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Maintenance and Survival of Vegetation on the Sunrise Campground, Cache National Forest

Alan R. Silker
Utah State University

MAINTENANCE AND SURVIVAL OF VEGETATION
ON THE SUNRISE CAMPGROUND,
CACHE NATIONAL FOREST

by

Alan R. Silker

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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in

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Maintenance and Survival of Vegetation

On the Sunrise Campground,

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by

Alan R. Silker, Master of Science

Utah State University, 1972

Major Professor: Dr. Philip A. Barker
Department: Forest Science

The goal of this study was to determine if watering and fertilizing would help maintain favorable vegetation conditions on forested recreation sites. Sunrise Campground on the Cache National Forest in northern Utah was the study site. Treatment applications of water and nitrogen-phosphorous fertilizer were made from 1964 through 1968.

Covariance analysis of variables indicated that all treatments produced significantly greater amounts of ground cover vegetation than control plots. Ground cover response to treatments was greater under aspen than under coniferous overstory, and treatments under aspen produced differences in appearance of vegetation. There were no significant differences in diameter growth of overstory trees. The results showed that watering and fertilizing are effective management tools for maintaining ground cover.

(48 pages)

INTRODUCTION

Problem

When outdoor recreation sites are opened for public use, the vegetation on the sites becomes susceptible to damage. Specifically, plant cover on campgrounds may be reduced significantly as a result of one year of use (LaPage, 1963). Other researchers, including Frisell and Duncan (1965), Magill and Nord (1963), and Meinecke (1928), have shown that recreational use of campground sites results in losses of grasses, forbs, and shrubs. Furthermore, soils may become compacted (Lutz, 1945), which further reduces plant growth (LaPage, 1962).

Vegetation damage or loss is often unsightly in recreation areas and problems of dust and mud can be a result as well. If maintenance methods could be developed, the need for extensive rehabilitation of vegetation could be eliminated.

Objectives

The objective of this study was to find ways of maintaining natural vegetation on a forested recreation site. The deterioration of vegetation on outdoor recreation sites has long been recognized, but only recently have attempts been made to develop management techniques for maintaining vegetation on these sites. Watering, cultivation, fertilizing, and use of paved pathways have been standard procedures for vegetation maintenance in urban areas for many years. Their effectiveness needs to be evaluated for recreation sites in forest settings.

Hypothesis

The hypothesis of this study was that watering and fertilizing treatments will maintain natural vegetation on a forested recreation site. These treatments may enable enhanced plant growth and thus more rapid recovery from trampling damage.

STUDY METHODS

Study area

The study involved the 27 family units of Sunrise Campground (Figure 1) which were constructed in 1963 and 1964. The campground is located along United States Highway 89 on the Cache National Forest 35 miles east of Logan, Utah. Highway 89 is a heavily traveled route leading to Yellowstone National Park. The campground is 7,500 feet above sea level. Situated on a small "bench" on the east slope of the Bear River Mountains, the area receives an average of 29 inches of annual precipitation occuring mostly as snow in the winter.

The north loop of the campground had a nearly pure stand of quaking aspen (Populus tremuloides); the south loop a nearly pure stand of lodgepole pine (Pinus contorta); and the overstory between these areas was mixed conifer composed of lodgepole pine, Douglas fir (Pseudostuga menziesii), and subalpine fir (Abies lasiocarpa). The aspen stand was approximately 60 years old. It appeared to be vigorous, although reproduction was sparce. The conifer stand was approximately 120 years old and reproduction in it was generally more abundant.

The ground in the aspen stand was generally covered with herbaceous vegetation consisting of a variety of grasses and forbs. In the conifer stand there was little herbaceous cover but instead a layer of needles and litter. Shrubs in the campground were widely scattered and included snowberry (Symphoricarpos spp.), serviceberry

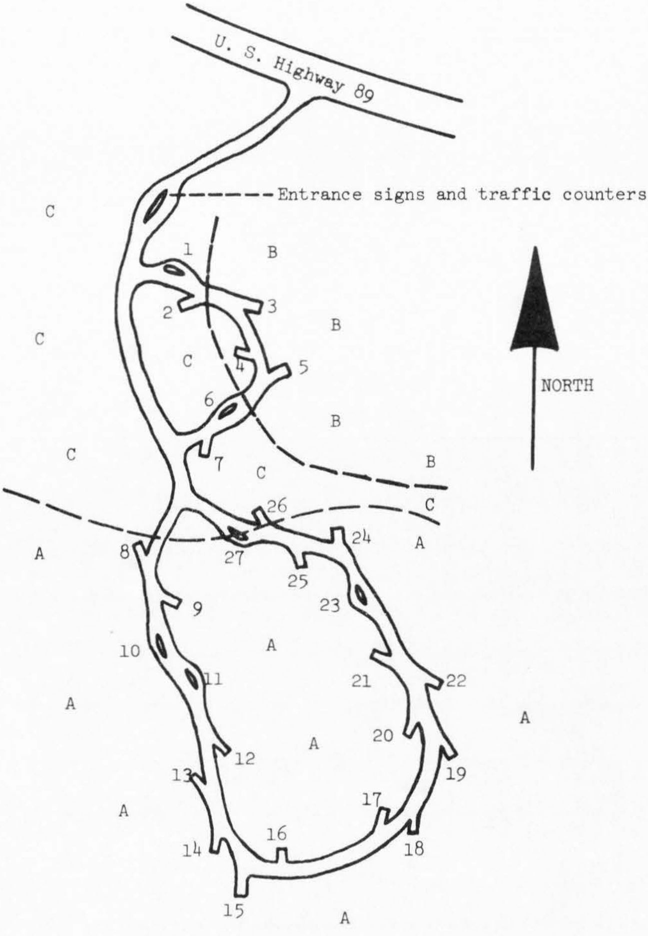

Figure 1. General layout of Sunrise Campground and location of the 27 family units. Soil types A, B, and C (described in Table 1) are indicated.

