrain Lower	0.9517	0.0127	Access trails
Ouzel Lake	0.9476	0.0143	Access trails
Over the Hill	0.9211	0.0263	Access trails
Summerland	-0.6687	0.0245	Access trails
Timber Creek	0.8461	0.0020	Access trails

Table 21 (cont.). Significant changes in total score over time for campsites (page 3 of 4).

Campsite	correlation	p-value	method two variable
Twinberry	-0.6344	0.0488	Access trails
Upper Chipmunk	0.8030	0.0052	Access trails
Big Pool	-0.7534	0.0119	Satellite sites
Glacier Gorge	-0.8882	0.0441	Satellite sites
Grouseberry	-0.7206	0.0187	Satellite sites
July	-0.6946	0.0041	Satellite sites
Lawn Lake	-0.5773	0.0077	Satellite sites
Long Draw	-0.5401	0.0308	Satellite sites
Mummy Pass Creek	-0.7171	0.0453	Satellite sites
Over The Hill	-0.9563	0.0109	Satellite sites
Pear Creek	-0.5799	0.0235	Satellite sites
Porcupine	-0.6854	0.0287	Satellite sites
Thunder Lake # 1	-0.9605	0.0094	Satellite sites
Red Gulch (G)	0.9649	0.0351	Satellite sites
Ditch Camp 3 (G/S)	-0.9810	0.0190	Satellite sites
Lawn Lake (S)	-0.9334	0.0204	Satellite sites
Boulder Brook	0.6415	0.0456	Cleanliness
Box Canyon	-0.8018	0.0167	Cleanliness
Foot Bridge	-0.7449	0.0035	Cleanliness
Glacier Gorge	-0.8882	0.0441	Cleanliness
Goblins Forest	-0.5724	0.0009	Cleanliness
Happily Lost	-0.8919	0.0420	Cleanliness
Kettle Tarn	-0.6403	0.0461	Cleanliness
La Poudre Pass	0.6325	0.0273	Cleanliness
Pear Creek	-0.7565	0.0011	Cleanliness
Peregrine	-0.8882	0.0441	Cleanliness
Pine Martin	0.8266	0.0032	Cleanliness
Sandbeach Lake	0.6211	0.0102	Cleanliness
Silvanmere	-0.7632	0.0102	Cleanliness
Snowbird	-0.8882	0.0006	Cleanliness
Twinberry	-0.7206	0.0187	Cleanliness
Valley View	0.8058	0.0157	Cleanliness
Big Pool	-0.8944	0.0027	Core area
Finch Lake	0.8197	0.0127	Core area
Goblins Forest	-0.8596	0.0001	Core area
Grouseberry	-0.8944	0.0027	Core area
Hitchins Gulch	-0.7252	0.0418	Core area

Table 21 (cont.). Significant changes in total score over time for campsites (page 4 of 4).

Campsite	correlation	p-value	method two variable
Lawn Lake	-0.6982	0.0026	Core area
Onahu Creek	0.7308	0.0395	Core area
Ouzel Lake	0.9562	0.0438	Core area
Porcupine	-0.8944	0.0027	Core area
Boulder Brook (G)	0.9506	0.0494	Core area
Summerland (G)	0.9661	0.0339	Core area
Lost Meadow (G/S)	-1.0000	0.0001	Core area

Discussion

There was no significant change found for the rating score of vegetative cover. This rating is obtained by estimating the amount of overstory and under story in the campsite. Since all of the campsites in this study were at least 18 years old, there is not much vegetative cover left in the campsite. It was not surprising that no change was found for this rating score.

Scores of social trails and access trails both increased. Once a trail is established, it is difficult to remove it. Social trails are established by campers walking to and from interest points. There are no management improvements (signing, water bars, etc.) On these trails. Interest points do no move in time so even if the trail is obliterated, it will be renewed by the next person on the way to an interest point. All trails are also subject to erosion, especially during wetter times.

Although it was expected that total score would increase over time, the observed trend was a decrease in total score over time. Tree/shrub damage, root exposure, satellite sites, cleanliness and core area all decreased significantly over time. One possible explanation for this is as campsites age, they become better due to management

intervention as explained below.

During the first few years a campsite is open, there will be a small core area with lots of vegetation. As time progresses, trees will become damaged from campers, vegetation trampled, and rocks and roots emerge. Satellite sites will develop as people search out for less impacted places to camp.

In the summer, the National park service improves campsites by removing trash, building and maintaining privies, removing illegal fire rings, building tent pads, and removing rocks that emerge in the center of the site (personal experience, Steele 1990-1996). This causes the main camp area to be cleaner and look more appealing to campers. Campers may then be more likely to use the site and not establish satellite sites. They may be more likely to use clean privies, and litter less when the site is maintained. This could explain the additional benefits of less damage to trees, shrubs and roots, less trash, and fewer satellite sites as the site is more cared for by campers. The decrease in score for core area may then be attributed to more concentration of use in the center of the site, where most improvement by the park service has occurred.

Another possible explanation is that the methodology of rating campsites using either method one or method two may not allow change over time to be recorded. For example, if a campsite is evaluated one year for shrub damage and there are 10 trees in the site and eight of them are damaged, the campsite will receive a higher score. The park service routinely removes trees in campsites which are considered hazards because they are damaged and may fall down on campers. The park service removes tree stumps and rocks in the core area. Therefore, the next year, after the eight trees have died and

been removed by the park service, the campsite's score will now be lower because the trees have been removed (producing less visible evidence of damage). This would falsely reflect a decrease in score over time. A second test of method two without the scores of vegetative cover, tree and shrub damage, and root exposure was performed to find out if these scores were falsely causing the decrease in total score.

Second Test of Method Two

Results

In the second test, a correlation between year and score for each of the five non-vegetative variables was performed. There was a significant change over time for all of the variables except the total score of the five variables. However, the trends were the same as in the first test of method two (Table 22).

Discussion

The results of the second test of method two follow closely the results of the first test. This indicates that the life cycle of a campsite was different from what was hypothesized. It appears that campsites deteriorate quickly over the first 3-5 years as predicted by Cole (1994). Then, instead of reaching a mature phase of 10-20% change per year, the campsite reaches a peak of resource damage, but, with the intervention of management (as discussed in the previous section), it slowly improves in condition until it reaches the steady state. Improvements in the campsite can cause the total score to

Table 22. Significant ($\alpha = 0.05$) changes (increase = I, decrease = D) between sub-categories within each category over time for method two variables excluding vegetative cover, shrub and root damage.

Category Sub-category	Social trails	Access trails	Satellite Sites	Clean-liness	Core area	Total score
Aspect						
NE	I	I	D	D		D
SE		I	D			D
SW	I	I	D			
NW	I		D	D		D
Campfire						
no fires	I	I	D	D	D	D
camp fires	I	I	D	D		D
Campsite Type						
group	I	I		D		
group/Stock	I	I				
individual	I	I	D	D		
llama		I				
stock	D		D		D	D
Distance						
close	I			D		D
middle	I	I	D	D		D
far	I	I	D		D	D
Elevation						
low	I	I	D	D		D
moderate	I	I	D		D	D
high			D			
Use						
feather		D		D		
light	D	D			D	D
heavy	I	I	D	D		D
Overall						
Trend	**I**	**I**	**D**	**D**	**D**	**not sig**

drop up to 60%. As long as management intervention continues, the campsite will not continue to degrade. If management intervention stops, the campsite will begin to have resource changes as predicted by Cole in the steady state at 10-20% each year. It is hypothesized that if campsites which are in locations that have been shown to increase in area or total score over time, are initially established with a tent pad already in place, that impacts in the first 3-5 years will not be as great as without these management

interventions. It is suggested that Cole's model be changed to reflect management intervention in the park (Figure 31).

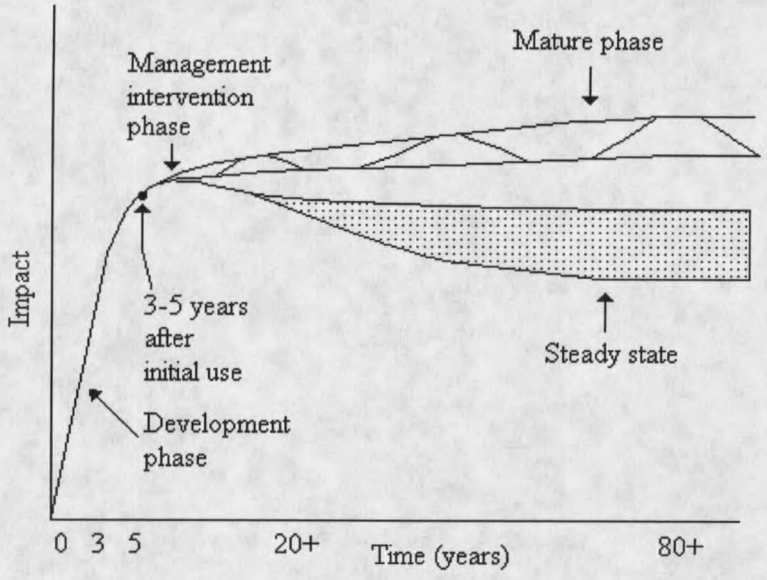


Figure 31. Life cycle of a campsite modified to reflect management intervention

Correlation of Use with Area and Total Score Over Time

Results

A correlation analysis was run for campsite use versus campsite area and total score (Table 23). Use was positively correlated with campsite area for the sub-categories of SE, SW, NW, campfire, no fire, group/stock, middle and far distances, moderate elevation, and heavy use. There was a significant positive correlation with use and area overall. There were no cases where use increased and area decreased significantly.

