AN ABSTRACT OF THE THESIS OF

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The hydrophobicity of soils of the Deschutes National Forest was studied. The soils are Cindery Typic Cryorthents, formed in cinders and ash from Mt. Mazama. Ponderosa pine is the dominant overstory vegetation. Of particular interest was the effect of prescribed burning on hydrophobicity. Fire has been shown to cause a normally hydrophilic soil to become hydrophobic. This non-wettability reduces water infiltration into the soil. As a result, the potential for erosion increases and less water is available for plant growth.

The objectives of the study were to determine (1) whether or not prescribed burning causes the formation of a water repellent layer, (2) which variables affect the hydrophobicity of the soil following burning, (3) the horizontal and vertical extent of the hydrophobic layer, and (4) how long the hydrophobicity persists in the soil.

Critical Surface Tension (CST) was measured to characterize hydrophobicity. A site burned 25 June 1982 and a site burned 15 September 1982 were sampled to meet objectives (1), (2), and (3). Objective (4) was met by sampling six additional sites where the time since burning ranged from 9 to 51 months.

The presence of pre-burn hydrophobicity, believed to be caused by fungal products, complicated determining the effects of burning on the hydrophobicity of the soil. Pre-burn hydrophobicity was more extensive on the site which was sampled in September than the site sampled in June. Ninety-six % of the sampling points were

hydrophobic during September and 42% during June. Two possible reasons were postulated for this difference. First, the amount of hydrophobicity due to the presence of fungal hyphae may vary seasonally; fungal products may accumulate during summer and then leach out of the profile with fall rains and spring snowmelt. Second, avoiding fungal pockets may not have been as successful when September sampling occurred as in June. Soil infected with fungal hyphae was avoided when CST was measured, because the fungal pockets did not form a continuous layer parallel to the surface. Fungal pockets were avoided by observing the light color of the dry fungal soil and the presence of hyphae. The soil had a light color because the water content was low. The soil was drier in September than in June. Distinguishing between fungal and non-fungal soil based on color differences was relatively easy in June, because the non-fungal soil was moist. However, the color difference between fungal and non-fungal soil was not as distinct during September sampling. The difference in color due to water content between fungal and non-fungal soil was small. As a result, the effort to avoid fungal caused water repellent areas was not as successful. More of the sampling points were hydrophobic in September.

The June burn caused an increase in the hydrophobicity of the soil. The increase was greatest at the 2-3 cm depth. The hydrophobicity of the soil following burning in the June burn was explained by the degree of litter combustion. Hydrophobicity was produced where complete combustion occurred but not with incomplete combustion of the litter.

Pre-burn hydrophobicity of the soil sampled in June occurred more often in the upper 2 cm than at the lower depths. Pre-burn hydrophobicity occurred at 42.5% of the sampling points. Post-burn hydrophobicity occurred randomly at all depths and occurred at 60.5% of the sampling points.

On the site burned in September, most sampling points were hydrophobic before burning because of the presence of fungal products. Hydrophobicity decreased in the upper 2 cm of the soil. It was postulated that the hydrophobic fungal products were volatilized by the high temperatures of the prescribed burn and diffused deeper into the soil where they then condensed.

The hydrophobicity of the soil following burning in the September burn was correlated with hydrophobicity of the soil before burning. Soil was found to be hydrophobic after burning if it was hydrophobic before burning. Measurements of litter depth, water content, and degree of combustion did not explain the variation in post-burn hydrophobicity of the soil at either site.

Pre-burn hydrophobicity of the soil sampled in September occurred more near the surface than deeper in the soil. Pre-burn hydrophobicity was found at 96% of the sampling points. Post-burn hydrophobicity was not quite as extensive; 92% of the sampling points were hydrophobic. Post-burn hydrophobicity occurred deeper in the soil than pre-burn hydrophobicity in September, but the difference between depths was not significant.

The percentage of hydrophobic sampling points decreased as time since burning increased. The relationship was significant at the 95% confidence level.

