From these data, it appears that dew formation following herbicidal application (simulated by mist treatments) would have little or no effect on legume seedlings emerging through plant residues that had been treated with the herbicides. Evidently, the activity of the herbicides is much reduced by the time actual seedling emergence takes place. This is possibly due to inactivation by environmental elements. Possibly, the misting treatment was sufficiently heavy to wash herbicides from the straw mulch into the soil, thereby causing reduced radicle elongation due to herbicide activity in the soil solution with Roundup. This is assumed to be possible only because the sand used in this study was sterile and possessed no chemical activity that might have otherwise rendered the Roundup inactive.

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Earth Sheltered Structures: Soil Temperature Variation and Site Aesthetics[1]

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ABSTRACT

Soil temperature variations were evaluated at an earth-sheltered church and several ancillary sites in Lubbock, Texas. The objectives were to compare the fluctuations in soil temperature over an existing earth sheltered structure versus those in a native soil, and to evaluate the influence of vegetation and water management on soil temperature fluctuations. In experiment I, thermocouples were installed at various depths under a bermudagrass (Cynodon dactylon) turf above the roof of an earth sheltered church and in a similarly vegetated area adjacent to the church. Temperatures were measured daily in both sites at four depths from July, 1983 through March, 1986. Mean soil temperatures above the roof were approximately 5⁰ F warmer from March to September and 5⁰ F cooler from October to February than the adjoining soil area. In a second experiment, the vegetative cover was evaluated using (1) bermudagrass, (2) buffalograss (Buchloe dactyloides), (3) and bare soil. Results indicated grass covers did not significantly (<2⁰ F) influence temperatures below 18 in. Separate water management studies indicated less temperature fluctuation in moist soils than in dry soils (11 vs. 14⁰ F) and temperature fluctuation was greater (14 vs. 9⁰ F) in summer than winter. Soil cover no deeper than 18 in. and plants able to thrive without irrigation should be advocated for this area's earth sheltered structures.

INTRODUCTION

Earth-sheltered structures are as old as humankind and as new as tomorrow. Golanz (1986) reported on below-ground dwellings in use for 4000 years in Turkey and on those currently inhabited by 40,000,000 Chinese in the loessial soils the controlling factor in the determination of architectural design. Today, earth-sheltered architecture has grown in popularity faster than technology can define its optimal design. In the interim, architects, builders, and engineers have progressed in the construction of earth-sheltered buildings guided by a blend of climatic knowledge and "conventional wisdom" (Geiger, 1965; Underground Space Center, 1982).

Supplementing the insulative quality of soil with plant materials in earth-sheltered structures is one example of conventional wisdom used to respond to contemporary situations. Depending on characteristics such as those of the site, (Robinette, 1976a), soil (Wright, 1986), plant materials (Taylor and Terrell, 1982; Robinette, 1972), and geography (Labs, 1982) designers modify the basic earth-sheltered shell to attempt to provide superior energy efficiency and aesthetics. Experience indicates that though deciduous woody ornamentals provide shade during the summer and light transmission in the winter, they are too deep rooted to be used above earth sheltered structures (Robinette, 1976b). However, deciduous woody ornamentals may be planted outside the soil envelope surrounding the earth sheltered structure to provide shading for entrances and wells. Herbaceous plant materials are more suited for "above structure" planting due to shallower rooting depths (Taylor and Terrell, 1982). Plant materials also have an important aesthetic role in the development and acceptance of earth-sheltered housing. The need exists to document vegetation and water management influences on temperature variation over earth-sheltered structures. Our objectives were to evaluate the fluctuation in soil temperature over an existing earth-sheltered structure and to investigate the influence of several vegetation and water management schemes on soil temperature variation.

MATERIALS AND METHODS

This study consisted of three independent experiments conducted in Lubbock, Texas. Data were analyzed using a completely randomized design with split plots (locations).

Experiment I: The primary site for this experiment was St. John Neumann Catholic Church, which is virtually earth

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covered to a depth of 2 ft. and vegetated with bermudagrass (**Cynodon dactylon**). Duplicate copper-constantan thermocouples were installed within the soil envelope at depths of 2, 6, 12, and 24 in. immediately above and adjacent to the styrofoam insulated roof. Duplicate thermocouples were buried in another bermudagrass location 12 ft. away from the building. Soil temperature, ambient air temperature, and interior building temperature (from return air ducts) were automatically recorded every six hours from July, 1983 through March, 1986. Mean monthly temperatures were determined by averaging daily data across all the depths.