Table 23. Correlation of use with area and total score. A negative correlation shows a decrease in area or total score with increasing use, while positive correlations show an increase in area or total score with increasing use. * Significant ($\alpha = 0.05$).

Category	**Area** Sub-Category correlation	p-value	**Total Score** correlation	p-value
Aspect				
NE	-0.0337	0.7065	0.1044	0.2429
SE	0.1254	0.0249 *	-0.0205	0.7151
SW	0.3053	0.0001 *	0.1427	0.0701
NW	0.2428	0.0062 *	-0.0244	0.7860
Fire				
no fires	0.1396	0.0004 *	0.0879	0.0264 *
campfires	0.3258	0.0011 *	-0.3337	0.0008 *
Campsite type				
group	-0.2631	0.0966	0.0714	0.6573
group/stock	0.4257	0.0268 *	-0.2968	0.1327
individual	0.0659	0.0950	-0.0016	0.9667
llama	0.3204	0.2641	-0.0997	0.7236
stock	-0.3903	0.3867	-0.6875	0.0878
Distance				
close	-0.0067	0.9448	-0.1796	0.0570
middle	0.2075	0.0001 *	0.1202	0.0228 *
far	0.2461	0.0001 *	-0.0549	0.3763
Elevation				
low	0.0153	0.8065	-0.0689	0.2677
moderate	0.2232	0.0001*	0.0762	0.1084
high	0.2100	0.2654	-0.0436	0.8191
Use				
feather	0.3908	0.0066	0.1151	0.4412
light	0.1046	0.1759	0.0438	0.5716
heavy	0.1569	0.0003 *	-0.0032	0.9414
Overall	0.1719	0.0001 *	0.0321	0.3849

Use was positively correlated with total score for the sub-categories of no fire and middle distance. Use was negatively correlated with total score for campfire sites.

Discussion

As use increases, campsite area increased as expected. This effect was most pronounced for heavily used campsites. As use increased, the total score of campfire sites decreased. A possible explanation for this is that campers may concentrate their use around a fire which would decrease the BCIAMS score for vegetative cover, social trails, satellite sites and core area. They might burn their trash which would decrease the score for cleanliness. Even if there was more tree and shrub damage from collecting fire wood, this increase in score might be offset by a decrease in the other scores. The overall trend was as use increased, total score increase.

Changes Over Time for Use

Results

A general linear model for use was run to find out if use increased in all sub-categories over time. All sub-categories showed significant increases in use over time (Table 24).

Discussion

As expected, use increased throughout the park on all sub-categories. Because use is increasing throughout the park and not in one particular area, these results can be applied park wide, and trends can be viewed as affecting all sites equally.

Table 24 . Change in use over time for sub-categories

		t value	p-value
Aspect	NE	7.11	0.0001
	SE	15.40	0.0001
	SW	11.07	0.0001
	NW	8.80	0.0001
Fire	no fires	19.16	0.0001
	campfire	14.65	0.0001
Campsite	group	6.34	0.0001
type	group/stock	8.47	0.0001
	individual	22.07	0.0010
	stock	3.28	0.0305
Distance	close	11.65	0.0001
	middle	12.24	0.0001
	far	19.47	0.0001
Elevation	low	16.39	0.0001
	moderate	15.73	0.0001
	high	6.13	0.0001

Changes Over Time on Each Campsite

Results

To find increases or decreases over time in area or total score for each campsite, a correlation was run between year and area and total score (Tables 25 and 26). Most campsites increased in area, but most campsites decreased in total score.

To find if use increased or decreased over time for each campsite, a correlation was run between year and area and total score (Tables 27). All campsites that had significant changes in use over time had an increase in use, except Box Canyon which decreased in use over time.

Table 25. Campsites that showed a significant ($\alpha = 0.05$) change in campsite area over time. A negative correlation shows a decrease in area, while positive correlations show an increase in area.

Campsite name	Positive correlation	p-value
Big Pool	0.7297	0.0166
Boundary Creek	0.8813	0.0038
Goblins Forest	0.6189	0.0013
Grouseberry	0.6831	0.0294
La Poudre Pass	0.6319	0.0275
Lost Falls	0.9266	0.0079
North Inlet Falls	0.9056	0.0343
North Inlet Junction	0.7419	0.0015
Pear Lake	0.9067	0.0337
Pine Martin	0.6995	0.0244
Silvanmere	0.7700	0.0254
Stormy Peaks	0.8407	0.0360
Sunset	0.9462	0.0149
Tahosa	0.8950	0.0402
Upper Wind River	0.6514	0.0413
Ypsilon Creek	0.9823	0.0177
Big Horn Mt. (G)/(S)	0.9881	0.0119
Ditch Camp 3 (G/S)	0.9783	0.0217
Lawn Lake (S)	0.9473	0.0144

Campsite name	Negative correlation	p-value
Fern Lake	-0.5182	0.0230
Lodgepole	-0.8042	0.0050
Long Draw	-0.8043	0.0016
Mummy Pass Creek	-0.7601	0.0286
Pear Creek	-0.7183	0.0085

Table 26. Campsites that showed a significant ($\alpha = 0.05$) change in campsite total score over time. A negative correlation shows a decrease in area, while positive correlations show an increase in area.

Campsite name	Positive correlation	p-value
Ditch Camp 3	0.8361	0.0097
East Meadow	0.8204	0.0011
Haynack	0.9226	0.0256
La Poudre Pass	0.6275	0.0289
Upper Onahu West	0.8998	0.0375

Campsite name	Negative correlation	p-value
Cache	-0.9396	0.0005
Fern Lake	-0.7662	0.0001
Goblins Forest	-0.8539	0.0001
Happily Lost	-0.9869	0.0018
Lawn Lake	-0.6702	0.0012
Long Draw	-0.7662	0.0037
Mirror Lake	-0.7201	0.0083
Mummy Pass Creek	-0.8458	0.0081
Slickrock	-0.9086	0.0327
Upper East Inlet	-0.8825	0.0475
Upper Onahu East	-0.9009	0.0369
Upper Wind River	-0.9536	0.0119
Chapin Creek (G)	-0.9521	0.0479
Fern Lake (G)	-0.8953	0.0400
Summerland (G)	-0.9065	0.0338
Lawn Lake (S)	-0.9259	0.0240

Discussion

Since it was found that for sub-categories, area increased and total score decreased, it is not surprising to find this same phenomena when campsites were tested alone. Campsite area increased from 1989, but total score decreased. Social trails and access trails have degraded over time. While there has been less damage to trees, shrubs and roots, less trash, a smaller core area and fewer satellite sites. With increased use, both social trials and access trails became more impacted. As the area of the campsite got larger, there may have been less need for campers to remove trees and shrubs in order to find a place to put a tent. Total score decreased, possibly due to management practices as discussed in the discussion section of method two analysis. Increase in use of backcountry sites in the park over the last eight years has not occurred in only a few campsites, but in all campsites.

Table 27. Campsites that showed a significant ($\alpha = 0.05$) change in use over time.

Campsite name	correlation	p-value
Big Pool	0.9978	0.0001
Box Canyon	-0.9908	0.0001
Cache	0.9767	0.0008
Cascade Falls	0.9976	0.0024
Cats Lair	0.9648	0.0001
Cutbank	0.9845	0.0155
Ditch Camp 3	0.8188	0.0463
East Meadow	0.9834	0.0001
Finch Lake	0.9884	0.0001
Foot Bridge	0.9589	0.0001
Goblins Forest	0.9958	0.0001
Golden Banner	0.9790	0.0210
Halfway	0.9796	0.0001
Happily Lost	0.9817	0.0183
Haynack	0.9553	0.0447
Hitchins Gulch	0.9972	0.0001
Hunters Creek	0.9456	0.0151
Jackstraw	0.9612	0.0001
July	0.9207	0.0001
Kettle Tarn	0.9949	0.0001
La Poudre Pass	0.9809	0.0001
Lake Verna	0.9768	0.0232
Lawn Lake	0.9759	0.0001
Lodgepole	0.9935	0.0001
Lost Falls	0.9760	0.0009
Lost Lake	0.9929	0.0001
Lower East Inlet	0.9911	0.0001
Lower Granite Falls	0.9890	0.0014
Lower Tileston	0.9820	0.0180
McGregor Mountain E.	0.9847	0.0153
McGregor Mountain W.	0.9847	0.0153
Mirror Lake	0.7837	0.0124
Moore Park	0.9418	0.0050
Mummy Pass Creek	0.9745	0.0010
North St. Vrain Lower	0.9872	0.0128
North St. Vrain Upper	0.9951	0.0049
North Inlet Falls	0.9608	0.0392
North Inlet Junction	0.9659	0.0001
Onahu Bridge East	0.9902	0.0099
Onahu Bridge West	0.9902	0.0099
Onahu Creek	0.9909	0.0001
Ouzel Lake	0.9890	0.0110
Paint Brush	0.9795	0.0001
Pear Creek	0.9770	0.0001
Pear Lake	0.9959	0.0041
Peregrine	0.9782	0.0218
Pine Martin	0.9940	0.0001
Pine Ridge, Lower	0.9920	0.0080
Pine Ridge, Upper	0.9920	0.0080
Porcupine	0.9602	0.0002
Rabbit Ears	0.9924	0.0076
Rock Slide	0.9621	0.0379
Sandbeach Lake	0.9830	0.0001
Silvanmere	0.9900	0.0001
Snowbird	0.9760	0.0001
Solitaire	0.9736	0.0264
South Meadow	0.9913	0.0087
Spruce Lake (SW)	0.9952	0.0049
Stage Road	0.9999	0.0078
Summerland	0.8652	0.0055
Sunset	0.9883	0.0117
Tahosa	0.9947	0.0053
Tileston Meadows	0.9977	0.0023
Timber Creek	0.9855	0.0001
Tonahutu Meadows	0.9570	0.0002
Twinberry	0.9913	0.0001
Upper Chipmunk	0.9941	0.0001
Upper East Inlet	0.9819	0.0181
Upper Onahu East	0.9690	0.0310
Upper Onahu West	0.9690	0.0310
Upper Ouzel Creek	0.9945	0.0055
Valley View	0.9638	0.0019
Ypsilon Creek	0.9953	0.0047
Aspen Meadow (G)	0.9812	0.0188
Finch Lake (G)	0.9748	0.0252
Red Gulch (G)	0.9974	0.0461
Summerland (G)	0.9891	0.0109
Big Horn Mt. (G/S)	0.9502	0.0498
Tonahutu (G/S)	0.9680	0.0320
North Inlet (G/S)	0.9915	0.0085
Aspen Knoll (L)	0.9905	0.0095
Ute Meadows (L)	0.9518	0.0482
Lawn Lake (S)	0.9515	0.0485

