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Aspects of Some Compacted Campground Ameliorating Practices

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ASPECTS OF SOME COMPACTED CAMPGROUND AMELIORATING PRACTICES

by

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THESIS

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INTRODUCTION

Clawson stated in 1959 that "By the year 2000, a combination of growing population, rising incomes, and increases in leisure time might raise the total demand for outdoor recreation to about ten times the present level. A dire need of planning for proper utilization of resources exists." This thesis deals with one such resource, the soil; more specifically, compacted soils on intensively used campgrounds.

Since 1929, when Meinecke published his article entitled "The effect of excessive tourist travel on the California Redwood parks", it has become necessary to recognize that the degree of soil compaction on a campground is directly related to the level of usage and the physical characteristics of the soil. As the demand for the recreation experience by the public is increasing, it is apparent that an answer should be forthcoming to alleviate or manage the problem of soil compaction.

Some suggested solutions to the problem include: 1. surfacing the campsite with asphalt, 2. closing the deteriorated campsites for rejuvenation by natural means, 3. limiting the usage through some sort of reservation system, 4. devising some system of intensive management to modify the soil characteristics and control the quantity and quality of the vegetative cover. While each of these suggestions have some merit and are being used, insufficient research has been conducted to determine the value of mechanical manipulation of compacted soils and the addition of organic materials to change the physical characteristics of the soil to promote vegetative establishment and growth. Therefore, the purposes of this study were:

1. To determine the value of mechanical manipulation of compacted soil by roto-tilling to decrease the bulk density.
2. To determine the effect on soil density by incorporating bark and wood chips.
3. To determine the effects on bulk density of planting grass on roto-tilled sites with bark or wood chip additives.
4. To determine the natural recovery time of compacted sandy loam East Texas soils using the closure method for rejuvenation.

LITERATURE REVIEW

Effects of Compaction

In situations where visitor use outweighs the natural capacity of soil and vegetation to repair themselves, deterioration will take place without added management (Wager, 1965). In 1970, McGill wrote that investigations of human impact on soils and vegetation of intensively used sites probably do little more than document the obvious. His study of campground conditions in 1963 of 137 National Forest campgrounds and picnic areas in California, reported evidence of soil deterioration, hard packed surfaces, and erosion of camp facilities all aggravated by removal of insulating layers of organic matter. This necessary organic layer reduces trampling shock, aids infiltration of water and retards loss of soil moisture through evaporation.

Research on the trafficability of soil shows that with trampling, macropore space is reduced with a corresponding decrease in air capacity and moisture content (Read 1956, Packer 1953, Hume 1957, Holers 1970). Permeability is decreased, so erosion occurs, as the filtration rate is more dependent upon the macro pore space than total pore space. To illustrate the detrimental effect of soil compaction on root growth, Minore in 1969 conducted a study involving seven western conifers. Using three different bulk densities, he found that in two years at bulk density 1.45, the roots of sitka spruce, western hemlock and western red cedar would not penetrate the soil. All test species roots grew through the soil with a bulk density of 1.32, while none grew through the 1.59 bulk density soil. Foil (1967), found that seedlings grown on soils compacted by different treatments indicated that even the smallest pressure applied reduced soil aeration and increased mechanical impedance to root growth to unfavorable levels. More importantly though, he found that the lack of non-capillary porosities limited the oxygen supply to the roots well before compaction restricted root penetration. Pomeroys' 1949 research with the germination and initial establishment of loblolly pine also indicated that soil compaction will decrease new plant establishment and survival rate.

Lutz (1945), in a study on soil conditions in parks in Connecticut reported that one of the more obvious effects of compaction was a decrease in the density of herbs, shrubs and tree seedlings. Ripley (1962), goes on to say that while perhaps it is not essential to have tree growth actually within the developed site, some sort of tree growth and nearly complete ground cover on such sites is desirable for protection of soil loss and root exposure. Lunt (1937), also points out that a litter layer is necessary to reduce the loss of surface moisture through evaporation and to protect the soil from compaction by rain.

Two studies concerning the effects of compacted soil on tree growth have differing conclusions. LaPage (1962), observing three New Hampshire State Parks to determine if there was a deterioration of site quality with continuing use as a campground or picnic area, determined a reduction in diameter growth of trees corresponded with the intensity of use of the sites. McGill (1970), in an evaluation of heavily used campgrounds in California stated that tree growth on study sites did not reveal any changes over a thirty year period that could be directly related to recreational use.

Treatments and Restorative Measures

Ripley, in 1965, outlined procedures for analysis of existing compacted campsites in terms of public demand and use value, to determine if they warranted rehabilitation or if it would be more advantageous economically to close them down. If they were considered worthwhile for rehabilitation, what course of action would be necessary to establish good drainage, soil structure, vegetative cover and aesthetic values.