(*Amelanchier alnifolia*), sagebrush (*Artemesia tridentata*), and rose (*Rosa woodsii*). The area has a history of grazing by sheep and cattle.

The soils in the campground have been described by Olson (1965) and are summarized in Table 1. They are essentially silty clay under the aspen and silty clay loam under the conifers (Figure 1). They average 3 to 5 feet in depth.

General procedures

To trace changes in vegetation, two types of plots were established in 1963, and individual trees were selected for growth measurements. At each of the 27 family units, a square, .064-acre plot was established to record the general condition and survival of trees in the zone expected to receive the heaviest wear. These .064-acre plots also served as areas for the application of treatments. Within each .064-acre plot, 16 circular mil-acre plots were established in which to record the condition and change in understory vegetation under impact of recreational use.

In addition, individual aspen trees were selected within some of the .064-acre plots for study of their rate of growth. For comparison, additional aspen trees were selected beyond the immediate influence of family units.

Treatments consisting of water (W), nitrogen-phosphorous (F), a combination of these (WF), and control (C) were randomly assigned to the .064-acre plots. Two different seeding treatments were applied to 14 of the 27 plots in additon to the treatments of water and

Table 1. Summary of major soil characteristics and field appraisals of selected soil qualities and hazards (Olson 1965).

Soil symbol	Productivity potentials						Soil profile	
(Figure 1)	Aspen	Conifers	Forb-Grass	pH	Drainage	Compactability	Thickness	Texture
A	Med.	High	Med.	Strongly acid	Well	High	3-7 inches	Silty clay loam
B	High	High	Med.	Strongly acid	Well	Low	5-10 inches	Gravelly loam
C	Med.	?	High	Slightly alkaline	Mod. well	High	10-18 inches	Silty clay

fertilizer. Because the seeding treatments were not constant and did not represent treatment of vegetation, these plots were eliminated from the study. This left 13 plots of various treatments as listed previously.

Initial measurements were taken in the summer of 1965. Further measurements were recorded each successive summer through 1968. Treatment means were adjusted by covariance analysis for differences in independent variables (Table 2) so that comparison of means could be accomplished by statistical testing.

Table 2. Independent variables expected to have an effect on understory vegetation and radial trunk growth of trees.

Understory vegetation

1. Distance of plot from facilities
2. Competition from surrounding trees
3. Percent shrub cover
4. Soil pH and moisture holding capacity
5. Season-long insolation
6. Percent overstory in conifers
7. Visitor use
8. Number of days between beginning of vegetation measurements and measurement of each plot
9. Percent non-growing space
10. Percent ground cover initially present

Radial tree growth

1. Tree diameter
2. Competition from surrounding trees
3. Soil texture, depth, and moisture holding capacity
4. Visitor use
5. Distance of tree from facilities

Plot establishment and measurement
of dependent variables

The .064-acre plots. The .064-acre (52.8 feet square) plots were established to include portions of the family unit expected to receive the heaviest wear (Figure 2).

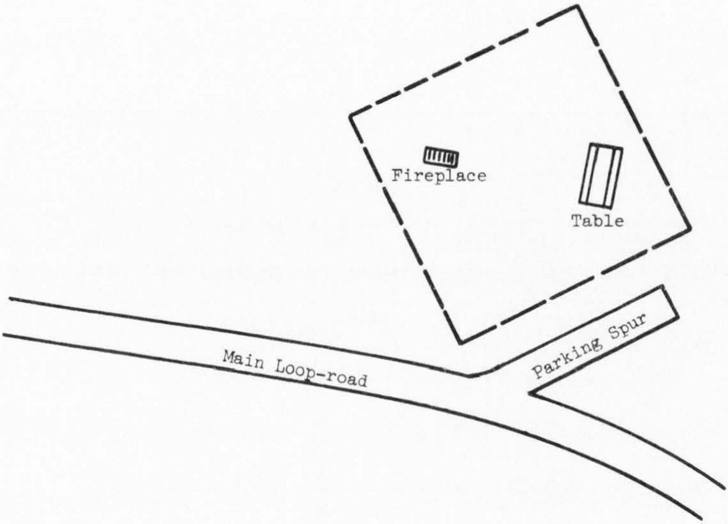

Figure 2. Representative positioning of the .064-acre plots.

Positioning of these plots was guided by the following principles. Plots included the planned locations of tables and fireplaces. Also, one side of the plot was placed close to the parking spur or loop.

Further, the plot was positioned to include areas expected to receive heavy trampling. Such areas included openings, routes from parking to tables, and paths to other facilities.