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The 1996 field study provided information about the variance in the data base, as well as the usefulness of the data. The variance in area and total score were dealt with mathematically. The spherical densiometer study showed that it is not possible to switch to quantitative methods from the current qualitative measurements, at least for vegetative cover. Therefore, the spherical densiometer study results were not used in this study.

Most sub-categories increased in area over time. These included: NE, SE, NW, no fire, campfire, individual, any distance from the trailhead, low or moderate in elevation and heavily used. Only two sub-categories (SW and no fire) increased in total score over time.

Group, group/stock, llama, and stock sites did not increase significantly in area over time, however group, group/stock, and stock sites were the largest overall sites in the park. They probably reached a maximum area before 1989, which was not reflected as an increase in area over the course of this study.

Heavily used campsites increased in area over time but lighter used sites did not. However, use is significantly increasing on all of these sites. With increasing use but no management, it is expected that these lighter used sites would increase significantly in

area over the next few years.

Sub-categories that increased significantly in total score over time were SW aspect and no fires. Stock sites decreased significantly over time in total score. When total score was analyzed as a separate variable over time, it decreased but not significantly. This explains the lack of significant values for the total score analysis. However, when each of the eight method two variables was analyzed separately across sub-category over time, significant changes were found.

Significant increases in total score were found in the method two variables of social and access trails. Social and access trails may have become more damaged over time because once a social trail is established, it is very difficult to remove the trail. Both social and access trails are subject to erosion, especially social trails which do not have water bars. Increasing camping use also increases traffic on all trails and they will subsequently increase in width, depth and number, which will increase their total score.

Significant decreases in total score over time were found for the method two variables of tree/shrub damage, root damage, satellite sites, cleanliness, and core area. A decrease in score indicates that there has been improvement over time. The five variables that decreased in score are all affected by management intervention. When the site is maintained and improved to provide an aesthetically pleasing place to camp, resource damage is reduced and these variables will all improve.

Both vegetative cover and total score did not show significant changes over time. All campsites in the park are well established and have long ago lost any on-site understory and overstory vegetation. This would be a variable to eliminate from the

BCIAMS study in the future, if time and resources were limited.

Use was positively correlated to an increase in campsite area and total score in all cases. Since visitor numbers have increased in the park over the course of the study, this was expected. Additionally, use increased significantly across all sub-categories and across campsites. Use increased park wide, in all campsites at all locations. No campsite in the park can be considered lightly used and all should be monitored and managed with this in mind.

When the time effect was not considered, group and group/stock sites were found to be larger in campsite area than all other site types. Stock sites were larger in campsite area than individual sites. The use of stock and groups causes the area of the campsite to be larger. This should be considered when deciding on party size limits.

Campsites far from the trailhead were larger in campsite area than sites close to the trailhead. In the park, sites that are far from the trailhead (greater than 5.5 miles) are also at higher elevations and, in middle elevation forests that retain snow into early summer (thus subject to damage during the melt out periods, and in higher elevations with vegetation communities (i.e. tundra) that rejuvenate very slowly. Once damage occurs in these areas, the site recovers very slowly and more damage may occur the next year.

Group/stock sites had higher total scores than all other site types. As with the analysis of campsite area, the use of groups and stock significantly increased the damage that occurred in these sites.

Moderate elevation sites had higher total scores than low elevation sites. It was

expected that the highest elevation sites would have the highest score. Apparently, moderate elevation sites that retain their snow the longest are subject to more damage than high elevation sites with slowly recovering vegetation. It is important to carefully monitor and enforce camping regulations during the spring melt out. It would also be beneficial to run an analysis of distance and elevation sub-categories with more sub-categories, or use the vegetative cover GIS data, to try and separate out sites that are in forests that retain their snow, and sites that are in timberline areas.

Recommendations for Further Studies

Management Intervention

Two of the major forms of management intervention are building tent pads and privies. Figure 6 illustrates how emergent rocks in a campsite have forced the visitor to put their tent off the pad. Figures 32 and 33 illustrate how a tent pad in a site has slowed the rate of degradation outside the tent pad over 5 years. In order to statistically establish that tent pads or privies slowed the rate of degradation of the campsite the study discussed below is recommended.

First, a record of the year and campsite where tent pads and privies were built should be completed for all campsites in the park. After the database of current tent pads in the park is established, 1989-1996 data can be analyzed to find out how tent pads and privies effected campsite area and total score. Then, tent pads should be established on randomly selected sites and on a few new sites. Next, data should be collected (method



Figure 32. Upper Wind River, 1993 (Thompson River files, 1996)



Figure 33. UpperWind River, 1996 (Thompson River files, 1996)

two rating scores and area measurements) for at least five years. This data can then be analyzed as it was in this study.

High Elevation Campsites

It was shown in this study that high elevation sites and sites far from the trailhead had larger campsite areas than low elevation sites and sites close to the trailhead. Increasing use was also correlated with an increase in area and total score.

Further research is necessary to fully understand how very high elevation sites are being affected by heavy use. In order to complete this study, some sites should be established at high elevations and data collected (method two rating scores and area measurements) for at least five years. Bivy use in (high elevation sites) records can be used to find if use in these areas is increasing. If it is found that high elevation sites are receiving increased use and are being degraded, management steps such as building tent sites, should be taken.

Stock Sites

Stock sites decreased in total score over the eight years of the study. There are several possible reasons for this. First, the use of stock sites by parties with stock may be decreasing so the site is only effected by 1-5 stock and 1-7 campers per night. Stock sites are used primarily by privately owned stock while group/stock sites are used primarily by concession owned stock. In 1993, all stock were required to have their feed for the entire trip brought in from outside the park. The feed was required to be state certified weed free hay. This regulation might have caused a decrease in the number of private stock

owners who camp in the park due to the inconvenience of this regulation and the non-regulated status of neighboring US Forest Service land. The number of stock used on stock and group/stock sites was not available for this analysis, but should be recorded in the future.

Second, there may be a threshold below which stock do not significantly effect the area and total score of a campsite. Park regulations permit only up to five horses, mules or llamas on stock sites. It is possible that this number of stock is not significantly affecting the campsite.

In order to find out how stock use is affecting campsites in the park, accurate use numbers must be obtained. It is necessary to accurately record how many stock and how many people without stock are using these sites. Then the area and total score of the campsite can be analyzed.

Spring Melt Out

In order to find out how campsite area and total score are affected by spring melt out, accurate melt out dates may be established for all site in the park. Then the BCIAMS data can be analyzed as it was in this study. Experimental sites may be established where camping is not allowed on them for five years during spring melt out. During this time, data could be collected on campsite area and BCIAMS scores. Then it could be analyzed with methods used in this study.

Recommendations for the Management of Backcountry Campsites

Previous studies have shown that concentration of use will slow the spread of campsites (Cole and Hall, 1992, Cole 1995). Cole (1993a) found that campsite proliferation was a result of two factors: 1) an increase in site-pioneering behavior without the discouragement of management, and 2) passive management programs that did little to decrease the number of campsites. It has been found that dispersal of campers is only effective in minimizing impacts only where use is very low (Cole and Fichtler, 1983). Constructing tent pads on campsites not only offers the visitor a comfortable place to put their tent, it helps to concentrate use. Tent pads help to limit impacts to the sites when the ground is wet and most vulnerable (Price, 1985).

Figures 32 and 33 show the Upper Wind River campsite in 1993 and 1996. From the photos, there is apparently minimal change in the campsite over the three years. This is perhaps due to the majority of camping use on the tent pad with limited resource damage and areal expansion outside of the site.

Since the group and group/stock sites had the largest campsite areas, and the highest total score, tent pads should be built in these locations first to try and concentrate use and limit damage. At present, there are no clearly defined areas where campers keep their stock in these sites. Defined stock zones should be established to limit resource damage caused by stock.

Previous studies have found strong correlations between canopy density and the accumulation and melt out patterns of snow (Packer, 1971; Gary and Troendle, 1982; Potts, 1984, Skidmore et al., 1994). These studies have shown that dense, closed-canopy,

coniferous forests have accumulate less snow, but retain snow longer during the spring melt out. Maximum damage occurs to sites during spring (Strand, 1979; Cole, 1994).