Hydrophobicity of Cindery Typic Cryorthents

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INTRODUCTION

Current Situation and Importance of Hydrophobicity

Fire has not been a part of the ecosystem in central Oregon since the advent of fire control. Prior to fire control, stands of Ponderosa pine burned at regular intervals of 3 to 10 years (Cooper, 1961). This relatively frequent burning resulted in removal of brush and light fuels, reducing the potential for devastating crown fires. Fire control in the area has caused a buildup in fuel levels so that, when fires occur now, they are major conflagrations which destroy not only brush and downed trees but also most of the standing pine.

Research has been conducted and is currently underway to prevent this type of disastrous fire. Research determines the conditions under which prescribed burns should be executed so the effects of fire on standing trees are minimized and decreasing the potential of the site for future timber production is minimized. There are several ways in which burning can reduce site productivity: the loss of nutrients by volatilization, destruction of organic matter, and decreasing the ability of the soil profile to recharge with water due to development of water repellency. This project concerns the development of water repellency caused by fires.

Fire has been shown to cause a wettable soil to become non-wettable. This non-wettability reduces the infiltration rate of the soil. In southern California the reduction in infiltration rate of coarse-textured, chaparral vegetated soils has resulted in large increases in the rates of erosion. Lateral flow of water, due to the reduction in infiltration rate of the soil, results in a loss of water which would otherwise recharge the soil profile. Consequently, less water is available for plant growth. The major interest in the formation of water repellent layers due to burning is not erosion but the reduction in the amount of water which is available to plant growth. Erosion is not as important because slopes in central Oregon (1-55%) are not as steep as the slopes in southern California.

The soils in central Oregon are coarse textured because they formed in deposits of cinders and ash from Mt. Mazama. Understory vegetation on the soils consists of various combinations of antelope bitterbrush (*Purshia tridentata*), greenleaf manzanita (*Arctostaphylos patula*), and snowbrush ceanothus (*Ceanothus velutinus*). The general similarities between the vegetation and soils of southern California and the vegetation and soils of central Oregon resulted in the question: does a water repellent layer form in central Oregon soils because of burning?

Objectives

The objectives of this study were to determine (1) whether or not prescribed burning causes the formation of a water repellent layer; (2) to what degree gravimetric soil water content, litter depth, degree of litter combustion which occurs during the burn, and pre-burn hydrophobicity affect post-burn hydrophobicity; (3) the horizontal and vertical extent of the hydrophobic layer; and (4) how long hydrophobicity persists in the soil.

LITERATURE REVIEW

Fire Induced Hydrophobicity

Water repellency occurs when a hydrophobic layer forms in the soil after heating (DeBano and Krammes, 1966). Normally, dry soil particles at the soil surface have a very strong affinity for water molecules and rapid infiltration occurs. However, if the soil particles are hydrophobic, the water molecules are attracted to each other more than to the soil particles and do not penetrate the soil. Infiltration rates are consequently much lower for soils which have a hydrophobic layer than for wettable soils (DeBano, 1981). DeBano et al. (1967) also found that the infiltration rate was lower for a soil in which the water repellent layer was a few centimeters below the soil surface than for a soil in which the water repellent layer was immediately below the surface. Zwolinski (1971), as cited by DeBano (1981), found that light intensity burns in some Ponderosa pine areas significantly reduced initial infiltration rates. However, Agee (1973) found that in some cases, water repellency was concentrated in the litter when the area was subjected to a light intensity fire, with an insignificant effect on the soil.

Mechanism of Formation of Hydrophobicity

The mechanisms by which fire induces water repellency are understood quite well. High surface temperatures result in organic substances being volatilized. Some of these products escape to the atmosphere while others diffuse into the soil. Since the soil is at a much lower temperature (200 C) during a fire only centimeters below the surface as compared to the temperature at the surface (1,400 C), the products condense onto soil particles to form a water repellent layer (DeBano, 1966).