On each .064-acre plot the two corners farthest from the parking spur were marked with one-half inch diameter alnico, bar magnets buried about 3 inches in the ground. These corners could be located with the use of a compass. Because the corner markers were not visible, they were disturbed very little by visitors. Two reference trees near each of the marked corners were identified on the plot map and blazed with yellow paint near their bases on the side facing the corner. Plot centers were located 37.4 feet from the four corners.

From plot center, the position of every tree on each plot was plane-table mapped. The map scale was 1 inch=48 inches. Trees were numbered and recorded in a clockwise direction around the plot, beginning with a line from plot center to the most northerly (magnetic) corner of the plot. Along each bearing, numbering normally progressed from trees near the plot center to trees farther from center. Numbering did not always progress in a perfectly clockwise sequence, especially when the number of trees was large. However, the combination of the map and a tree tally sheet for each plot provided a positive identification for each tree.

Both numbered trees and seedlings were recorded on the tally sheet by species, distance from center of plot, and a description of damage or other characteristics likely to affect survival or thrift. Numbered trees were also listed by diameter and crown class (i.e.

dominant, codominant, etc.). For seedlings (DBH of 0.8 inch or less) total height was recorded in place of crown class. Initial overstory observations were made in September, 1965. At each annual measurement, tree mortality and damage on the .064-acre plots were recorded along with probable causes of death or injury.

Mil-acre plots and ground cover measurements. Within each of the .064-acre plots, 16, circular, mil-acre plots (radius of 3.72 feet) were established with plot centers spaced uniformly in a 13.2 by 13.2 foot pattern (Figure 3).

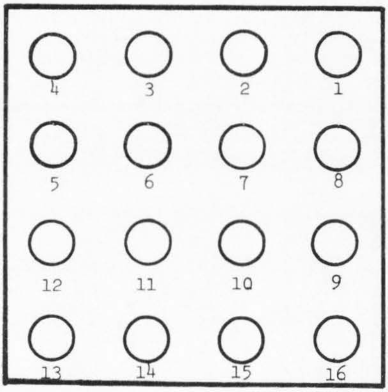

Figure 3. Arrangement and numbering of mil-acre plots (radius of 3.72 feet) within the .064-acre plots.

The plot positions and their numbers were also located on the maps prepared for each .064-acre plot. The mil-acre plot centers were marked with large metal pins which were buried a few inches in the ground so that they could be located only by using a metal detector.

On each mil-acre plot, the areas occupied by ground cover vegetation, shrub cover, litter, debris, rock (3 inches or more in diameter), bare soil, and stems of trees and shrubs were recorded to the nearest one-tenth percent. The area of ground cover vegetation and shrub cover were recorded as a percentage of plot area occupied by the estimated aerial area of stems and leaves. Estimation of ground and shrub cover was guided by use of a pie-shaped overlay consisting of a wooden frame and wire grid (Figure 4).

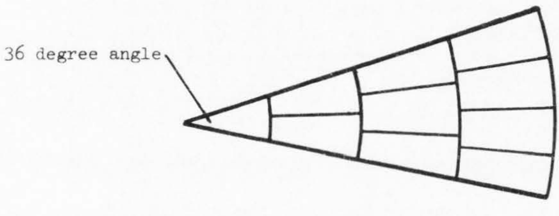

Figure 4. Grid overlay (radius of 3.72 feet) used to guide estimation of aerial parts of vegetation.

Designed to cover a 36 degree sector of the mil-acre plot, the overlay continually showed the estimator how much of the mil-acre plot was actually covered with aerial parts of herbaceous vegetation. Although trees and shrubs prevented the overlay from being placed over some parts of the plot, it was usually placed near enough to serve as a useful guide. The overlay was placed atop shrubs to guide estimation of their aerial parts.

Initial stocking was measured in 1965. Measurements were taken at the end of the growing season. Since ground cover measurements required over one week to be completed, the dates of measurement were recorded. It was felt that this procedure would account for variation that might be caused by apparent losses due to desiccation of plants late in the growing season.

For each plot the percentages of area in various species, litter, and other categories totaled 100 percent. Since shrubs were a different level of vegetation, they were not included in the 100 percent devoted to ground cover, but were recorded separately.

Mil-acre plots were examined to determine the percentage of each plot disturbed during the installation of facilities. Mil-acre plots within which facilities were constructed were eliminated from the study and were not remeasured.

Radial trunk growth of individual trees. On the .064-acre plots covered by aspen, 44 aspen trees were selected for radial trunk growth measurements by the dial-gauge (microdendrometer) method. This method was decided upon because of its precision and ease of measurement. The measured trees were tagged with a number for identification purposes. In stands that were similar but well away from family units, an additional 21 aspen trees were selected for radial growth measurements that could be compared to the "on-plot" trees.

At a height of ten feet above ground, each tree selected for radial growth measurement received three screws to form a reference plane for the microdendrometer. The height of ten feet was chosen to keep the screws out of reach and general observation of recreationists. Initial dendrometer readings were taken in early summer of 1965 and at the end of that and each succeeding summer through 1967. No conifers were tested for growth data.

Measurement of independent variables

Distance from facilities. Due to the arrangement of facilities, the impact of visitor use on vegetation was expected to differ throughout a family unit. Therefore, it was necessary to measure the distance separating each mil-acre plot and growth measurement tree from the "facility zone" around which use concentrated.

At each family unit a "facility zone" polygon was drawn on the plot maps to include the fireplace, table, tent site, and access path from the parking spur or loop (Figure 5). Shortest distances were then measured on the maps from the edges of the polygons to the centers of the mil-acre plots and growth measurement trees.