The results of this study showed that moderate elevation sites had higher total scores than other sites. At moderate elevations, the snow stays on the sites into late June or early July. As campers avoid the snow, the site expands and more resource damage occurs. It is recommended that the park establish a new and more effective policy to keep people off fragile, wet areas during melt out times to reduce the size of campsites.

Rocky Mountain National Park has established an effective set of regulations dealing with backcountry camping. Where use is low, the best management technique is to allow campers to camp one night in a non-denuded area that they choose, then move their camp the next night. However, where use is high, a better management technique is to concentrate use in established campsites (Cole, 1987, 1989a, Cole, 1995). It is recommended that the park continue current backcountry camping regulations for party size and stay limits as suggested from evidence from other studies from Cole (1989a, 1995).

It is recommended that campsites not be moved unless they are in an area that can and will be rehabilitated (Cole, 1993a and 1995). Once sites have been established, leaving them where they are is better based on previous studies which have shown that most impacts on sites occur within the first 3-5 years, but rehabilitation takes much longer (Cole and Marion, 1988, Cole and Hall, 1992).

Recommendations for the BCIAMS Study

This study has been conducted for eight years. All campsites were evaluated in five separate years. The collection of the BCIAMS data takes a great deal of time both in the field and in entering data in the office. The study has succeeded in establishing a baseline of data that can be used in the future. In order to improve the effectiveness of the study, several changes are recommended.

According to Cole (1983) a good system for monitoring will have four characteristics. These are: 1) meaningful measures of impact, 2) reliable and sensitive measurements, 3) reasonable cost in time and money, and 4) measurements can be precisely relocated. Data recording tasks are important to track use in backcountry sites (Lime, 1974). A total of five types of data, in addition to BCIAMS scores, are recommended (Table 28). These include three record keeping tasks that can be stored on

Table 28. Recommendations for types of data to collect for BCIAMS study.

Record keeping	
1. Campsite use	a) the number of nights a site was used b) number of people on the site per night c) number of stock animals per site per night
2. Melt out dates	date per site for each year
3. Tent pad and privy	a) the year the tent pad or privy was established b) the exact campsite code where the tent pad was built
Quantitative data	
3. Area	a) measures of the length and width with a tape measure b) general sketch of the points of measurement in the site c) pace the perimeter of the campsite d) general description of the shape of the campsite

Qualitative data

5. Photos	quality photographs without shadows take photos from same spot and season each year 1-2 photos per site

the backcountry office computer from permit information, one quantitative measure and one qualitative measure that are time effective and more accurate. This data can later be used to analyze changes in use and other factors over time.

Accurate measurements are preferable to estimates in most situations (Cole, 1983). To improve the accuracy of the area measure, which were highly variable in this study, it is recommended the denuded area by measured with a tape measure. There are measurements that should be taken to improve the accuracy of campsite area measurements. First, it is also important to establish clear directions for defining the boundary of the campsite. Next, the length X width should be measured from the widest points, or from the points used in previous years. A general sketch of the campsite with locations of area measurements is also required for consistency over time. The perimeter of the campsite should be paced. This number gives an indication of the amount of the campsite that has an edge which is exposed for damage. Finally, a general description of the campsite (oval, circle, figure eight, etc.) should be included to track changes in the site over time.

The qualitative measurement is to take good photographs. It is recommended that two photographs of the each campsite from marked photo points be taken (Cole, 1983). Previous photos (obtained from photo files) can be used to decide the best location for a photo point and to try to extend the photo record as far back as possible. The older

photograph should be taken to the field for reference. The photos should be taken at a time of day when the sun does not cast long shadows (Cole, 1983). Take photos during the same season each year, preferable in the summer.

This study demonstrated the validity of assessing, monitoring and managing campsites over time. Managing campsites increases their aesthetic quality, concentrates use, and slows the rate of degradation in and around the campsite. With continued management of campsites, our natural areas can be preserved for future generations.

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APPENDIX A

BACKCOUNTRY CAMPSITES

List of Backcountry Campsites in Rocky Mountain National Park

Rocky Mountain National Park designated backcountry campsites in the five districts of the park (Sweet, 1997; Thomas, 1996). *Un-annotated campsites are individual sites.

District	Campsite Name	Campsite type*	Number of campsites: individual	group	Campfire sites (CF)	Distance from trailhead (mi)	Elevation (feet)
North Fork District							
001	Boundary Creek		2		CF	4.6	9,120
002	Kettle Tarn		2			4.9	9,200
003	Silvanmere		2		CF	5.7	9,360
004	Halfway		2		CF	5.6	9,360
005	Aspen Meadow	Group	1		CF	5.9	9,520
006	Happily Lost		1		CF	6.2	9,560
007	Lost Falls		2		CF	6.7	9,600
008	Sugarloaf		1			8.2	10,290
009	Stormy Peaks South		1			8.6	10,840
010	Stormy Peaks		2	1		11.0	11,160
1	Lost Meadow	Group/Stock	1	1		8.4	10,420
012	Lost Lake		4			9.7	10,714
013	Rabbit Ears		1			1.4	8,100
014	Peregrine		1			2.0	8,480
015	McGregor Mt.		2		CF	4.5	9,040
016	Bighorn Mt.	Group/Stock		1	CF	6.5	10,620
Fall River District							
017	Lower Tileston		1			6.3	10,650
018	Tileston Meadows		2			6.0	10,800
019	Upper Chipmunk		2			4.2	10,640
020	Ypsilon Creek		1			2.6	9,560
021	Cutbank		1			2.3	9,620
022	Golden Banner		1			2.6	9,600
023	Lawn Lake	1 Stock	5			6.1	10,987
025	Ute Meadow	Llama	1			2.2	10,000
Thompson River District							
024	Little Rock Lake		1			6.0	10,280
026	Arch Rock		1			1.6	8,240
027	Old Forest Inn		2			1.7	8,400
028	Fern Lake		4	1		3.8	9,530
029	Spruce Lake	1 Llama	2			4.6	9,670
030	Odessa Lake		2			4.8	10,020
031	Sourdough		1			2.5	10,600
032	Cub Creek		2			2.2	8,600
033	Mill Creek Basin		2			1.6	9,000
034	Upper Mill Creek		2			1.8	9,200
035	Wind River Bluff		1			2.5	8,800
036	Over the Hill		1			2.2	8,800
037	Upper Wind River		2			1.9	8,940

038	Boulder Brook		2	1		3.6	10,200
039	Glacier Gorge		1			3.5	10,000
040	Andrews Creek		1			3.3	10,560
H1	Sprague Lake	Handicamp	1			0.6	8,760
Longs Peak District							
041	Moore Park		2			1.7	9760
042	Goblin's Forest		6			1.2	10,120
043	Battle Mountain	Group		1		2.8	11,000
044	Boulderfield		9			6.0	12,760
Wild Basin District							
045	Hole-in-the-Wall		1			1.9	9,240
046	Campers Creek		1			2.3	9,600
047	Beaver Mill		1			3.0	9,640
048	Hunters Creek		1			3.3	9,760
049	Sandbeach Lake		4	1		4.2	10,283
050	Pine Ridge		2			1.4	8,880
051	Tahosa		1			1.7	9,040
052	Aspen Knoll	llama	1			2.3	9,400
053	Siskin		1			3.2	9,460
054	North St. Vrain		2			3.5	9,560
055	Thunder Lake	1 Stock	4	1		6.8	10,574
056	Ouzel Lake		1			4.3	10,020
057	Upper Ouzel Creek		1			6.0	10,600
058	Finch Lake	Group/Stock	2	1		4.5	9,912
059	Pear Creek		3			6.4	10,550
060	Pear Lake		1			6.6	10,582
West District							
061	East Meadow		2		CF	1.5	8,550
062	Lower East Inlet		2			2.3	8,640
063	Cats Lair		3			4.0	9,200
064	Gray Jay	Group	1		CF	4.9	9,650
065	Slick Rock		1			6.0	10,000
066	Solitaire		1			6.2	10,120
067	Upper East Inlet		1			6.6	10,200
068	Lake Verna		1			6.9	10,280
069	Summerland Park		1	1	CF	1.2	8,535
070	Twinberry		2			3.0	8,680
071	Cascade Falls		1			3.5	8,840
072	Big Pool		2			5.0	9,160
073	Grouseberry		2			6.2	9,250
074	North Inlet	Group/Stock	1		CF	6.5	9,290
075	Foot Bridge		1		CF	6.5	9,290
076	Ptarmagin		1			6.7	9,360
077	Porcupine		2		CF	6.8	9,360
078	North Inlet Junction		3			7.5	9,600
079	North inlet Falls		1			7.6	9,540
080	Pine Marten		2			7.8	9,560
081	July		3			9.7	11,760
082	Lodgepole		2			1.7	9,200

083	Paint Brush		2			2.3	9,320
084	South Meadow		1			2.4	9,360
085	Big Meadows	Group	1			1.9	9,400
086	Sunset		1			3.0	9,550
087	Sunrise		1			3.5	9,600
088	Lower Granite Falls		2			5.1	9,760
089	Granite Falls		2			5.4	9,840
090	Tonahutu Meadows		2			6.2	10,050
091	Tonahutu	Group/Stock	1		CF	6.6	10,160
092	Renegade		1			7.0	10,200
093	Haynack	1 Llama	2			7.2	10,760
094	Timberline	Group	1			7.4	10,570
095	Onahu Creek		2			2.4	9,480
096	Upper Onahu		2			2.8	9,600
097	Onahu Bridge		2			2.9	9,650
098	Timber Creek		2			3.0	10,400
099	Jackstraw		2			4.0	10,760
100	Rockslide		1			4.5	10,960
101	Snowbird		2			4.6	11,010
102	Valley View		2			3.2	10,260
104	Opposition Creek		1			3.5	10,440
105	Red Gulch	Group	1			5.8	10,320
106	Hitchins Gulch		2			5.8	10,480
107	Dutch Town		1			6.2	10,760
108	Stage Road		1			4.2	9,530
009	Ditch Camp	Group/Stock	2	1		4.6	10,160
110	Skeleton Gulch		1			6.7	10,560
111	Box Canyon		2			5.5	10,480
112	LaPoudre Pass		3			7.8	10,200
113	Cache		2			5.0	10,150
114	Chapin Creek	Group	1			5.5	10,240
115	Hague Creek	Group/Stock	2	1		1.6	9,720
116	Desolation		1			2.3	9,840
117	Flatiron		1		CF	2.8	9,840
118	Mummy Pass Creek		2		CF	4.6	10,640
119	Koenig	Stock	1			5.2	10,680
120	Mirror Lake		3			6.1	11,000

APPENDIX B

CORRELATIONS FOR METHOD TWO

Correlations Between Sub-categories for Method Two

Significant ($\alpha = 0.05$) changes changes between sub-categories within each category over time. A negative correlation indicates a decrease in score, while a positive correlation indicates an increase in score.