Ratliff (1971) completed a study supporting the idea of closure as a means to decrease surface soil bulk density by natural means. His investigations on pasture land to determine if surface soil bulk densities where grazing had been absent for a number of years differed significantly from those where grazing had continued, showed that areas removed from grazing decreased in surface density. Factors responsible for loosening the soil were (a) freezing and thawing of the soil surface, (b) residues and mechanical effects of plant roots, (c) byproducts and activities of soil microflora, (d) thick mulch to break the force of raindrops, and (e) animal burrowing.

Thorud (1969) also suggested closure or a rest-rotation scheme as the simplest and least costly system for natural rejuvenation. He attempted to determine the recovery time following artificial trampling for Minnesota sandy loam and loamy sand soils to return to their normal bulk density. He determined that near normal bulk density could probably be attained in five or six years. Freezing-thawing action in the winter and wetting-drying in the summer were felt to be the primary restorative agents. Lutz (1945) also determined that soil compaction was lessened by the frost action of winter weather. Of course the length of time required for a site to rejuvenate by natural means is dependent upon the severity of the original compaction, the soil texture, and the weather conditions existing during the closure interval.

To determine other means of rejuvenating compacted soils, experiments turned towards cultural improvement to benefit the vegetation, and to the addition of amendments to the soil. To aid in establishing and maintaining ground cover, several studies were completed suggesting the use of irrigation and fertilization on compacted sites. (Beardsley, et al 1971, 1974). Although this practice, even on a limited scale, would increase the management and maintenance costs, Richards and Leonard (1973) contend that because of the heavy use pressures, the recreation sites' higher value justifies this intensive management. Beardsley and Wagar (1971) state that any site that is to be artificially watered should also be fertilized and seeded. The additional costs are small compared to the costs for just watering, and could result in substantial increases in ground cover vegetation. They go on to say that as conditions for the establishment of herbaceous ground cover are not always favorable under predominantly coniferous stands, even when water, fertilizer and seed are applied, ground cover establishment should only be attempted where the density of the overstory permits enough sunlight to filter through. On the other hand, Cordell and Talhelm (1969) concluded that planting grass was impractical, as the intensive public use of the sites trampled out the grass before the summer recreation season was over. They did not attempt to irrigate or fertilize the grass, and this may have had a bearing on the low survival rate.

Much of the literature on soil amendments deals with bark or wood chip residues. Lunt (1955) found that wood chips, sawdust, or other types of wood fragments were beneficial to the soil, particularly where the texture was sandy loam or coarser. He also found that the repeated use of wood chips every few years, along with good soil management, would result in appreciable and permanent soil improvement. Wright and Fitzgerald (1969), in addition to investigating the use of bark as a soil conditioner, included cottonseed hulls, straw and peat moss, both fertilized and non-fertilized, to test for their effectiveness under controlled growing conditions. Pine bark was generally more effective as a conditioner and ranked higher in comparison with other materials.

Although wood wastes have a beneficial effect on soil, care must be taken to avoid nitrogen deficiency (Bollen and Glennie 1961, 1963). The desirability of bark for mulching and soil conditioning would be greatly enhanced if its nitrogen content could be increased. Three methods suggested for doing this are: (1) to include nitrogen fertilizer with the raw wood wastes, (2) chemical processing of wood wastes to incorporate nitrogen, and (3) a process of composting the wood wastes before incorporating into the soil.

Wright and Fitzgerald (1972), after a three year study of pine bark, peat moss and sawdust as soil amendments, determined that large sized particles of bark were of no disadvantage over the other amendments tested. Also, that pine bark amendments gave significantly higher results than peat moss and sawdust, with no significant differences between peat moss and sawdust when growing the hybrid Tea Rose.

As early as 1950, Appel suggested roto-tilling a layer of sawdust into the upper layers of the soil to increase the availability of soil moisture, oxygen, and to decrease the bulk density on recreation areas. Soil loosening treatments on campsites were also recommended by Hatchell (1970), to break up the soil and provide better surface and internal drainage. Loosening would also provide a more favorable environment for improvement of tilth by natural forces. Other than the latter two references to mechanical manipulation to improve the condition of compacted soils, no other documentation was found suggesting such ameliorative practices.

DESCRIPTION OF STUDY AREA

The study was conducted in Caney Creek Recreation Area, a U.S. Forest Service campground on the Southeastern shore of Lake Sam Rayburn in East Texas, located 6 miles North of the town of Zavalla off Texas Highway 147.