Point density competition. Because the growth, volume, and vigor of ground cover vegetation may be strongly influenced by competition from nearby trees, some expression of this competition was needed. Although no precise measures of competition from trees were known, the "point density" method reported by Spurr (1962) was used in this study. Essentially, this method measured the basal area per acre that each tree contributed to competition upon a selected mil-acre

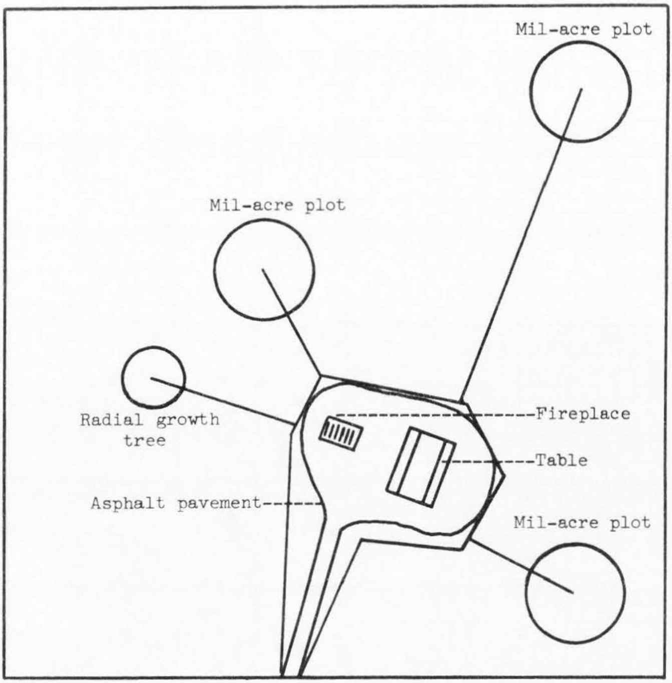

Figure 5. .064-acre plot showing a typical facility polygon from which distances were measured to mil-acre plots and radial growth trees.

plot or radial growth tree. Contributions of the ten trees intercepting the largest angles from point of impact, were totaled for an approximation of their competitive influence. The contribution of each tree was computed by dividing the (tree DBH)^2 by the (distance)^2 of the tree from the point of impact. These measurements were taken at the end of the summer to prevent early season trampling of the vegetation.

Solar insolation. It was thought that the amount of solar radiation reaching each mil-acre plot would have a measureable effect similar to competition. Therefore, a method using a solar insolation grid developed by Wagar (1964) was used to measure the percent of open canopy allowing sunlight to reach the subplots. The tripod and insolation grid were set up at every subplot, and a reading was taken. Insolation readings were taken each summer from 1965 through 1967, but were taken only in aspen plots in 1967.

Visitor use. The number of parties that used each family unit was determined by having all visitors register. By the time the campground opened to the public, the Cache National Forest had installed a card deposit box at each family unit. Directions for registering (Appendix A) were posted and a supply of registration cards (Appendix B) was maintained at the campground entrance.

Data from the registration cards were summarized at the end of each season of use. Visitor hours were computed in total hours of use. For example, if a party of two visited for six hours, 12 visitor hours would be added to the total for that specific family unit. A total visitor use over all years was also calculated since the effect of use may carry over from year to year.

To check the accuracy of the registration system, a vehicle counter was installed in 1966 at the entrance and exit. It included a 24 hour clock-operated printout which gave the number of axles that passed the counter each hour. This printout was checked by making counts of actual numbers of axles present and adjusting for extra axles counted which were contributed by non-recreation use. Only visitor hours contributed up to the time of vegetation measurements were considered in the analysis.

Topography and soils. Because the topography within this campground was fairly uniform, there seemed to be little need to measure distances from ridge lines or drainages. Such factors probably were adequately expressed by soil thickness. Aspect and maximum slope across each mil-acre plot were measured using a hand compass and Abney level.

Thickness of each soil horizon down to 50 inches was measured at the center of each mil-acre plot or as close to plot center as was possible along a radius toward magnetic north. Horizon measurements were made by using a soil auger and by measuring the depth each time the horizon changed. Where soils appeared uniform in adjacent mil-acre plots, fewer measurements of depth and texture were taken. Depths and textures were interpolated for the unsampled plots.

Samples of each horizon were collected for texture analysis by the hydrometer method. Each sample included three to four cubic inches of soil. Soil was sampled for horizon thickness, texture, and pH once on each .064-acre plot. Because of disturbance to plot vegetation during soil sampling, such sampling was done after vegetation measurements in late summer of 1964.

Soil surface density was measured with a Troxler, radioactive surface density gauge on the same schedule as vegetation measurements. Two, three-minute counts were made on each mil-acre plot. Initial measurements were made as soon as the campground opened. Density measurements were corrected for soil moisture, which was read at the same time and location.

Treatments

By random assignment, five .064-acre plots were left untreated as controls; three plots were watered only; three plots were fertilized with nitrogen and phosphorous only; and two plots were watered and fertilized (Table 3).

Table 3. Treatments assigned to the various .064-acre plots.