Factors Affecting Degree of Hydrophobicity

DeBano and Krammes (1966) found that whether hydrophobicity is produced or destroyed depends on the temperature to which the sample is heated and the duration of heating (Fig. 1). Slightly non-wettable soil was heated in a muffle furnace. They measured hydrophobicity by placing a drop of water on the surface of a soil sample and recording the time which elapsed before the drop of water disappeared into the soil. The water drop penetration time (WDPT) was recorded after 5, 10, 15, and 20 minutes of heating had occurred for each of six different temperatures. The general trend was an increase in the WDPT with an increase in the temperature at which a soil was heated or the length of time during which a soil was heated. When a soil was heated at 149 C, the WDPT remained zero throughout the 20 minutes of heating. Heating a soil at 204 C resulted in moderate water repellency (WDPT = 35 min.) being induced. Heating the soil at a higher temperature (260 C) caused the wettable soil to become hydrophobic (WDPT = 40 min.) sooner, after 10 minutes of heating. The WDPT was 80 minutes following 15 minutes of heating. This increase in hydrophobicity, with an increase in temperature, can also be seen when the soil was heated at 316 C. The soil was strongly hydrophobic (WDPT = 80 min.) after 10 minutes of heating. Prolonged heating at a high temperature caused a decrease in hydrophobicity. Heating the soil at 427 C caused the soil to become strongly hydrophobic (WDPT = 80 min.) after only five minutes of burning, but the hydrophobicity decreased (WDPT = 20 min) after 15 minutes of burning. Further heating at 427 C caused a decrease in the WDPT to 15 minutes. Heating at the temperature of 482 C also resulted in the soil becoming strongly hydrophobic (WDPT = 80 min.) after 5 minutes, but the hydrophobic nature was completely destroyed (WDPT = 0 min.) after heating the soil for 15 minutes. Initial heating of the soil above the temperature of 400 C caused organic substances to fix to the soil particles, but further heating caused the substances to be revolatilized. This explains why a thin, 1-2cm