The terrain is relatively flat with campsite elevations 10-15 feet above the normal lake surface. The soils are predominantly of the Susquehanna Series (fine, montmorillonitic, Thermic family of Vertic Paleudalf. The Bouyoucous analysis showed 71% sand, 9% clay and 20% silt for a textural classification of sandy loam. Mean surface bulk density for undisturbed soils was 1.08 gm/cm^3. Vegetation on undisturbed portions of the recreation area consists primarily of the following species: Pinus taeda L.(loblolly), and Pinus echinata Mill. (shortleaf), Liguidambar styraciflua L. (sweet gum), Quercus falcata Michx. (red oak) and Quercus nigra L. (white oak). Other species exist, but are less than 2% relative dominance. On the campsite proper, the only vegetation found was a few trees and grasses growing in protected places. Rainfall is approxiamtely 40 inches per year occurring mostly in the winter and spring.

Caney Creek campground was selected for this study as it has received heavy seasonal use over the past seven years on most sites, and heavy year round use on sites located near the boat launching ramp. However, the use level has declined the past few years due to several factors: low lake level, other campgrounds more readily accessible, and the general decline in public mobility during the initial oil crisis (Fig. 1).

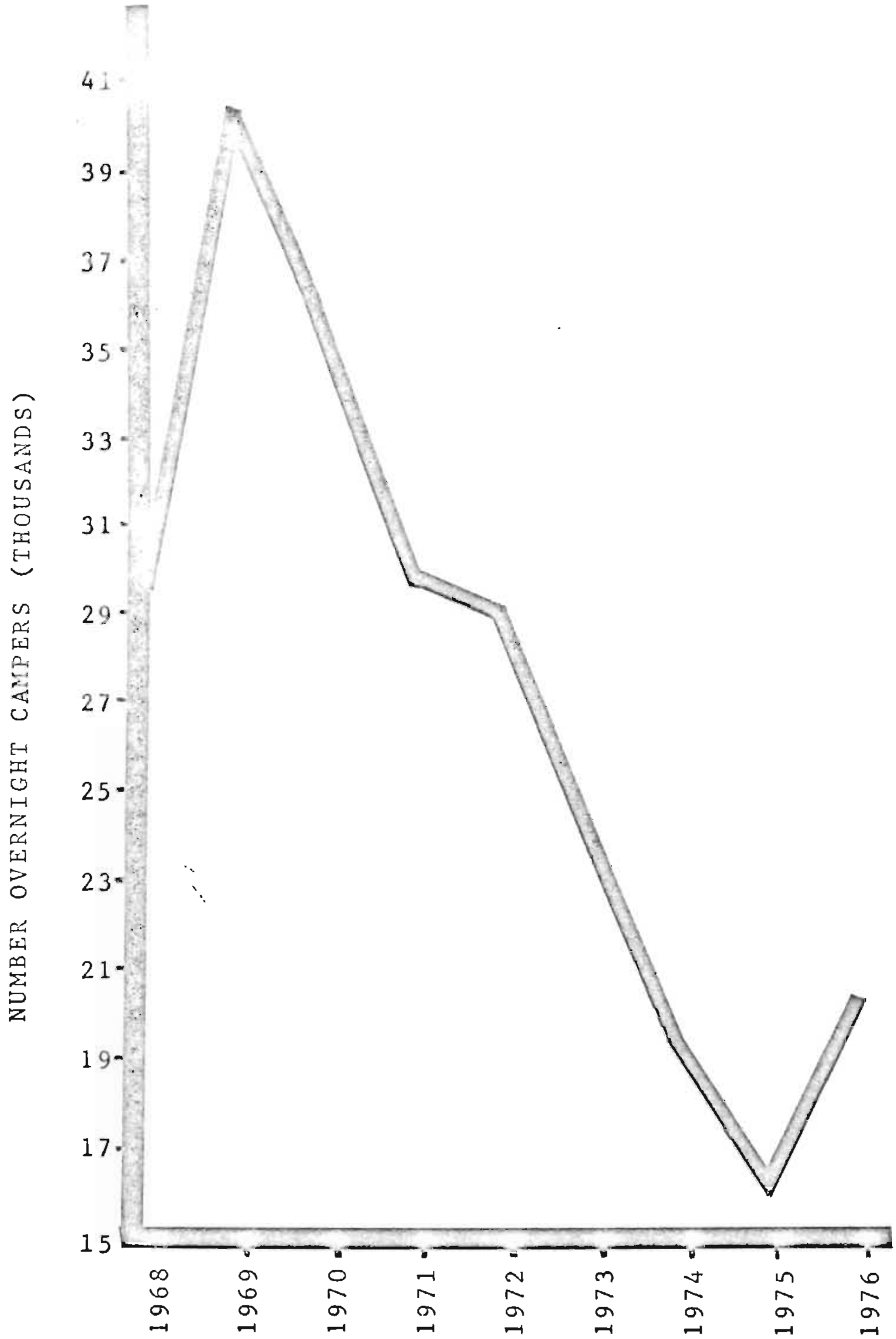

Figure 1 Caney Creek Campground overnight camper use levels

PROCEDURES

Soil bulk density on drive-in campsites was compared over a two year period following application of six different treatments.