Category	Sub category		Vegetative cover	Shrub damage	Root exposure	Social trails
Aspect	NE	correlation	-0.0291	-0.4076	-0.4083	0.1938
		p-value	0.7060	0.0001	0.0001	0.0111
	SE	correlation	0.0000	-0.3683	-0.2675	0.0398
		p-value	0.9994	0.0001	0.0001	0.4180
	SW	correlation	0.0959	-0.1933	-0.3075	0.1765
		p-value	0.1419	0.0029	0.0001	0.0066
	NW	correlation	0.2487	-0.2179	-0.2644	0.2618
		p-value	0.0014	0.0052	0.0006	0.0007
Campfire	NF	correlation	0.0592	-0.3023	-0.2930	0.1341
		p-value	0.0849	0.0001	0.0001	0.0001
	CF	correlation	0.0716	-0.3780	-0.3213	0.1656
		p-value	0.4041	0.0001	0.0001	0.0523
Campsite type	group	correlation	0.1574	-0.2936	-0.1370	0.2386
		p-value	0.2468	0.0281	0.3139	0.0765
	group/	correlation	0.0009	-0.2979	-0.2470	0.2991
	stock	p-value	0.9957	0.0619	0.1245	0.0609
	individual	correlation	0.0608	-0.3044	-0.3119	0.1289
		p-value	0.0744	0.0001	0.0001	0.0001
	llama	correlation	0.0409	-0.6757	-0.3333	0.3485
		p-value	0.8680	0.0015	0.1633	0.1437
	stock	correlation	-0.4941	-0.7115	-0.1250	-0.6325
		p-value	0.1764	0.0316	0.7486	0.0676
Distance	close	correlation	-0.0736	-0.3950	-0.3438	0.1798
		p-value	0.3790	0.0001	0.0001	0.0304
	middle	correlation	0.0920	-0.2706	-0.3546	0.1198
		p-value	0.0513	0.0001	0.0001	0.0110
	far	correlation	0.0928	-0.3203	-0.2115	0.1475
		p-value	0.0754	0.0001	0.0001	0.0046
Elevation	low	correlation	0.0993	-0.3322	-0.3466	0.1775
		p-value	0.0671	0.0001	0.0001	0.0010
	moderate	correlation	0.0297	-0.3116	-0.2853	0.1291
		p-value	0.4684	0.0001	0.0001	0.0015
	high	correlation	0.2302	-0.1632	-0.1341	-0.0449
		p-value	0.1282	0.2841	0.3800	0.7696
Use	feather	correlation	-0.0443	-0.2454	-0.0791	0.0427
		p-value	0.7530	0.0765	0.5734	0.7614
	light	correlation	0.1737	-0.1273	-0.0513	-0.2254
		p-value	0.0178	0.0835	0.4872	0.0020
	heavy	correlation	-0.0281	-0.4550	-0.4296	0.2165
		p-value	0.5146	0.0001	0.0001	0.0001
Overall		correlation	0.0608	-0.3099	-0.2968	0.1385
		p-value	0.0564	0.0001	0.0001	0.0001

Category	Sub category		Access trails	Satellite sites	Clean-liness	Core area	Total score
Aspect	NE	correlation	0.2081	-0.1852	-0.3117	-0.0528	-0.2760
		p-value	0.0063	0.0153	0.0001	0.5329	0.0003
	SE	correlation	0.2567	-0.2376	-0.0163	-0.0638	-0.2151
		p-value	0.0001	0.0001	0.7397	0.2399	0.0001
	SW	correlation	0.3440	-0.1899	-0.0449	-0.0963	-0.0841
		p-value	0.0001	0.0034	0.4923	0.1761	0.1979
	NW	correlation	0.1606	-0.3513	-0.1671	-0.1372	-0.2033

		p-value	0.0406	0.0001	0.0330	0.1152	0.0093
Campfire	NF	correlation	0.2523	-0.2173	-0.0660	-0.0821	-0.0208
		p-value	0.0001	0.0001	0.0546	0.0301	0.5448
	CF	correlation	0.2532	-0.3412	-0.3630	-0.0777	-0.2123
		p-value	0.0027	0.0001	0.0001	0.4053	0.0124
Campsite type	group	correlation	0.1582	-0.1898	-0.3309	-0.2615	-0.1066
		p-value	0.2444	0.1611	0.0128	0.0792	0.4343
	group/	correlation	0.3514	-0.1778	-0.1366	-0.0688	-0.0562
	stock	p-value	0.0262	0.2725	0.4008	0.6991	0.7307
	individual	correlation	0.2521	-0.2396	-0.0864	-0.0647	-0.0322
		p-value	0.0001	0.0001	0.0112	0.0845	0.3446
	llama	correlation	0.4556	-0.1444	0.0024	-0.3152	-0.0815
		p-value	0.0500	0.5554	0.9922	0.2524	0.7400
	stock	correlation	0.0177	-0.8000	-0.2125	-0.7303	-0.7906
		p-value	0.9640	0.0096	0.5831	0.0397	0.0112
Distance	close	correlation	0.0971	-0.1425	-0.1665	-0.0509	-0.2740
		p-value	0.2453	0.0873	0.0453	0.5778	0.0009
	middle	correlation	0.3440	-0.2541	-0.1159	-0.0338	-0.1821
		p-value	0.0001	0.0001	0.0140	0.5187	0.0001
	far	correlation	0.2627	-0.2492	-0.0107	-0.1271	-0.1530
		p-value	0.0001	0.0001	0.8379	0.0272	0.0033
Elevation	low	correlation	0.2215	-0.2617	-0.1829	-0.0373	-0.2371
		p-value	0.0001	0.0001	0.0007	0.5323	0.0001
	moderate	correlation	0.2738	-0.2128	-0.0450	-0.0927	-0.1733
		p-value	0.0001	0.0001	0.2708	0.0392	0.0001
	high	correlation	0.1983	-0.4036	-0.1951	-0.1546	-0.1672
		p-value	0.1916	0.0060	0.1991	0.3610	0.2723
Use	feather	correlation	-0.3254	-0.0327	-0.3084	0.0326	-0.2249
		p-value	0.0174	0.8164	0.0247	0.8170	0.1054
	light	correlation	-0.1482	-0.1333	0.0319	-0.2114	-0.1582
		p-value	0.0435	0.0698	0.6658	0.0045	0.0311
	heavy	correlation	0.2739	-0.3256	-0.1686	-0.0979	-0.3293
		p-value	0.0001	0.0001	0.0001	0.0546	0.0001
Overall		correlation	0.2519	-0.2344	-0.1009	-0.0813	-0.0374
		p-value	0.0001	0.0001	0.0015	0.0203	0.2406

Correlations Between Sub-categories for Method Two Excluding Vegetative Cover, Root and Shrub damage

Significant ($\alpha = 0.05$) changes between sub-categories within each category over time for method two variables excluding vegetative cover, shrub and root damage.