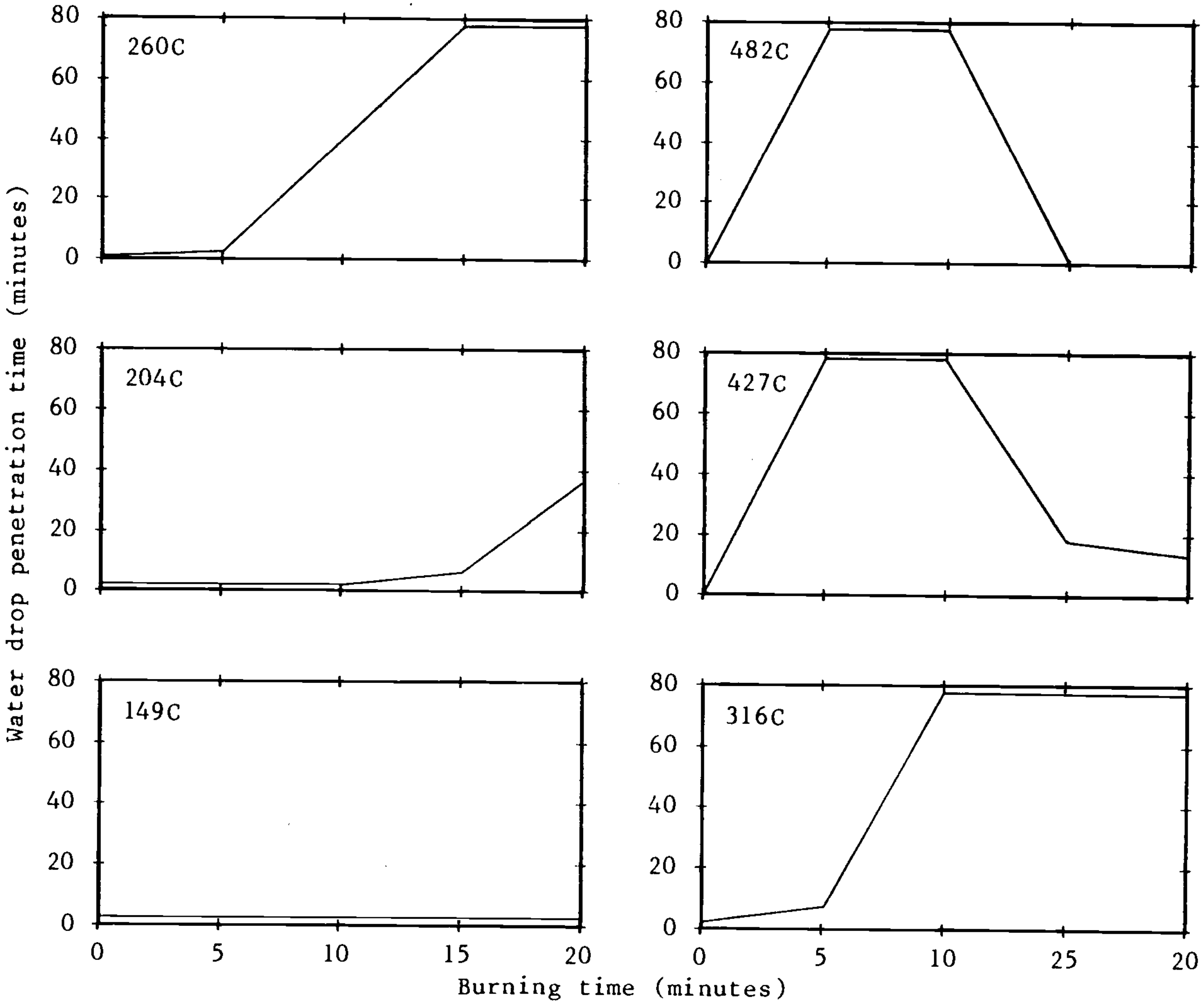

Figure 1. The effect of heating time and temperature on soil water repellency after heating (after: DeBano and Krammes, 1966).

thick wettable layer often overlies the water repellent layer which is caused by burning.

DeBano (1966) proposed that temperature gradients existing in the upper few inches of the soil during burning may be more important than the temperature at any particular depth. Savage et al. (1972) illustrated that the mechanism is not a simple condensation of hydrophobic material because extreme water repellency was produced when the products of the fire were heated following their condensation. They found that following the translocation of organic substances into the soil, a heat pulse moved through the soil which "fixed" the more polar hydrophobic substances and revolatilized the less polar substances which then condensed deeper in the profile. They also found that 250 C was the temperature required to "fix" the more polar substances and revolatilize the less polar substances. Scholl (1975) determined that the water repellency of the soil remained at 350 C if the soil was heated in a closed container. Heating to 350 C in an open container allowed the volatile gases to escape and water repellency to be lost.

There are several other factors, in addition to temperature, which determine whether or not a water repellent layer forms in a soil. Some of these factors affect temperature while others may be considered as independent of temperature.

The amount of water in the profile determines to what extent, both in thickness and severity, as measured by contact angle or water drop penetration time, a hydrophobic layer forms by affecting the temperature gradient which develops during burning. Temperatures are much lower during burning in wet soils than in dry soils. Temperatures in wet soils did not appreciably exceed 100 C until most of the water was removed from of the horizon (DeBano et al., 1976). DeByle's (1973) study agrees with this observation. He found that the water content decreased from 30 to 19% by weight and the temperature reached 130 C at the 0.5 cm depth and 107 C at the depth of 1 cm during a fire in relatively dry slash and duff. When moist slash and duff were burned in a similar area water content decreased 1 to 2% and the fire did not affect the soil. DeBano et al. (1976) found that the thickest and strongest hydrophobic layer formed from a short duration burn over dry soils.

The water content of the soil is not the only factor which influences temperature gradients and therefore water repellent layer formation under burns. The type of plant cover also influences formation of hydrophobic layers. Adams et al. (1969) observed non-hydrophobic soil following fire beyond the dripline of three species of plants: Larrea, Prosopis, and Cerdidium, but not under the shrubs themselves. She hypothesized that the difference between the soil under the shrubs which became hydrophobic and the grass covered soil which did not become hydrophobic was due either to the intensity of the burn or to the fact that more hydrophobic material was produced under the shrub vegetation. The difference in water repellency was evidenced by the fact that there was a marked increase in the number of annuals present after the fire where the soil became wettable 2.5 feet from the center of the hummock.