Twenty-four campsites with similar vegetation types and use levels were selected from the available one-hundred twenty-eight. The twenty-four sites were then randomly divided into six groups of four, with each group receiving a different treatment.

Two transect lines were established through each site using permanent stakes, so the lines could be re-located easily for subsequent density readings. The lines were laid out so as to intersect at the center of use of the sampling unit, the most heavily compacted area between the picnic table, fireplace, and tent pad (Fig. 2). Bulk density readings were taken at one meter intervals going out on each transect for a distance of 6 meters. The sixth bulk density reading was usually at the fringe of the site, so a range in density of most to least was attained in each direction for site compaction. Eighteen randomly located bulk density readings were taken off the margin of the units to establish an approximate normal mean bulk density for the surrounding relatively undisturbed area.

Before the six treatment were applied in November of

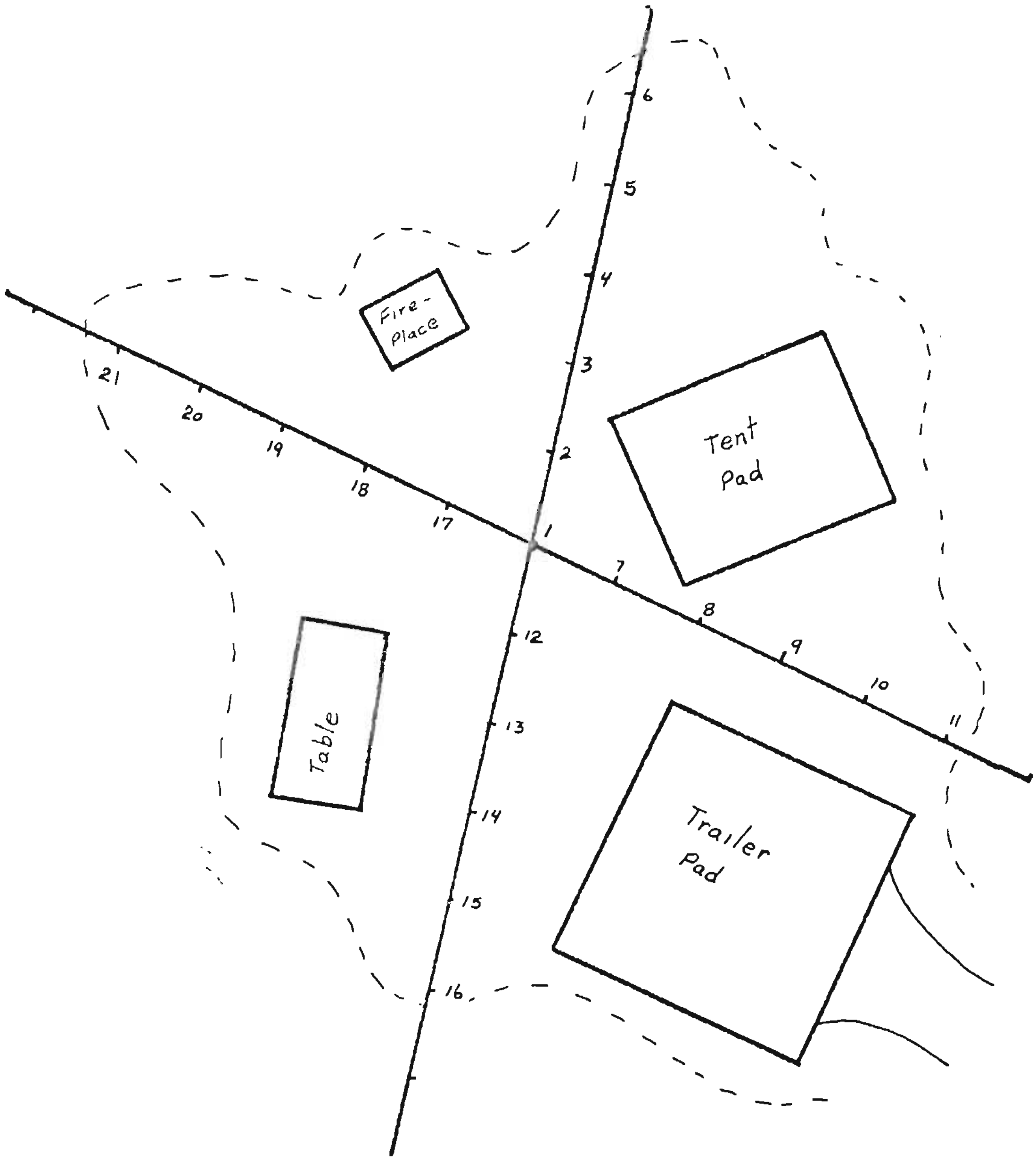

Figure 2 Typical transect layout through campground for bulk density sample area.

1974, initial bulk density readings were made to establish the untreated conditions and the site variability, if any.