Category	Sub category		Social trails	Access trails	Satellite sites	Clean-liness	Core area	Total score
Aspect								
	NE	correlation	0.1876	0.2004	-0.2124	-0.3478	-0.0854	-0.3211
		p-value	0.0158	0.0099	0.0062	0.0001	0.3213	0.0001
	SE	correlation	0.0344	0.2650	-0.2518	-0.0237	-0.0599	-0.2429
		p-value	0.4950	0.0001	0.0001	0.6382	0.2829	0.0001
	SW	correlation	0.1700	0.3464	-0.2067	-0.0596	-0.0927	-0.1062
		p-value	0.0108	0.0001	0.0019	0.3749	0.2059	0.1128
	NW	correlation	0.2585	0.1530	-0.3708	-0.1862	-0.1368	-0.2210
		p-value	0.0011	0.0557	0.0001	0.0196	0.1250	0.0054
Campfire								
	NF	correlation	0.1241	0.2487	-0.2391	-0.0837	-0.0848	-0.2074
		p-value	0.0004	0.0001	0.0001	0.0174	0.0297	0.0001
	CF	correlation	0.1861	0.2849	-0.3322	-0.3444	-0.0777	-0.2986
		p-value	0.0295	0.0007	0.0001	0.0001	0.4053	0.0004
Campsite Type								
	group	correlation	0.3112	0.2307	-0.1537	-0.2932	-0.2615	0.0298
		p-value	0.0207	0.0902	0.2627	0.0298	0.0792	0.8288
	group/	correlation	0.2991	0.3514	-0.1778	-0.1366	-0.0688	0.1457
	stock	p-value	0.0609	0.0262	0.2725	0.4008	0.6991	0.3696
	indivdual	correlation	0.1193	0.2487	-0.2617	-0.1056	-0.0664	0.0189
		p-value	0.0006	0.0001	0.0001	0.0025	0.0854	0.5889
	llama	correlation	0.3485	0.4556	-0.1444	0.0024	-0.3152	0.1713
		p-value	0.1437	0.0500	0.5554	0.9922	0.2524	0.4833
	stock	correlation	-0.6325	0.0177	-0.8000	-0.2125	-0.7303	-0.7944
		p-value	0.0676	0.9640	0.0096	0.5831	0.0397	0.0105
Distance								
	close	correlation	0.1988	0.1206	-0.1275	-0.1539	-0.0509	-0.2480
		p-value	0.0169	0.1500	0.1277	0.0655	0.5778	0.0027
	middle	correlation	0.1101	0.3495	-0.2768	-0.1385	-0.0224	-0.2237
		p-value	0.0235	0.0001	0.0001	0.0043	0.6804	0.0001
	far	correlation	0.1321	0.2526	-0.2771	-0.0317	-0.1479	-0.1875
		p-value	0.0131	0.0001	0.0001	0.5532	0.0120	0.0004
Elevation								
	low	correlation	0.1931	0.2443	-0.2619	-0.1802	-0.0303	-0.2266
		p-value	0.0004	0.0001	0.0001	0.0010	0.6172	0.0001
	moderate	correlation	0.1105	0.2633	-0.2433	-0.0718	-0.0999	-0.2236
		p-value	0.0085	0.0001	0.0001	0.0875	0.0317	0.0001
	high	correlation	-0.0449	0.1983	-0.4036	-0.1951	-0.1546	-0.1672
		p-value	0.7696	0.1916	0.0060	0.1991	0.3610	0.2723
Use								
	feather	correlation	0.0268	-0.3699	-0.0498	-0.3449	0.0176	-0.2774
		p-value	0.8533	0.0082	0.7313	0.0142	0.9037	0.0511
	light	correlation	-0.2397	-0.1619	-0.1400	0.0289	-0.2143	-0.1748
		p-value	0.0013	0.0313	0.0631	0.7023	0.0050	0.0200
	heavy	correlation	0.2198	0.2823	-0.3375	-0.1780	-0.0883	-0.3488
		p-value	0.0001	0.0001	0.0001	0.0001	0.0902	0.0001
Overall		correlation	0.1333	0.2523	-0.2524	-0.1165	-0.0836	0.0244
		p-value	0.0001	0.0001	0.0001	0.0003	0.0199	0.4540

APPENDIX C

CART DECISION TREE ANALYSIS

CART Decision Tree Analsysis

A useful tool for making sense of the six categories and their sub-categories and is the CART decision tree program for analysis (Steinberg and Colla, 1995). CART is a non-parametric statistical program that allows both categorical and numerical variables to be used to create a decision tree which yields the best grouping of data, in this data the six independent variables were grouped. CART uses a series of yes/no questions to make the decision tree based on the most important factors to make each decision.

CART was run on the BCIAMS data with campsite area as the dependent variable. The log of the area was used because it reduced area variance thereby allowing meaningful branching decisions which yielded better results. Campsites with missing area measurements were dropped from the analysis. Total score was not used as a factor on which to make a decision tree due to the poor results, large variance, and the unreliability of this data.

Nine nodes were produced in the decision tree based on campsite area. Each node is a branch of the decision tree. There are 10 terminal nodes. The terminal node represents the end of a branch where no further yes/no decisions can be meaningfully made. It should be noted that the splits that CART generated for dividing each category are extremely close to how the categories were broken down for analysis in this study.

There are 227 campsites in the database, with area measurements for up to eight years each for a total of 1047 data points. Starting at node 1 at the top of the tree sites

(848 records) are different in area than group, group/stock, stock, and llama (120

records). If node 1 is followed to node 2, is can be seen that the next most important factor in determining campsite area is if it is a group site or if it is a group/stock, stock, and llama. Group campsites are in one category as shown by the terminal node number 3 (55 records).

If a campsite is not a group campsite, the next most important factor is aspect. Those sites with aspects less than 130 have similar areas (terminal node 1 one has nine records), and those sites with aspects greater than 130 (terminal node 2 with 56 records). If node 1 is followed to node 4, a different set of branches and terminal nodes can be followed.

Terminal node 8 is particularly interesting. There are 16 records in this terminal node. They are all individual campsites that are far from the trailhead and at high elevations. These campsites (8 years of data on three campsites is 16 records) are the Boulderfield which is located well above treeline in a boulder field (12,760 feet, 3890 meters), July which is located at treeline (11,760 feet, 3585 meters), and Stormy Peaks which is located at treeline (11,160 feet, 3402 meters). The decision tree has shown that these sites are unique in their campsite area, as was expected.

The branches and nodes of the decision tree fall very close to groupings of sub-categories in the BCIAMS analysis. In future work, a tree can be set up before analysis to better decide on ranges of sub-categories for analysis.

Decision Tree for the log area of campsites

G, G/S, S, L (120) — **1** — I (848)

G/S, S, L (65) — **2** — G (55)

3 (55)

Distance < 7.55 (777) — **4** — Distance > 7.55 (71)

Aspect < 130 (9) — **3** — Aspect > 130 (56)

1 (4)

2 (56)

Elevation < 11025 (761) — **5** — Elevation > 11025 (16)

8 (16)

Use < 87.25 (54) — **9** — Use > 87.25 (17)

9 (54)

10 (17)

Distance < 2.25 (169) — **6** — Distance > 2.25 (592)

7 (592)

Aspect < 77.5 (26) — **7** — Aspect > 77.5 (143)

4 (26)

Elevation < 10109 (123) — **8** — Elevation > 10109 (20)

5 (123)

6 (20)

Legend:

Node = Terminal Node = #

G = Group G/S = Group/stock

Number of campsites per terminal node = (#)

S = Stock L = llama I = Individual

APPENDIX D

DATA SHEETS FOR METHOD ONE

ROMO 187 (5/92) CAMPSITE INVENTORY DATA SHEET SUBDISTRICT:

1. Site name: 2. Site code:

3. Site type: a. Individual, b. Group, c. Horse, d. x-country zone, e. Bivouac site, f. Other

4. Recorder: 5. Date: 6. Drainage:

7. Location: UTME. UTMN

8. Elevation (nearest (10') 9. Aspect: 10. Slope

11. Estimated tent capacity: 12. Main trail/rout number:

13. Distance from main trail (ft.)

14. Number of social trials and/or way trails:

15. Closest water source for site: 16. Distance from site (ft.)

17. Crowding (Distance, Direction, Visible ?, Audible?):

18. Does the site have a privy: 19. Distance to nearest water:

20. Points of interest:

21. Dimensions: a. Length max: Width max: Area total:

22. Birds/Rodents: 23. Habitat of the site:

24. Understory moisture class: X = Xeric, MX = Mesoxeric, XM = Xeromeso, M = Mesic

25. Impact rating score: 26. Improved rating score is site is maintained:

27. Expansion potential/restraints:

28. Potential for fire to spread: (high, medium, low)

29. Canopy cover directly over the site:
O = Open (Less than 30%), I = intermediate (30-50%), C = Closed (75% or more)

30. Comments or discussion: (include discussion on potential for the site to get worse and what can be done to improve it. I.e. Stoves only, put in a tent pad.)

ROMO 188 (6/95) IMPACT RATING SUMMARY SHEET FOR INDIVIDUAL, GROUP AND STOCK SITES

Numerical Scores from Rating sheet:

1. Vegetation cover
   - a. % overstory _____
   - b. % understory _____
   - c. distribution _____
2. Tent pad
   - a. erosion _____
   - b. excavations and trenches _____
3. Vegetative litter
   - a. % cover _____
   - b. distribution of what is present in the site _____
   - c. condition _____
4. Access trails
   - a. number _____
   - b. width _____
   - c. depth _____
   - d. profile _____
5. Side trails
   - a. number _____
   - b. width _____
   - c. depth _____
6. Satellite sites
   - a. number _____
   - b. condition _____
7. Shrub damage: in and adjacent to site
   - a. % damaged, reduced vigor _____
   - b. root exposure _____
8. Tree damage: in and adjacent to site
   - a. broken limbs, gashes, etc. _____
   - b. root exposure _____
9. Human waste
   - a. toilet paper _____
   - b. fecal matter _____
10. Fire pits
    - a. number _____
    - b. rock scarring _____
    - c. charcoal and ash _____
11. Trash _____
12. Land form shape _____
13. Elevation _____
14. Core area _____

ROMO-190 Backcountry Impact Assessment and Monitoring System

11/89 BACKPACKING CAMPSITE IMPACT RATING KEY FOR DESIGNATE SITES INCLUDING GROUP AND HORSE/PACK STOCK SITES

Item Rated	Excellent		Good		Fair		Poor	
1. VEGETATION COVER								
a. % overstory	20% reduction in contrast to adjacent areas	0.5	20-40% reduction	1.0	40-80% reduction	1.5	>80% reduction	2.0
b. % understory	20% reduction in contrast to adjacent areas	1.0	30-40% reduction	2.0	40-80% reduction	3.0	>80% reduction	3.5
c. Distribution	Vegetation evenly distributed throughout site	1.0	20% of vegetation in site is accumulated or appearing in distinct isolated "islands" around shrubs or other stable objects.	2.0	20-50% of veg. Built up in "islands"	3.0	>50% of vegetation appearing in "islands	4.5
2. TENT PAD								