Treatment	Plots treated
Control	6, 8, 10, 16, 25
Water	1, 11, 14
Fertilizer	13, 15, 19
Water and fertilizer	2, 24

Watering. Watering was done each summer from 1964 through 1968 between late July and late August depending on availability of labor and how soon watering was judged to be needed. Approximately one-half inch of water was applied with each application. The number of applications varied by year as follows: 1964, 2; 1965, 4; 1966, 5; 1967, 6; and 1968, 7. Watering was accomplished by pumping from a truck-mounted tank into four garden hoses connected to oscillating garden sprinklers. This sprinkler system gave an even distribution with some minor adjustments.

In 1964 and 1965 watering was done throughout the week. Evidence suggested that this was causing damage as a result of heavy use on weekends immediately after the watering. Schedules were changed in 1966 to prevent further damage. Increased tank capacity in 1966 allowed watering to be completed by Wednesday or early Thursday morning.

To measure natural precipitation, an 8 inch precipitation gauge was installed on a hill approximately 100 yards west of the campground. Measurements of precipitation were made after each rain or snow storm during spring and summer months.

Fertilizing. Fertilizer was applied three times to the designated plots with the first application in late June of 1964, the second in October of 1964, and the third in June of 1966. Since the total area to be treated was less than an acre, the nitrogen and phosphorous fertilizer was applied by hand broadcasting. Fertilizer applications were at rates of 120 pounds per acre of elemental nitrogen and 90 pounds of P_2O_5 per acre. The nitrogen fertilizer was in the form of urea for the 1964 applications and urea formaldehyde for 1966. The phosphorous fertilizer was in the form of superphosphate.

Data analysis

Statistical. Covariance analysis methods were used to adjust treatment means for possible differences in site factors and other variables. Multiple regression analyses run in 1965 showed unexplainable interactions when all plots were analyzed together. Therefore, aspen and conifer plots were separated for covariance analysis. To test for significant differences between treatments, the Scheffe test as discussed by Snedecor and Cochran (1967) was employed. All tests of significance were made at the .10, .05, or .01 levels.

Nonstatistical. General observations were recorded for shrub response. Photographic records showing differences in appearance of treated and untreated vegetation were made.

RESULTS AND DISCUSSION

Ground cover vegetation

Aerial coverage. Covariance analysis and the Scheffe Test[1] showed the combination of water and fertilizer to be of most significance in increasing aerial percentage of ground cover vegetation. Adjusted treatment means for ground cover under aspen and conifer overstory were plotted in Figures 6 and 7, respectively. By 1968, all "applied" treatments tested, resulted in significantly greater amounts of ground cover than amounts produced by control plots (Table 4).

Table 4. Significant treatment differences as shown by Scheffe tests at the .10 level or higher for aspen and conifer overstory plots.

1966	1967	1968
C<WF	C<WF	C<W
W<WF		C<WF
F<WF		W<WF
		F<WF

(<) Significantly less than
C - Control, W - Water, F - Fertilizer

These results had been anticipated, but were surprisingly more significant than expected. The fact that water produced significant

[1]The Scheffe Test is a statistical procedure for testing comparisons of treatment means for significant differences.

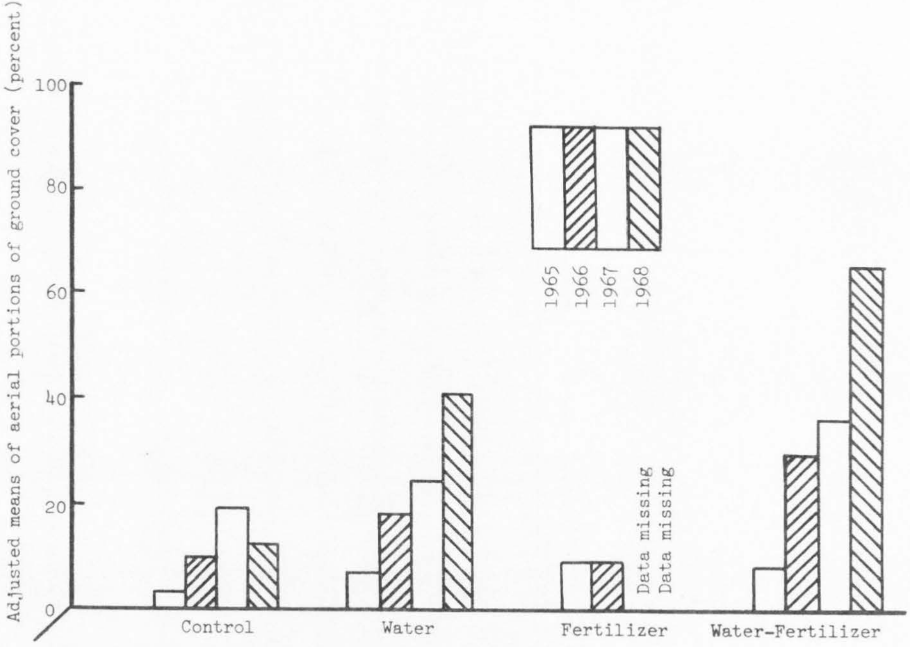

Figure 6. Amount of herbaceous ground cover on aspen units in response to various treatments (1965-1968).