The six treatments were then applied as follows:

1. fenced to keep all activity off the camping unit for the period of the test,
2. open year round for normal usage,
3. open summer, (April - Oct.), closed during the winter months (Nov. - March)
4. roto-tilled and raked smooth, open summer, closed winter,
5. roto-tilled, mixed with wood chips, open summer, closed winter,
6. roto-tilled, mixed with bark, open summer, closed winter.

To minimize damage to tree and brush root systems, roto-tilling did not extend deeper than six inches into the soil. Before tilling on sites designated for additives, a three inch layer of bark or wood chips was spread (Fig. 3). Tilling then produced a thick, friable mixture of sandy-loam soil and bark or wood chips to a depth of nine inches. The sites were then raked to a smooth and level appearance (Fig. 4).

Two of the four sites that were tilled with bark were planted with grass as were two of the sites with wood chips. This modification of treatments 5 and 6 was to determine if

A. Roto-tilling campsite with 4 H. P. tiller.

B. Relative size of bark and wood chips incorporated into soil by roto-tilling.

Figure 3

A. Wood chips on campsite after incorporating into soil by roto-tilling.

B. Bark chips on campsite after incorporating into soil by roto-tilling.

Figure 4

the addition of grasses to the sites produced any beneficial effect. *Festuca arundinacea* (KY 31 tall fescue) and *Lolium multiflorum* (Gulf annual rye) were applied at rates of 80 lbs/A each. Ammonium nitrate was applied at a rate of 900 lbs/A to each of the four grassed sites one month after the grass sprouted.

Successive bulk density readings were made in March and November of 1975 and March of 1976. All readings were made by the Troxler 2400 Series nuclear surface density gauge. To calibrate the density gauge for sandy-loam soil, a series of test readings were made and compared to actual dry bulk densities as determined by laboratory procedures. The resulting calibration is expressed by the following regressional equation:

$$Y = .54746 + .63910X$$

where:

Y = the gravimetrically determined density

X = nuclear surface density gauge measurement

$r^2 = .7255.$

Computer analysis was accomplished by using the Statistical Package for the Social Sciences (SPSS). One-way analysis of variance with Duncan test gave the data required to compare treatments.

As observation date is directly related to the season of the year and passage of time, and considering that seasonal temperature changes, rainfall and weathering action acted upon all sites and treatments equally, the analysis of data is one-way only, using density by treatment as the variable.

RESULTS AND DISCUSSION

To determine if site bulk densities were homogeneous before treatments were applied, a one-way analysis of variance was made for observation date 1 (Nov. 1974), with bulk density as the dependent variable. The mean site bulk densities were found to be between 1.29 and 1.37.[1], and were homogeneous at the 1% level of significance (Table 1). As the site densities were homogeneous, it was assumed that any differences in density found by subsequent observations would be due to the effects of the applied treatments. Since the sites utilized for this study had a history of long and intensive use, the homogeneity of bulk densities may indicate a maximum level of compaction had been reached and sustained.

The mean for each treatment for each date was then computed providing an overview through time of the effect of each treatment on site bulk density (Table 1).

Combining data on site mean bulk densities through time by treatments, a change in overall bulk density and a percent change in this density was calculated (Table 2).

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[1] All bulk density readings in grams per cubic centimeter, g/cm^3.

Table 1: Mean bulk density (gm/cm^3) by treatment for observation date.

OBSERVATION DATE	1 Closed	2 Open	3 Seasonal Open	4 Roto-Till	5[(2)] Till+ Chips	6[(2)] Till+ Bark
Date 1* Nov '74	1.32	1.37	1.30	1.29	1.35	1.32
Date 2 Mar '75	1.22	1.29	1.16	1.29	.95	.89
Date 3 Nov '75	1.12	1.27	1.12	1.20	1.01	.96
Date 4 Mar '76 (1)	1.11 b	1.18 c	1.10 b	1.22 c	.96 a	.95 a

*Before treatments applied

(1) Means with different subscripts are different at the 0.5 level of significance.

(2) Bulk density means include measurements from sites with and without grass.

Table 2: Mean bulk density (gm/cm^3) change and percent change by treatment for test period.

OBSERVATION DATE	1 Closed	2 Open	3 Seasonal Open	4 Roto-Till	5(1) Till+ Chips	6(1) Till+ Bark
Date 1* Nov '74	1.32	1.37	1.30	1.29	1.35	1.32
Date 4 Mar '75	1.11	1.18	1.10	1.22	.96	.95
Change	.21	.19	.20	.07	.39	.37
% Change	15.9	13.9	15.4	5.4	28.9	28.0

* Before treatments applied

(1) Bulk density include measurements from sites with and without grass.