Item Rated	Excellent		Good		Fair		Poor	
a. Erosion	Site(s) for tents in good shape; no plant roots exposed. Site is level. Site next to arrowhead used the most	1.5	Loss of soil evident in contrast to adjacent undisturbed area. Site(s) for tents still in good shape. No plant roots exposed. Campsite is not level, however, site next to arrowhead still sued to most. Potential for site getting worse is low.	3.0	Loss of soil evident in contrast to adjacent undisturbed area. Some plant roots are exposed in site near the arrowhead but site is still useable. Site is not level. Other sites away from arrowhead frequently used. Potential for site getting worse is medium. Some rilling occurring within the campsite. Hardening rent pad is recommended.	4.5	Plant roots are exposed at site near the arrowhead. Designated site presently is not useable for a tent. Satellite sites heavily used. Potential for site getting worse is high. Rilling occurring within the campsite. Hardening tent pad necessary.	6.0
b. Excavations and trenches	None present	1.5	1 or 2 trenches. Other excavations present	3.0	3-4 trenches or other excavations present.	4.5	4 excavations or trenches present.	6.0
3. VEGETATIVE LITTER								
a. % cover	20% reduction i contrast to adjacent areas of similar habitat	1.0	20-30% reduction in contrast to adjacent undisturbed areas of similar habitat	2.0	40-60% reduction in contrast to adjacent undisturbed areas of similar habitat	3.0	>60% reduction in contrast to adjacent undisturbed areas of similar habitat	4.0
b. Distribution of what is present in the site	Evenly distributed	1.0	50% of litter concentrated around base of stable objects and edges of site	2.0	50-80% of litter around base of stable objects and edge of site	3.0	>80% of litter around base of stable objects and edges of site	4.0
c. Condition	No obvious signs of broken or crushed litter	1.0	40% of litter appears crushed or broken	2.0	40-80% appears crushed or broken	3.0	80% appears crushed of broken	4.0
4. ACCESS TRAILS								

Item Rated	Excellent		Good		Fair		Poor	
a. Number	Only 1 access trail to site from main trail and/or one trail to toilet	0.5	2 access trails to site from main trail and/or toilet	1.0	3 access trails to site from main trial and/or toilet	1.5	>3 access trails to site from main trail and/or toilet	2.0
b. Width	Trail(s) average width of 12"	0.5	Avg. Width of trail(s) 12-18"	1.0	Avg. Width of 18" on trails and 2 merging in one location	1.5	Avg. Width of 18" >2 trails, merging in one location	2.0
c. Depth	Trail(s) even with ground level when viewed in cross-section	0.5	1 trail eroded below ground level when viewed in cross-section	1.0	2 trails eroded below ground level when viewed in cross-section	1.5	>2 trails eroded below ground level when viewed in cross-section	2.0
d. Profile	Trail(s) show no erosion along profile from main trial to the site	0.5	1 trail shows erosion in 2 or more places	1.0	Trail(s) show erosion throughout most of its length but restoration is feasible.	1.5	Trails(s) severely eroded, should be rerouted, restoration will be difficult	2.0
5. SIDE TRAILS								
a. Number	No more than 2 social or way trails, no spur trails off of the trails. One trail leading to a destination point such as a lake, viewpoint, cliff.	1.5	2-4 side trials present, no spur trails off of side trails. 2 side trails leading to different destination points.	3.0	4-6 side trails. No more than 2 spur trails present off these trails. Footprints off trails and/or matted vegetation apparent. 2-4 side trails lead to destination points. 2 trails lead to the same destination point.	4.0	6 side trails. More than 2 spur trails present. Footprints off trails and/or matted vegetation may be apparent. More than 4 side trails lead to same destination or point. >2 trails lead to same destination point.	5.0
b. Width	Average width: 12"	1.0	Average width of 1 trail, >12"	2.0	Avg width of 2-3 trails 12" wide and/or trails merging in 1 location	3.0	All trails 12" wide and/or trails merging in >1 location	4.0

Item Rated	Excellent		Good		Fair		Poor	
c. Depth	Trail at same level as adjacent area	1.0	1 trail worn below ground surface of adjacent area	2.0	2-3 trails worn below ground surface of adjacent area	3.0	>3 trails worn below ground surface of adjacent area	4.0
6. SATELLITE SITES								
a. Number	None Present	1.0	1 present	2.0	2 present	3.0	3 or more	4.5
b. Condition	No area outside the main site is disturbed	1.0	30% vegetation reduction in contrast to surrounding undisturbed area	2.0	30-60% vegetation reduction in contrast to surrounding undisturbed area	3.0	>60% of vegetation reduction in contrast to surrounding undisturbed area	4.0
7. SHRUB DAMAGE In and adjacent to site								
a. % damaged, reduced vigor	No damage apparent or no shrubs present adjacent to the site	1.5	Less than 20% of shrubs present in or adjacent to the site show damage (broken limbs, crushed limbs)	3.0	20-40% of present shrubs show damage in or adjacent to the site	4.5	>40% of shrubs show damage in or adjacent to the site	6.0
b. Root exposure	1 shrub has exposed roots showing in or adjacent to the site	1.5	Exposed roots on 2 shrubs	3.0	Exposed roots on 3 shrubs	4.5	Exposed roots on 4 shrubs	6.0
8. TREE DAMAGE In and adjacent to site								
a. Broken limbs, gashes, etc.	No damage, or no trees present	1.0	20% of trees show human caused damage within or adjacent to the site	2.0	20-50% of trees show human caused damage in or adjacent to the site	3.0	>50% or trees in or adjacent to the site show damage	4.0
b. Root exposure	No roots exposed, or no trees present	1.0	1-2 roots exposed	2.0	3-4 roots exposed	3.0	More than 4 roots exposed in site	4.0

Item Rated	Excellent		Good		Fair		Poor	
9. HUMAN WASTE								
a. Toilet paper	None present in or adjacent to the site	1.0	1-2 pieces of toilet paper present in or adjacent to the site	2.0	2-4 pieces of toilet paper in or adjacent to the site	3.0	>4 pieces of toilet pater in to adjacent to the site	4.0
b. Fecal matter	None present	1.0	1 pile of feces encountered in or adjacent to the site	2.0	2 piles of feces encountered in or adjacent to the site	3.0	>2 pieces of feces encountered	4.0
10. FIRE PITS								
a. Number	None present	1.0	Designated fire ring present	2.0	1 designated fire ring present and/or sign of one illegal ring	3.0	1 designated fire ring present and 2 or more other fire rings	4.0
b. Rock scarring	None	0.5	1 prominent rock shows a fire scar that is not part of a designated fire ring	2.0	2 prominent rocks or boulders show fire scars that is not part of a designated fire ring	3.0	>2 prominent rocks show scarring	4.0
c. Charcoal and ash	None Present	0.5	Charcoal and ash in the site can easily be removed or scattered and the site restored to natural conditions	2.0	Charcoal and ash concentrated 3 in a pile away from the fire ring in a designated fire site or present in a non-designated site	3.0	Charcoal and ash scattered throughout site, mixing into soil. Soil would have to be removed to remove the ash or charcoal	4.0
11. TRASH	0-5 pieces of biodegradable or non-biodegradable tras h present	1.0	6-10 pieces of biodegradable or non-biodegradable trash present	2.0	10-20 pieces of biodegradable or non-biodegradable trash present	3.0	>20 pieces of trash present	4.0

Item Rated	Excellent		Good		Fair		Poor	
12. LAND FORM SHAPE	Core area of the campsite is level. No constructed tent pad present	2.0	Core area has no more than a 5% slope. Potential for erosion or gullying in the future is minimal or tent pad had been constructed	3.0	5-10% slope in the core area of the site. Potential for erosion or gullying in the future is moderate. Hardeningthe site with a tent pad is recommended or has been done. Potential for the site to get worse is moderate	4.5	>10% slope. Potential for the site to get worse is high, closing the site recommended	6.0
13. ELEVATION	Site is not higher than 9,000 ft. Above sea level	1.0	Site is 9,000 to 10,000 ft. Above sea level	2.0	Site is 10,000 to 11,000 ft above sea level	3.0	Site is above 11,000 ft.	4.0
14. CORE AREA	75% of the total disturbed are is the core are of the site and not satellite sites	1.0	51-75% of the total disturbed area is the core area of the site	2.0	21-50% of the total disturbed area is the core area of the site	3.0	20% of the total disturbed area is the core area of the site	4.0

APPENDIX E

DATA SHEETS FOR METHOD TWO

ROMO-187 (8/95) ROCKY MOUNTAIN NATIONAL PARK

Backcountry Campsite Impact Assessment and Monitoring System

Campsite Inventory Form

General campsite information

1. Site Code:

2. Site Name:

3. Site Type: ( ) Individual ( ) Group ( ) Stock

4. Recorder(s): _____

5. Date: ____/____/____

6. Location: UTME _____ UTMN _____
( ) Tent Pad(s) # ___

7. Elevation: _____ (nearest 10')

8. Aspect: _____

9. Slope: _____

10. Distance from site to main trail: _____ (in feet)

11. Distance from site to water: _____ (in feet)
Type: ( ) River/Creek ( ) Lake/Pond ( ) Spring ( )Wetland

12. Distance from privy to water: _____ (in feet)
Type: ( ) River/Creek ( ) Lake/Pond ( ) Spring ( )Wetland

13. Soil moisture class: ( ) Dry ( ) Moist ( ) Wet

14. Habitat of site: ( ) Meadow ( ) Ponderosa ( ) Aspen
( ) Lodgepole ( ) Spruce/Fir ( ) _____

15. Screening from other sites/main trail:
( )Complete ( ) Partial ( ) None

16. Firewood availability:
( ) Abundant <100' ( ) Abundant >100' ( ) None

17. Facilities: ( ) Fire Grate ( ) Food Storage ( ) Hitchrack
( ) Signs # ___

Privy Type:
( ) None
( ) Throne w/o screening
( ) Throne w/constructed screening
( ) Outhouse
( ) Solar
( ) Composting
( ) Other ___

Privy Capacity: ( ) 0-2 ft . ( )2-4 ft. ( ) 4-6 ft. ( ) >6 ft.