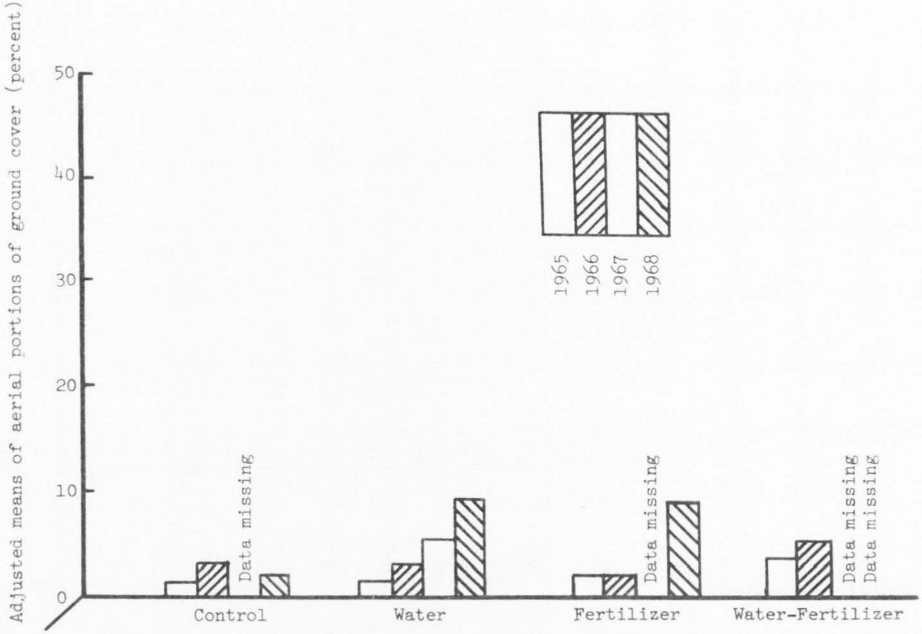

Figure 7. Amount of herbaceous ground cover on conifer units in response to various treatments (1965-1968).

results was expected since growing seasons were normally quite dry. These results appeared to support the suggestion by Treshow (1970), that soil moisture levels would probably not be optimal during the growing season.

According to Beardsley and Wagar (1971), who reported on the same study, fertilizer alone seems to have little influence on the quantity of vegetation. This statement contradicts the response to fertilizer shown in Figure 7. By 1968 the fertilizer treatment produced nearly identical amounts of vegetation to that of the water treatment in the conifer covered plots. This finding concurs with Wagar (1961), who found definite increases in vegetation after a single application of mineral nutrients to trampled vegetation on a forested recreation site.

All of the data bars of Figure 6 and the water treatment data bars of Figure 7 present a striking pattern of incremental increase of understory vegetation over time. This pattern for fertilized plots could be due to increased soil nutrient levels which may have risen in response to fertilizer treatments. This incremental increase might have been due, also, to increased uptake of nutrients each succeeding year due to corresponding greater root mass. Other change may be the result of grazing release since prior to development of the site the land had been grazed by sheep and cattle. Furthermore, the increased number and amounts of watering applications over a longer period of weeks might have been responsible for the increasing responses for watered plots.

Beardsley and Wagar (1971) suggest none of the previous explanations for increased vegetation with time, except for the possibility of release from grazing. Instead, they suggest that grasses and other species that tend to withstand trampling, replaced forbs that were abundant when the campground was opened. They suggest that a replacement of forbs with grasses would be especially noticeable during fall measurements, since grasses tend to retain their maximum sizes while forbs have often dried and withered. This explanation is feasible but not likely to be responsible for much of the increase as long as the trampling impact is sufficient to drive out the forbs. They also suggest that site design may have effectively protected ground cover from visitor use. Although this last explanation may have merit, it contradicts the previous suggestion of grasses replacing forbs that had supposedly been trampled out.

The increasing trend over time appears to hold true for vegetation on control plots too, although the upward trend is ended by an abrupt loss in 1968. The upward trend for controls might be a result of protective site design as suggested by Beardsley and Wagar (1971). The sudden loss of seven of the nineteen units of vegetation under aspen overstory in 1968 as shown in Figure 6 seems to deny this possibility, since no losses of vegetation were observed on areas outside but adjacent to these control plots. The short period of increase may have come from grazing release, from temporary increases in root stock, or from increases in natural precipitation during the growing seasons.

The upward trend of vegetation amounts on control plots is similar to results observed by Magill (1970). He found no losses of vegetation in five heavily used campgrounds in California, and he indicated that untreated ground cover may be capable of maintaining itself at original levels. The loss of ground cover on controls in 1968 negates the upward trend and tends to oppose Magill's suggestion that ground cover may be able to maintain itself.

Vegetation response was greater under aspen stands than under conifers as was shown by Figures 6 and 7. Since these two overstory types were analyzed as separate treatment blocks, this indicates that "blocking" was effective in controlling error. This difference probably resulted from more suitable soil moisture and pH as indicated in Table 1 and Figure 1. Less overstory competition (Table 5) may have been a factor responsible for greater response on aspen plots as well. Also, there was more vegetation already established and

Table 5. Competition factors as found on typical aspen and conifer plots.

Type of overstory	Competition factor	Percent overstory in type
Conifer	9.054	93.1
Aspen	3.550	100.0

ready to respond to treatment under aspen than under the conifer stand. This, as well as the data of Table 5, reflects the findings of Ripley (1962) that ground cover decreases as the overstory canopy increases. These ground cover responses correspond to the productivity potentials shown in Table 1, as forecast by Olson.