Site Reactions to Treatments Through Time

Treatment 1: The units that were fenced and closed year round, showed continuing decreases in bulk density from 1.32 for observation date 1 (Nov. 1974) before fencing, through 1.22 in March 1975, 1.12 in Nov. 1975 and 1.11 in March 1976 (Table 1). This decrease in bulk density was anticipated on sites allowed to self-rejuvenate, although the extent of decrease was probably relative to the initial degree of compaction, soil type and texture, and variability of rainfall and temperature. It can be seen in this situation that the bulk density decrease was initially very rapid, 0.10 for the first time interval or winter (Nov. 1974-March 1975), 0.10 for the second interval or summer (April 1975-Oct. 1975), and decreased to less than 0.01 during the third time interval (Nov. 1975 - March 1976). The bulk density could be expected to continue to decrease as the soil returned to its natural, undisturbed structure. Treatment 1, fenced and closed year round, had a 0.21 overall reduction in bulk density for a 15.9% change over the test period (Table 2).

Treatment 2: Sites open for continual year round usage, showed a decrease in bulk density from 1.37 for observation date 1, through 1.29, 1.27 and 1.18 for observation dates 2, 3, and 4 respectively (Table 1). A decrease in bulk density occurred through time even though no ameliorating treatment was applied. Forest Service campground user fee records show that a significant reduction in usage occurred during this period, which may account for this recovery. This decrease, with the decrease in treatment 1, support the assumption that weathering through time has a recovering effect on compacted soils. In this case, as the sites were still being utilized, the recovering effect was not as dramatic. A situation could arise where the usage level would be so high so as to completely negate the self-rejuvenation effect and leave the bulk density the same or even higher if the maximum had not already been achieved. The decrease in bulk density for the first time interval (Nov. 1974 - March 1975), was 0.08, the second interval (April 1975 - Oct. 1975), 0.02, while the third interval during the winter-spring of 1975 - 1976 showed a decrease of approximately 0.09. The trend here is a larger decrease in bulk density during the two overwinter periods, 0.08 and 0.09, when camper usage was low, with a very small decrease of 0.02 over the summer high usage period. Depending upon the degree of usage, the overall trend in bulk density could decrease as was the case here during the 1974 - 1976 seasons, or increase as must have been the case to reach the 1.37 bulk density at the start of the test. Treatment 2, open year round, had a 0.19 reduction in bulk density over the test period for a 13.9% change (Table 2).

Treatment 3: Sites open for summer use (April - Oct.) and closed winters for recovery, showed a decrease in bulk density from the initial 1.30 to 1.10 by the end of the study. In this treatment, the closure of the sites over the first winter months (1974 - 1975), allowed a decrease in bulk density of 0.14, a fairly large amount. The summer usage period allowed a 0.04 decrease. The second winter period (1975 - 1976), bulk density only decreased 0.02. There was no significant difference between the final bulk density measurements for this treatment and for campsites which were closed year around. Bulk density decreased 0.20 over the test period for an overall change of 15.4%, very close to the 15.9% change of treatment 1 (Table 2).

Treatment 4: On campsites which were roto-tilled and raked smooth, the initial bulk density before tilling in Nov. 1974 was 1.29. In March 1976, after tilling and the opportunity to self-rejuvenate through the winter months, the bulk density had increased slightly over 1.29 (Table 1). As the first three treatments prompted decreases in bulk density, it may be assumed that the tilling of the soil and destruction of its structure caused the opposite reaction. During the summer usage months the bulk density decreased by 0.09 to 1.20, a larger decrease than found under treatments 2 and 3 for the same period, but this may be a reaction to the unnatural conditions created by roto-tilling. The third time interval (Nov. 1975 - March 1976), showed a slight increase in bulk density to 1.22. This increase could be the result of the unstructured or partially structured soil breaking down during the harsher winter weathering and returning to a more compacted state. Treatment 4 had a total reduction of 0.07 over the test period for a 5.4% change in bulk density (Table 2).

Treatment 5: Sites which were roto-tilled with an organic amendment of wood chips, showed a significant difference from the first 4 treatments (Table 1). The initial bulk density was 1.35 in November 1974 before tilling. In March of 1975, four months after tilling and adding chips, the bulk density was 0.95, a reduction of 0.40. The addition of organic matter in the form of wood chips evidently offset any damage to soil structure done in the process of roto-tilling. During the second time interval of summer 1975, the bulk density rose by 0.06 to 1.01. This rise is probably due to a very unnaturally loose soil being compacted by the initial camper usage. The third time interval (Nov. 1975 - March 1976) showed a decrease of 0.05 in the bulk density, again as a result of self-rejuvenation, to 0.96. Assuming that the natural soil bulk density was around 1.08 as determined by off-site measurements, this bulk density of 0.96 is below normal and at some future date would increase, although probably not until all wood chips had deteriorated and the soil had returned to its normal soil-organic matter ratio. Treatment 5, roto-till and chips had a reduction of 0.39 in bulk density over the period of the test for an overall 28.9% change (Table 2).