Experiment II. To study the effects of vegetative cover on soil temperature fluctuation, three additional Lubbock sites were selected with similar soil characteristics. Sites were chosen with the following cover conditions — (1) mature stand of buffalograss (**Buchloe dactyloides**), (2) mature, well-managed bermudagrass lawn, and (3) bare soil. Each site was instrumented with thermocouple pairs at 0.5, 2, 6, 12, 18, and 24 in. depth and replicated three times. Soil and air temperatures were manually determined biweekly for 17 months. The bermudagrass was mowed twice weekly during the summer and received 12 in. of irrigation and 6 lbs. N per 1000 ft.^{2}. The dryland buffalo grass was shreaded annually. The bare soil treatment was periodically sprayed with herbicide (Roundup, 2% solution) to eliminate seasonal weed growth over the instrumented profile.

Experiment III. Additional bare plots on campus were used to determine irrigation water temperature effects on soil temperature. Sites were instrumented similarly to the plots in experiment II except for the omission of the 0.5 and 24 in. depth thermocouples. Two inches of hot, tepid, or cold water (treatments) were added once in the summer and once in the winter. The summer conditions were as follows: 77° F initial (dawn) soil temperature; 73° F initial air temperature; hot water, 176° F; tepid water 68° F; cold water, 40° F. The winter conditions were as follows: 32° F initial (dawn) soil temperature; 33° F initial air temperature; hot water, 140° F; tepid water, 57° F, and cold water, 37° F.

RESULTS

I. Earth Sheltered Structure Study

Soil temperatures above the church roof were cooler in the winter and warmer in the summer than temperatures in the adjacent soil (Fig. 1). The exceptions were December 1984