Texture affects the formation of water repellent layers independently of temperature. DeBano et al. (1970) found that thick, more hydrophobic, layers formed in coarse textured soils than in fine textured soils. They did not know if a certain amount of organic substance coated less surface area in coarse textured soils than in fine textured soils or if there were fewer sites to which the substances bound in a coarse textured soil. However, they did conclude that the strength and thickness of the layer formed depends on the surface area of the soil. Observations by Bond and Harris (1964) agree. They observed that hydrophobic soils in Australia never contain more than 5% clay.

Nature of Products

The nature of hydrophobic substances and their bonding with soil particles is still not understood very well. Savage (1974) reported that the hydrophobic materials could not be extracted with benzene-methanol when water repellency was induced by heating naturally occurring soils. However, these same substances could be extracted from a recently ground quartz sand.

Persistence

The length of time fire induced water repellency remains in the soil is not consistent. Dyrness (1976) observed that fire induced water repellency persisted for up to five years following wildfire. However, DeByle's (1973) results indicated that fire induced water repellency decreased to pre-burn levels in one year.

Leached Products

Water repellency can be induced by mechanisms other than fire. Organic substances leached from a water repellent soil can cause a non-hydrophobic soil to become hydrophobic. Van't Woudt (1959) found that the extract obtained from a water repellent volcanic ash soil could cause a wettable soil to become non-wettable. The shrub monoao was the dominant plant species on this water repellent, volcanic ash soil. On nearby sites, water repellent soil was not found under grass vegetation. Organic substances leached from plant parts can also cause a non-hydrophobic soil to become hydrophobic. Letey et al. (1962) showed that extract of chaparral litter produced non-wettability in formerly wettable sands. Meeuwig (1971) found water repellent soil which occurred in a continuous layer under Ponderosa pine litter. Pockets of water repellent soil were found under chaparral but not in a continuous layer.

Fungal Induced Hydrophobicity

Water repellency can form as a result of deposition of fungal products. Bond and Harris (1964) found intermediate degrees of water repellency associated with basidiomycetes fruiting bodies. They suggested that the water repellency in sands is linked to the dominance of basidiomycetes in the microflora. Bond (1964) found that there was a difference in infiltration rate due to the type of vegetation. He postulated that this was due to different species of basidiomycetes growing under different plants. He believed that the difference was due to different species of microorganisms growing in association with the plants, since fungal species vary in their ability to produce water repellency.

METHODS AND MATERIALS

Measuring Hydrophobicity

Measurements of water repellency are based on the fact that the contact angle of water with a non-wettable soil is greater than with a wettable soil. The contact angle that forms when a drop of water placed on a solid surface comes to rest is an indication of the hydrophobicity of that surface. The resulting angle (θ) (Fig. 2) depends on the force due to surface tension between the solid and the liquid (γ_{SL}), the force due to the surface tension between the gas and the solid (γ_{GS}), and the force due to the surface tension between the liquid and the gas (γ_{LG}) (Hillel, 1981). If a drop placed on a solid surface is to come to equilibrium, the vector sum of the three forces arising from the three types of surface tension must equal zero, or the force due to the surface tension between the gas and solid must be equal to the sum of the other two forces.

$$\gamma_{GS} = \gamma_{SL} + \gamma_{LG} \cos \theta \qquad (1)$$

and therefore,

$$\cos \theta = (\gamma_{GS} - \gamma_{SL}) / \gamma_{LG} \qquad (2)$$

Stated simply in terms of water repellency, if the adhesive forces between the liquid and solid are greater than the cohesive forces between the liquid molecules and greater than the forces of attraction between the gas and solid, the contact angle will be small and the liquid will wet the solid. The surface is hydrophillic. If the opposite is true, the contact angle is greater than 90. The liquid will not wet the surface, and the surface is hydrophobic.