Appearance. Not only did the water and fertilizer treatments increase the amounts of vegetation under aspen, but they also maintained the vegetation in a healthy, vigorous condition. Very few desiccated stems of grass or forbs were observed during measurement of those plots receiving water and fertilizer treatments. This improved the appearance of these campsites, and in general they might be considered to be more pleasant and desireable than bare ground and litter which can become dust and mud. For example, dark green vegetation on a treated plot contrasted sharply with the bare soil and litter outside the plot (Figure 8). Also, as shown in Figure 9, a tall grass stand on a watered and fertilized plot was noticeably different from the area outside the plot.

Tree growth and mortality

Response of diameter growth of aspen to the treatments showed no significant differences in treatment means (Figure 10). The true results of tree growth may have been masked, because of the possible faulty procedure used in backing out the dendrometer screws.

Since the nitrogen and phosphorous fertilizer was hand broadcast, it may have been intercepted by understory before reaching the root

Figure 8. Dark green vegetation on a watered-fertilized plot is shown on the right of the tape, while the left side (untreated) is mostly bare soil.

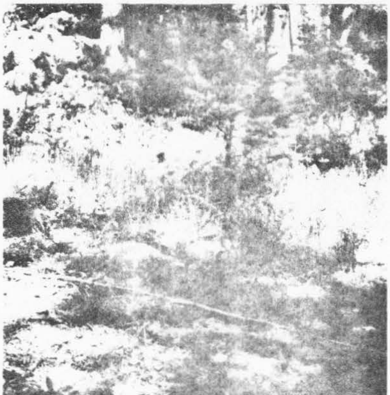

Figure 9. The tall grass stand above the tape (lower center) is inside a watered-fertilized plot.

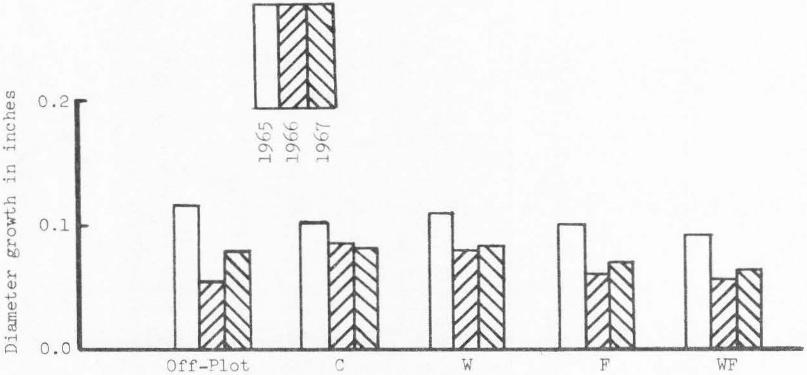

Figure 10. The response of diameter growth of aspen to: no treatment (C), water (W), fertilizer (F), and combined W and F. The off-plot response is also shown.

systems of overstory trees. The fertilizer treatment may have produced significant differences if it had been applied differently.

The survival of trees and tree seedlings provided no evidence of improved survival rates resulting from treatment. However, from observation, it appeared that wounds healed better on aspen that received water and fertilizer. On untreated trees, cuts and wounds often led to increase in disease.

Shrub response

Table 6 shows the gross changes in shrub cover from 1967 to 1968. Units expressed are totals for one .064-acre plot of each treatment.

Table 6. Total units of aerial shrub parts on .064-acre plots under aspen in 1967 and 1968, by treatments.

	Water	Water-Fertilizer	Control
1967	6.1	11.4	13.8
1968	10.4	34.9	19.4

It is immediately noticeable from these data that aerial shrub parts increased from 1967 to 1968, regardless of treatment. The shrub increase on controls is similar to ground cover vegetation increases on control plots and approximates the findings of Magill (1970), who suggested that ecosystems might be able to adjust and provide some type of vegetative cover even under heavy use. Shrubs tend to be sturdy obstacles to recreation activity and repel trampling, thus they are likely to show continuing increases whether treated or untreated.

SUMMARY AND CONCLUSIONS

Summary

The major objective of this study was to examine management methods for maintaining vegetation in a forested recreation site. Water and nitrogen-phosphorous fertilizer were applied to randomly chosen plots at family units of a campground in northern Utah. Site factors and visitor use appearing to be related to vegetation changes were measured. Analysis of covariance and the Scheffe Test of data produced the following results.

Watering-fertilizing treatments were statistically most significant in increasing ground cover vegetation, and all treatments resulted in significantly greater amounts of vegetation than found on control sites. Treatments resulted in increasing responses with time. A similar increasing trend for control units did not appear to be constant. Ground cover response was greater under aspen than conifer overstory. Treatments also resulted in visibly perceptable differences in appearance of vegetation. There were no significant differences in diameter growth of overstory trees. Increases in shrub cover were observed on all treatments and control plots under aspen overstory.

Conclusions

Combinations or separate applications of water and nitrogen-phosphorous fertilizer at the applied rates can be significant in maintaining or improving the amounts and conditions of ground cover vegetation under aspen overstory, although possibly not under conifers. These two treatments combined appear to be even more effective. On moist locations, fertilizer alone may be an effective treatment. These treatments not only increase the amounts and improve the condition of vegetation, but also increase the site's capability to withstand recreational impacts without significant destruction of vegetation initially present.