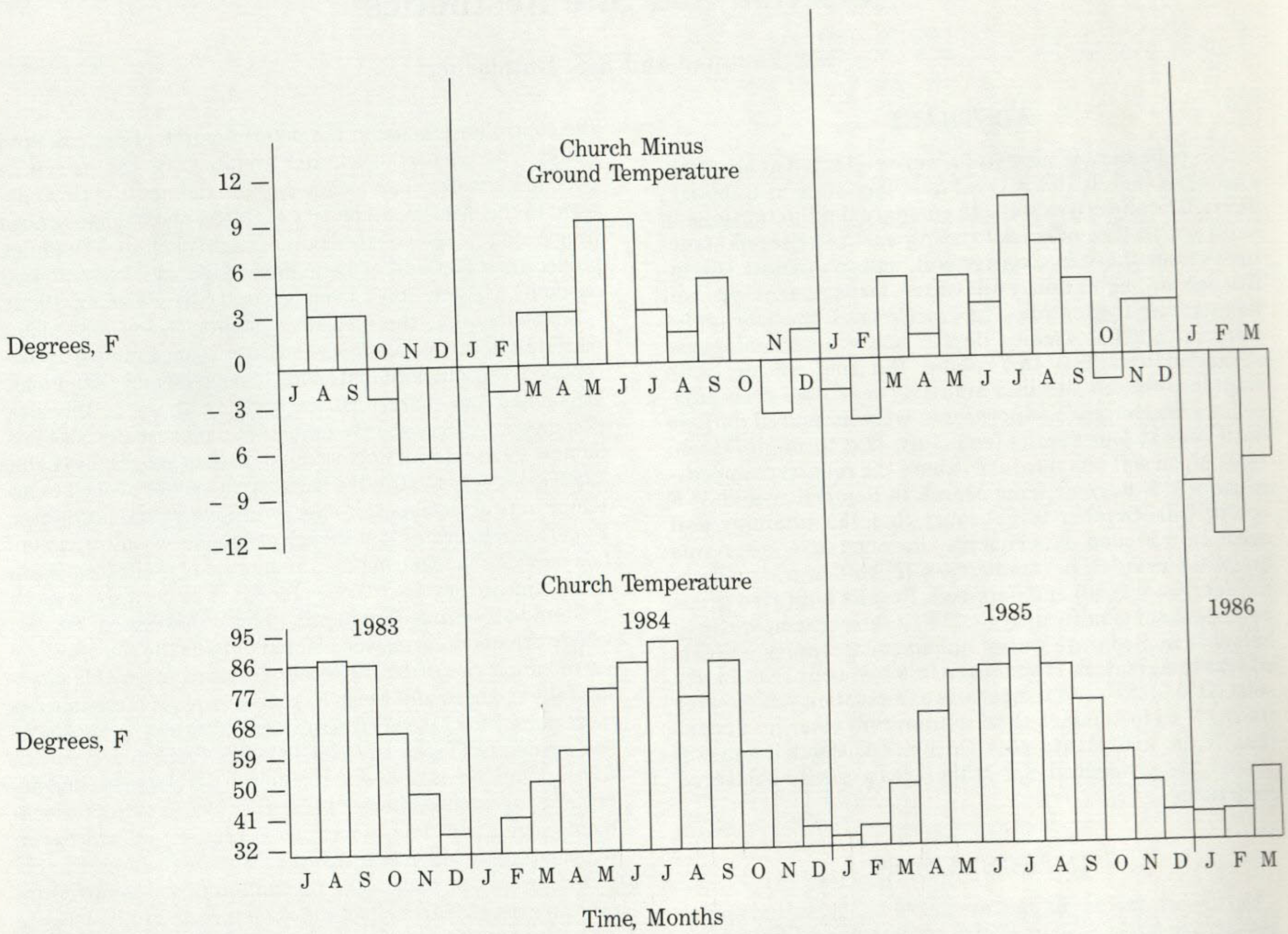

Fig. 1. Monthly Soil Temperature above St. John Neumann Church in Lubbock, Texas and Temperature Difference between Church and Ground. (Experiment 1)

and November and December 1985. Above roof soil temperatures fluctuated from a warm monthly (July) average of 95° F to a cold monthly average of 32° F (January, 1984). Temperature for the soil plots adjacent to the church were cooler in summer (July, 85° F maximum) and warmer in the winter (January, 38° F minimum). Soil temperature amplitude for the test period was less (63 vs 47° F) due to the soil mass acting as heat sink/source to the soil. From October to February, the soil below the zones of measurement served as heat source for the soil above. The insulated church roof did not supply comparable heat during this period of time. From March through September, the soil above roof was approximately 5° F warmer than the adjacent soil. Temperature differences again were due to the insulated roof. As the solar radiation and heat load increased, the insulated church did not act as a heat sink to the same extent as the soil mass in the adjacent site. The soil temperature increased above the roof more than in the adjacent area; however, had a lower peak temperature than the ambient outside air temperature.

II. Vegetation and Temperature Fluctuation Study

Soil temperature varied with depth, cover treatment, and air temperature. The fluctuations in soil temperature were greatest at the shallow depths under all cover treatments. The annual fluctuation at the 2 in. depth was 72° F while it was only 36° F at 24 in. Deeper depths had less fluctuation, thus demonstrating the buffering effect of the soil. Differences due to mulching effects between the three sites were evident in magnitude of temperature variation as a function of depth (Table 1). Temperature fluctuation was also noticeably dampened by a cover crop at the shallow depth of 2 in. Depth, however, was more efficient in dampening temperature variation than was cover crop. Specifically, from March through July, the bare soil was significantly warmer (5 to 9° F) at the 0.5 and 2 in. depth than either grass. At the 6 and 12 in. depth the bare soil was approximately 2° F warmer than the grasses from April through July. The bare soil was approximately 2° F warmer than the grasses from mid-April to June and May for the 18 and 24 in. depths, respectively. The buffalograss and bermudagrass did not exhibit significantly different temperatures despite supplemental irrigation of the bermudagrass.

Table 1. Mean soil temperature variation with time as a function of vegetative cover, 1982. (Experiment II)

	Bufallo-grass	Bare Soil	Bermuda-grass
		° F	
Jan	40	41	42
Feb	46	48	45
Mar	53	56	54
Apr	64	66	63
May	69	72	69
June	73	76	76
July	79	86	81
Aug	84	87	92
Sept	86	91	80
Oct	75	79	73
Nov	57	59	56
Dec	44	46	45

III. Water Management Study

The water management was evaluated to determine the efficiency of water in cooling and heating a soil. Results (Table 2) indicated that moist soils had less diurnal temperature fluctuation than dry soils in the summer. The very presence of water in the soil acts as a temperature buffer due to the differences in specific heat capacity of water and soil. Although the hot water treatment summer soil temperature initially increased from 77 to 86 and 82° F at the 2 and 6 in. depth, respectively; after 8 hours there were no significant differences in temperatures. In the summer, the wet soil treatments remained 3 to 7° F cooler after 8 hours than the dry one demonstrating that the presence of water was more important than its application temperature. The hot water treatment soil temperature increased at the 2 and 6 in. depth for 45 min. before it stabilized and began to cool. The heating of the day caused increased temperature at 300 min. The soil temperature of the dry and tepid water treatments remained relatively constant (<2° F) at the 2 in. and 6 in. depth, until the afternoon warming. The cold water treatment decreased for 45 and 120 min. at the 2 in. and 6 in. depth, respectively, before warming. In the winter, due to initial cold soil temperature (32 and 36° F for the 2 and 6 in. depth respectively) and the cold air temperature, little response to irrigation water temperature were evidenced. These results indicated that in the environment of Lubbock, Texas, application of irrigation water had no significant long term effect on the structure.