Treatment 6: Sites roto-tilled and with bark added, reacted about the same as treatment 5. At the end of the study there was no significant difference between sites treated with bark amendments and those treated with wood chips (Table 1). From the initial bulk density of 1.32, the first decrease over the winter of 1974-1975 was 0.43 to 0.89. This was over 0.06 lower than the roto-till and wood chip treatment. The lower bulk density was probably the result of the bark chips being larger than the wood chips and thus occupying a greater percentage of space than the soil. The summer of 1975 time interval saw a 0.07 increase in bulk density to 0.96. Here again this increase could be the result of initial compaction of a very loose and unstable soil-organic mixture. The following winter time interval, November 1975-March 1976, showed a decrease of 0.01 to 0.95. Again, a bulk density much lower than the bulk density of the natural soil-organic mixture/structure. Treatment 6, till with bark, had an overall reduction of 0.37 for a 28.0% change in bulk density and very close to the 28.9% change for till and chips (Table 2).

Briefly, the change in bulk density through time for treatments 1, 2 and 3 was a decrease following expected patterns of self-rejuvenation. Treatment 4, roto-tilling only, caused bulk density to increase through the winter months and drop during summer months with a very small overall change probably due to the massive soil structure destruction. The bulk density in treatments involving roto-tilling plus chips or bark/soil amendments were greatly reduced following treatment. Densities rose during the initial usage period in the summer and fell again during the winter to below normal levels due to the high percentage of organic matter in the soil

To determine if planting grass on sites with roto-tilling and bark or chips made a significant difference, a one-way analysis of variance was run. Analysis showed a significant difference between bark-chips-grass bulk density and bark-chips without grass bulk density (Fig 6). While the bark-chips-grass bulk density was higher, the grass apparently acted as a stabilizing factor in reducing bulk density fluctuations. Visual inspection showed that grasses grew well during the winter months and acted as a soil stabilizer against erosion. The root systems of both ryegrass and fescue grew in and around the loose soil-bark-chip mixtures holding them in a firmly bonded structure (Fig. 5). This bond prevented the chips and bark from floating away during heavy rains. The grass cover also acted as a cushion effect on raindrops to reduce the erosion causing splash. Even though the grass died out during the summer months, the dead grasses did have the effect of adding to the organic matter on and in the soil to perpetuate the looser structural stability, increasing infiltration and reducing evaporation.