These findings, along with others, merely scratch the surface in developing vegetation management techniques for use in outdoor recreation areas. However, the use of watering and fertilizing treatments as employed in this study have valuable application for forested recreation sites with similar ecological characteristics.

RECOMMENDATIONS FOR FUTURE STUDIES

Attempts should be made in future studies to avoid the magnitude of experimental error that is suspected to have occurred in this study. This could be accomplished in part by better coordination between the research team and cooperating agencies. For example, during one season, an agency employee unknowingly emptied ashes from a fireplace onto some mil-acre plots. This action certainly modified the treatment being applied to those plots.

Changes in treatment patterns, such as application of different amounts of water each year, interfered with treatment effects. The seeding, as mentioned on page five, eliminated many replications of water and fertilizer treatments. Changes such as these certainly contributed to experimental error.

Once a study plan is decided upon, it should be followed as nearly as possible. Measurements must be taken carefully and always in the same manner. This study would have undoubtedly provided more reliable results had only one person been in charge of measurements throughout its lifetime instead of three or four different persons.

A follow-up study on this same site or a similar one might be helpful in clarifying the results obtained. Although watering and fertilizing treatments proved effective in generating significant plant growth, the simultaneous increase in shrub and ground cover on control plots suggest, as Magill (1970) indicated, that damage may be more apparent than real. Data and observations from this study suggest that there are certain levels of vegetation that can be maintained without treatment.

A factor that may affect the optimum level of vegetation is the amount of protective devices available for ground cover to nestle around. Trees and some shrubs definitely have a protective effect as well as a competitive effect on ground cover vegetation. For example, if one plot has two trees surrounded by 10 total units of ground cover, and another plot has three trees surrounded by a total of 15 units, is the difference a result of treatment effect or "protective effect"? Development of such a factor may help explain the "apparent-real" discrepancy as noted by Magill.

As a comparison, application of treatments to recreation sites without good site design might provide more indication of the ability of site design to protect or maintain vegetation. Also, application of treatments to plots outside the recreation use areas at Sunrise Campground might have provided more clues to aid in interpreting treatment effects; effects of visitor use on vegetation; and effect of pavement in preventing site deterioration.

Development of better analysis of visitor days use must be made if this factor is to reflect true impact on the site. Types of activity, camping equipment, and hours of use on the plot must be known and accounted for more accurately. Twelve visitor days use may have no impact on the vegetation if all the time is spent in a pickup camper. Thus, adjustments are needed to get a true measure of visitor impact.

Finally, if new studies are developed, the procedures need to be developed fully with a workable statistical design and analysis in mind. This study was initiated with the idea that results could be summarized by multiple regression methods. Nearly four years into the study, it was recognized that multiple regression would not produce treatment data that could be compared for significant differences, and that covariance procedures would be necessary to produce meaningful results. This was a valuable student learning experience but did little to enhance reliability and aid interpretation of the data.

Only when multiple regression analysis was attempted on some of the early data, was it recognized that aspen and conifer overstory represented different blocks in the experimental design. This division significantly reduced the treatment replications for each overstory type. It may have been advisable to reduce the size of treatment units and attempt to get several replications of each treatment within each .064-acre plot. This geographical and ecological consolidation of treatment units would certainly help reduce variation in sites receiving the various treatments. Such increases in replications may be economically unfeasible to establish, especially in field trials at recreation sites.

In review, it is apparent that this study had some flaws which must have introduced considerable error. The low percentage of total variation accounted for on aspen plots (48 to 79) and on conifer plots (38 to 47) certainly points this out. Every effort should be made to analyze future study proposals more critically. The areas of study encompassed by this research include disciplines such as plant physiology, which if considered separately could probably have provided subject areas for several other tests of hypothesis.

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APPENDIXES

Appendix A. Registration Instruction Sign

> VISITORS MUST REGISTER
>
> One person from each group fill out a registration card and drop it in the numbered box at the site you use during your visit here. This information is used for research to improve campgrounds. Thank you.

Appendix B. The Registration Card

> Name:____________________ Number of people in group________
>
> Address:____
> (Street or route) (City or post office) (State or county)
>
> Time of arrival: _______196_ _______ a.m. / p.m. (cross out one)
> (date) (time)
>
> Expected time of departure:_____196_ _______ a.m. / p.m. (cross out one)
> (date) (time)
>
> If camping, please indicate type of shelter used (umbrella tent, 15-foot trailer, etc.) ________________________
>
> Remarks (use back of card if necessary):

VITA

Alan R. Silker

Candidate for the Degree of

Master of Science

Thesis: Maintenance and Survival of Vegetation on the Sunrise Campground, Cache National Forest

Major Field: Forest Science

Biographical Information:

Personal Data: Born at Knoxville, Tennessee, March 18, 1945, son of Theodore H. and Cleo Marie Silker; married Beverly Mills on March 20, 1969.

Education: Attended elementary school in Kirbyville, Texas; graduated from C. E. Donart High School in Stillwater, Oklahoma in 1963; received Bachelor of Science degree from Oklahoma State University, with a major in Forest Management in 1967; did graduate study for Master of Science degree at Utah State University, 1967-1969.

Professional Experience: 1970 through 1972, Recreation Forester, Brush Creek District, Medicine Bow National Forest, Wyoming; 1969, Research Forester, North Central Forest Experiment Station, United States Forest Service, St. Paul, Minnesota.