Table 2. Two and 6 inch depth soil temperatures as a function of time and temperature of water applied. (Experiment III)

Time	Season															
	Summer								Winter							
	Hot		Dry		Tepid		Cold		Hot		Dry		Tepid		Cold	
Min	2″	6″	2″	6″	2″	6″	2″	6″	2″	6″	2″	6″	2″	6″	2″	6″
0	77	77	77	77	77	77	77	77	32	36	32	36	32	36	32	36
15	79	77	79	77	75	77	66	77	48	41	32	36	32	36	32	36
30	88	81	79	79	77	77	61	72	53	43	32	34	32	36	32	34
45	88	82	79	79	75	77	59	70	57	45	34	34	34	37	32	34
60	86	82	79	79	75	77	61	68	59	45	34	34	37	37	32	34
90	84	82	79	79	77	77	63	68	63	45	32	34	41	41	34	36
120	84	82	81	79	77	77	66	68	63	45	34	34	41	41	34	36
180	84	82	82	81	82	77	77	72	63	45	34	34	43	41	36	37
240	80	82	86	82	88	82	77	73	61	45	36	36	43	43	37	37
300	86	84	86	82	86	82	79	77	61	45	39	37	45	43	39	37
360	86	84	90	86	86	82	82	77	59	45	43	39	45	43	41	37
420	88	84	91	88	88	82	82	79	46	45	43	39	45	45	41	37
480	88	86	91	90	88	86	84	81	45	45	43	41	45	45	41	39

CONCLUSIONS

The major influence on the soil as a contributor to the energy balance of an earth-sheltered structure was its mass. Data indicated that increasing soil depth decreased temperature fluctuation. However, the influence of each additional inch of soil must be weighed against its impact on the structural components of the building. No reason to advocate soil depths greater than 18 in. could be substantiated by this research.

Secondly, the use of plant materials on earth covered roofs and walls should be promoted primarily for aesthetic reasons, as their effect at an 18 in. depth was not significant. Similarly, the use of water to irrigate plants, especially water that has been heated or cooled, did not significantly benefit the structure's energy balance. Since elimination of irrigation lessens the challenges to the building's waterproofing barriers, planting should be designed to minimize irrigation demands while maintaining aesthetic quality. We believe that native and naturalized plants which are able to thrive without supplementary irrigation would be the best choice for vegetative cover on earth structures.

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Effects of Repeated Shredding on a Guajillo (*Acacia belandieri*) Community

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ABSTRACT

Shredding is often used to manage brush in South Texas. The objective of this study was to determine the effects of repeated shredding on density and canopy cover of browse plants used by white-tailed deer (*Odocoileus virginianus*) and on brush species diversity in a guajillo (*Acacia berlandieri*) community. About 2000 acres in Zavala County were shredded at 3-year intervals from 1969-1978 with a drag-type shredder. In 1985, brush density and canopy cover were determined in 5 unshredded and adjacent shredded areas. Shredding had little effect on density and canopy cover of high, medium, and low value browse plants. Density of exceptionally palatable plants was lower on shredded than on unshredded areas. Brush species diversity was also lower on shredded range.

INTRODUCTION

Shredding is widely used for brush management on the South Texas Plains (Hamilton et al., 1981). The treatment removes top growth but rarely kills brush (Welch et al., 1985). Although top growth is replaced within 2-3 years (Welch et al., 1985), a short-term increase in forage production often occurs following shredding (Scifres, 1980). Other advantages of shredding include improved management efficiency by increasing visibility of livestock and improved grazing distribution (Scifres, 1980). Hamilton et al. (1981) suggested shredding at 3-5 year intervals to suppress stands of mixed brush in South Texas.

Top removal increases palatability of brush for cattle and white-tailed deer (**Odocoileus virginianus**) (Box and Powell, 1965; Powell and Box, 1966). Powell and Box (1966) attributed increased palatability to greater browse availability and nutritional quality. Everitt (1983) found that regrowth of shredded brush had higher crude protein and phosphorus levels than current growth from nonshredded plants.

Guajillo (**Acacia berlandieri**) is a desirable livestock and wildlife browse species that dominates shallow ridges in the Rio Grande Plain of Texas (Davis and Spicer, 1965). The USDA Soil Conservation Service recommends shredding for management of guajillo because of its value for browse (Scifres, 1980). The objective of this study was to determine the effects of shredding at 3-year intervals for 9 years on white-tailed deer browse and brush species diversity of a Guajillo community.

MATERIALS AND METHODS

The study was conducted on the A.L. Cardwell Ranch in Zavala County in the South Texas Plains. The study area is a Gravelly Ridge range site with gravelly loam over caliche

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