A. Dead summer grasses that form cushion effect on raindrops to retard bark and wood chips from floating away.

B. Soil clod and wood chips held together by roots of annual rye and tall fescue.

Figure 4

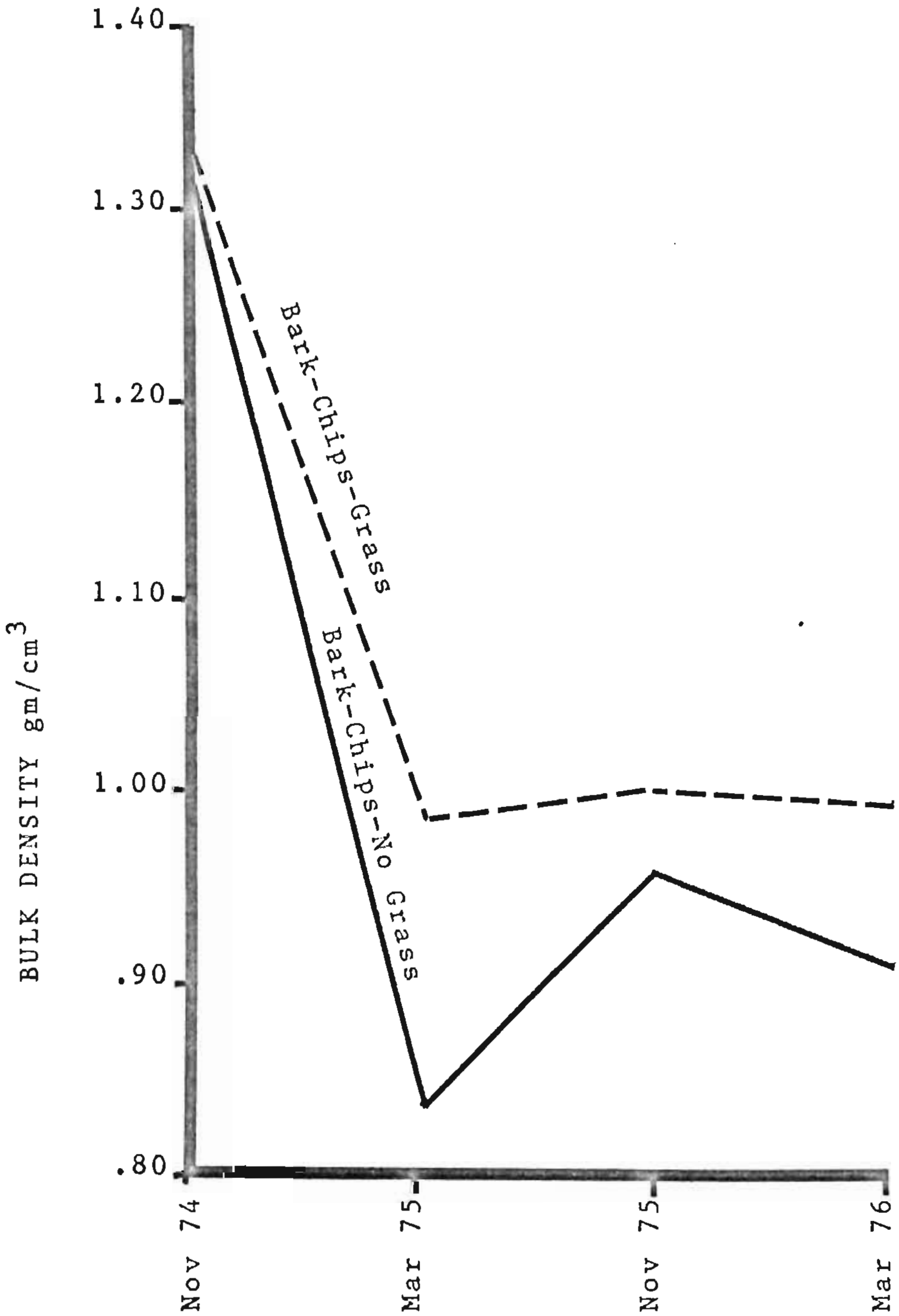

Figure 6 Bulk density comparisons of bark-chip-grass and bark-chips-no grass treatments.

CONCLUSIONS AND RECOMMENDATIONS

Ameliorating actions for compacted campsites can be divided into two groups. Group one involves little manpower and achieves fairly good results over time. Closure or partial (seasonal) closure of campsites will reduce compaction to an acceptable level in a few years in the East Texas Region. A rotation of open sites over a three year period would work very well for the soil type and usage level at Caney Creek. Group two actions involve roto-tilling and possibly the addition of organic matter and grasses. Roto-tilling alone is the least effective, and could be categorized as destructive for certain periods. Roto-tilling and the addition of bark or chips to maintain the loose soil structure and low bulk density has very good results. These results could be sustained by planting of grasses during the off season.

This study indicates that soil bulk density may be much more sensitive and vary more readily and in greater amounts in reaction to usage and weathering than was first suspected.

The initial bulk densities of the sites were homogeneous and indicated a high level of compaction had been reached. Knowledge of this bulk density of 1.29 to 1.37 gm/cm^3, could be used as a tool in monitoring existing or future campsites to determine the carrying capacity on this soil type. The 1.08 gm/cm^3 figure from the off-site undisturbed areas, could be used to establish a bulk density standard for rejuvenated sites ready for camper usage.

Further study should be made on the planting of grasses on camp sites with or without chips or bark. Many of the benefits seem obvious, but need quantitative analysis to substantiate.

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APPENDIX

Table 1 Analysis of variance to test homogenetity of initial campsite bulk density.

Source of Variation	DF	SS	MS	F
Between Groups	5	3465.0	693.00	*3.21231
Within Groups	493	106356.0	215.732	
TOTAL	498	109821.0		

* Significant at 0.1 percent level

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An Abstract of a Thesis

APPROVED:

(Thesis Director)

Dean of the Graduate School

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by

KEITH FOSTER FARNHAM, B.S.F.

AN ABSTRACT OF A THESIS

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In Partial Fulfillment

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For the Degree of

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STEPHEN F. AUSTIN STATE UNIVERSITY

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ABSTRACT

The purpose of this study was to determine if the direct mechanical manipulation of compacted campground soils, with and without the addition of organic materials and the planting of grasses, had any long lasting effect on the amelioration of these deteriorated campsites. An attempt was also made to determine the natural recovery time for East Texas sandy loam soils using the campground closure method.

Closure or partial (seasonal) closure of campsites reduced compaction to an acceptable level in three years. Roto-tilling alone was the least effective treatment. Roto-tilling and the addition of bark or chips to maintain the loose soil structure and low bulk density had very good results. These results could be sustained by planting of grasses during the off season.

VITA

Keith Foster Farnham was born in Seattle, Washington on December 5, 1932, the son of Hobart D. Farnham and Ruth E. Farnham. After graduating from Queen Anne High School in Seattle in 1951, he entered military service with the U.S. Navy. After duty with the Air Force and Army, he retired with twenty years service in 1972. He entered Stephen F. Austin State University at Nacogdoches, Texas in September of 1972, and received his Bachelor of Science in Forestry in August of 1974. In September of 1974, he entered the Graduate School of Stephen F. Austin State University.

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