18. Area adequate for human waste catholes: ( ) Yes ( ) No

19. Campsite dimensions: (length x width in feet at widest points)
A. _____ B. _____ C. _____ Total: _____(sq ft)

20. Barren Core Dimensions: (length x width in feet at widest points)
A. _____ B. _____ C. _____
D. _____ E. _____F. _____ Total: _____(sq ft)

IMPACT RATING (Circle one category)

	0	1	2	3	Category impact rating
21. Vegetation/Ground Condition	Non-impacted	Impacted	Bare Ground	Eroded	
22. Tree/shrub damage (limbs broken, carved on, scarred, felled)	None	1-20% damaged	21-50% damaged	>50% damaged	
23. Root exposure	None	1-20% or trees/shrubs with exposed roots	21-50% of trees/shrubs with exposed roots	>50% trees/shrubs with exposed roots	
24. Social trail(s) (non-designated)	None	No more than 1 discernable	2-3 discernable or max 1 well worn	>3 discernable or >1 well worn	
25. Access trail(s) Tread conditions	No erosion/widening impact	1-3" deep and/or 12-18" wide	3-6" deep and/ore 18-24" wide	>6" deep and/or >24" wide	
26. Illegal satellite site(s)	None	1	2	>2	
27. Cleanliness (# illegal fire sites/scars, feces, tp)	Unnoticeable	1 fire scar some ashes scattered 1-2 feces/tp visible	2 fire scars ashes scattered noticeable 3-4 feces/tp visible	>2 fire scars ashes concentrated >4 feces/tp visible	
28. Barren core camp area (sq ft)	(Individual site) <400'	400' - 800'	801' - 1,200'	>1,200'	
	(Group/stock site) <800'	800' - 1,200'	1,200' - 2,000'	>2,000'	

Impact Rating _____

30. COMMENTS: (management suggestions, site problems, potential impacts, reference to numbered item(s))

APPENDIX F

DATA SHEETS FOR 1996 FIELD STUDIES

Instructions for Spherical Densiometer Study:

Lisa and Dan,

There are two parts to your mission, should you choose to accept it.

1) Please take the spherical densiometer (which I will leave with Dan in dispatch for the duration of the study) to the following sites and record measurements on the data sheet below. Just record the number of quarter-squares, I can get the computer to do all the calculations. Please visit each of the 6 sites once during each of the following times periods:

July 1-July 14th, and August 18-August 31st.

I only have one densiometer, so please coordinate your use of it as your schedule allows. You may hike together, but you must complete your own work. If a campsite has more than one site, just evaluate the site highlighted on the site map.

2) While visiting the sites (in July only) please fill out the site evaluations. There are two evaluation sheets (method 1 and method 2) for each site. Instructions for completing evaluations are included. Evaluations must be completed in the order listed.

Thank you for all your help. I would not be able to complete the study without you. If you have any questions please do not hesitate to ask.. Vicki Steele 586-4975.

Dan:			**Lisa:**		
Site	**Order of Evaluations**		**Site**	**Order of Evaluations**	
Pine Ridge	1	2	Pine Ridge	1	2
Thunder Lake	1	2	Thunder Lake	2	1
Arch Rocks	2	1	Arch Rocks	1	2
Odessa Lake	2	1	Odessa Lake	1	2
Golden Banner	1	2	Golden Banner	2	1
Ute Meadows	2	1	Ute Meadows	1	2
Goblins Forest	1	1	Goblins Forest	2	2
Upper Ouzel	2	2	Upper Ouzel	1	1

Data Sheet for Spherical Densiometer: **Name** _____ **Date**_____

Site _____

Direction	**Number of Quarter-Squares**
North	___ ___ ___ ___
South	___ ___ ___ ___
East	___ ___ ___ ___
West	___ ___ ___ ___

Notes: _____
Notes: _____
Notes: _____

Site _____

Direction	**Number of Quarter-Squares**
North	___ ___ ___ ___
South	___ ___ ___ ___
East	___ ___ ___ ___
West	___ ___ ___ ___

Notes: _____
Notes: _____
Notes: _____

Site _____

Direction	**Number of Quarter-Squares**
North	___ ___ ___ ___
South	___ ___ ___ ___
East	___ ___ ___ ___
West	___ ___ ___ ___

Notes: _____
Notes: _____
Notes: _____

Site _____

Direction	**Number of Quarter-Squares**
North	___ ___ ___ ___
South	___ ___ ___ ___
East	___ ___ ___ ___
West	___ ___ ___ ___

Notes: _____
Notes: _____

Site _____

Direction	**Number of Quarter-Squares**
North	___ ___ ___ ___
South	___ ___ ___ ___
East	___ ___ ___ ___
West	___ ___ ___ ___

Notes: _____
Notes: _____
Notes: _____

Site _____

Direction	**Number of Quarter-Squares**
North	___ ___ ___ ___
South	___ ___ ___ ___
East	___ ___ ___ ___
West	___ ___ ___ ___

Notes: _____
Notes: _____

Site _____

Direction	**Number of Quarter-Squares**
North	___ ___ ___ ___
South	___ ___ ___ ___
East	___ ___ ___ ___
West	___ ___ ___ ___

Notes: _____
Notes: _____

Hello Volunteers!

Thank you for your time in this project.

Inside this packet you will find the names of your sites, order you are to perform the evaluations, instructions to complete the evaluations, site maps, and data sheets.

You will have two weeks to complete the project. You may evaluate the sites any time between July 1 and July 14th.

Please feel free to hike with others, but be sure to complete your work without any suggestions or discussions from others.

It is also important that you complete the evaluations in the order assigned.

If there are more than one site at your campsite, complete only the evaluation on the site which highlighted on the site map.

Any questions, please do not hesitate to call me at 586-4975 or 586-3861.

Please return the data sheets to me when you are through. Have fun and enjoy your hikes.

Again, I, the park, and my thesis committee thank you for your time.

Sincerely,

Vicki Steele
Wild Basin Ranger Station
Rocky Mountain National Park
Estes Park, CO 80517

BCIAMS STUDY INSTRUCTIONS

Instructions common to each evaluation:

1. Fill out only the information indicated below

3. Do not draw a site map

3. Make estimates for ratings based on your gut feeling and information provided in the data sheets, do not discuss your decisions with others

4. Complete the evaluations on both sites in the order indicated in your assignment

Instructions for completing evaluation Number 1

1. Fill out the entire sheet.

2. To estimate size, pace the site (widest spot by narrowest spot), or estimate. Do not use a tape measure. Indicate how you came up with the measurement on the data sheet.

Instructions for completing evaluation Number 2

1. On side 1 (general information), fill out only the following information:
Numbers 2, 4, 5, 10, 11, 12, 15, 16, 19, 20

2. On side 2 (Impact rating), circle the appropriate square for each category.

3. To estimate size, pace the site (widest spot by narrowest spot), estimate, or use a tape measure. Indicate how you came up with the measurement on the data sheet.

Data sheet for evaluation number 1

General Information:

Site: _____

Name: _____ Date:_____

Distance from main trail (ft). _____ Distance to water (ft.) _____

Dimensions: Length Max: _____ Width Max: _____ Area Total: _____

How did you measure the site?

_____

Canopy cover directly over the site: Less than 30% _____ 30-75% _____>75% _____

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IMPACT RATING SUMMARY SHEET FOR INDIVIDUAL, GROUP AND STOCK SITES

Numerical Scores from Rating sheet:

1. Vegetation cover
   - a. % overstory _____
   - b. % understory _____
   - c. distribution _____
2. Tent pad
   - a. erosion _____
   - b. excavations and trenches _____
3. Vegetative litter
   - a. % cover _____
   - b. distribution of what is present in the site _____
   - c. condition _____
4. Access trails
   - a. number _____
   - b. width _____
   - c. depth _____
   - d. profile _____
5. Side trails
   - a. number _____
   - b. width _____
   - c. depth _____
6. Satellite sites
   - a. number _____
   - b. condition _____
7. Shrub damage: in and adjacent to site
   - a. % damaged, reduced vigor _____
   - b. root exposure _____
8. Tree damage: in and adjacent to site
   - a. broken limbs, gashes, etc. _____
   - b. root exposure _____
9. Human waste
   - a. toilet paper _____
   - b. fecal matter _____
10. Fire pits
    - a. number _____
    - b. rock scarring _____
    - c. charcoal and ash _____
11. Trash _____
12. Land form shape _____
13. Elevation _____
14. Core area _____

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