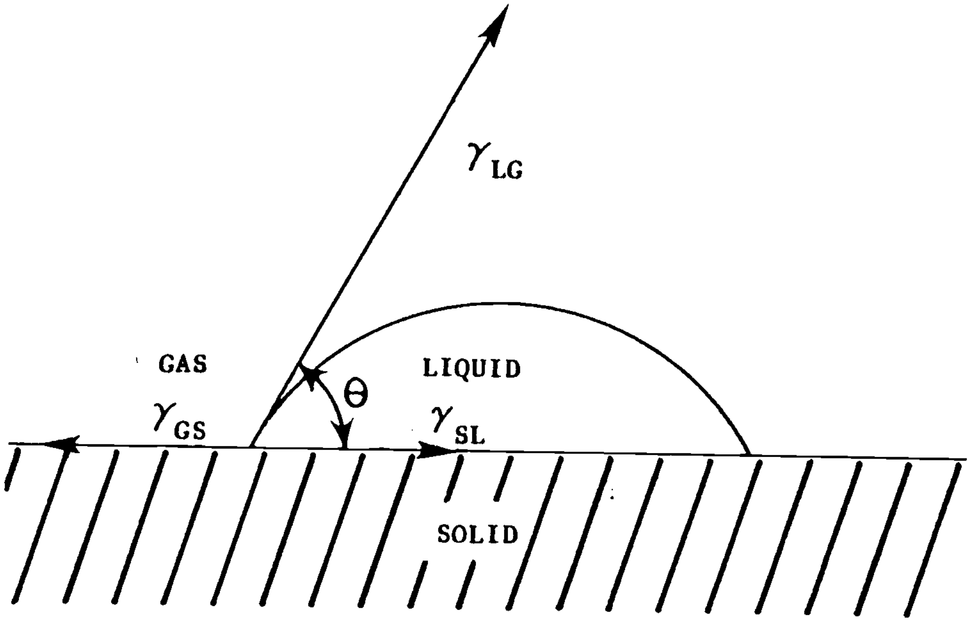

Figure 2. Contact angle of a drop of water on a flat surface (after: Hillel, 1980).

Capillary Height Rise

Soil particles do not have flat surfaces, so contact angle can not be measured geometrically. The soil-water contact angle must be measured indirectly. There are two methods for indirectly measuring contact angle based on the equation which describes capillary rise in soils:

$$h = \frac{2\gamma \cos\theta}{\rho g r} \qquad (3)$$

where,

h = height of capillary rise (cm)
γ = surface tension of the solution (dynes/cm)
θ = liquid-solid contact angle (degrees)
ρ = density of the solution (g/cm^3)
g = gravitational constant (cm/sec^2)
r = effective pore radius (cm)

In this equation r and θ are unknown. Letey et al. (1962) developed a method for measuring the liquid-solid contact angle of a hydrophobic soil by first solving the capillary rise equation for the effective pore radius. This was done by measuring the height of capillary rise for a column of water repellent soil imbibing pure ethanol; they observed that pure ethanol wets all solids with the same contact angle. The contact angle was assumed to be zero. The effective pore radius was calculated from the measured height of capillary rise. The equilibrium height of rise was arbitrarily set at 24 hours as they determined that little additional rise would occur after 24 hours. The height of capillary rise was then measured for another column of water repellent soil imbibing distilled water. From this height, and the pore radius derived earlier, the contact angle was calculated.

A simple equation can be derived from the capillary rise equation for the method developed by Letey et al. which shows the relationship between height (cm) of capillary rise of distilled water (hw), height (cm) of capillary rise of ethanol (he), and apparent contact angle (θw) (degrees), namely,

$$\cos \theta w = 0.369 \frac{hw}{he} \qquad (4)$$

The constant 0.369 is derived from known values of density and surface tension of water and ethanol at 20 C. The main disadvantage of this method is that the surface tension of the liquid decreases as the soil adsorbs the liquid because it reacts with the soil. This results in a smaller measured contact angle than it actually is because of the long equilibration time (24 hrs.).

Emerson and Bond (1963) developed a different method for determining the contact angle based on the capillary rise equation and Darcy's Law. They assumed that the equation which describes capillary rise was only valid when the moisture content below the height of rise was constant. The water content was constant when the rate of rise was zero. They measured the rate of capillary rise for a column of soil imbibing water. From this rate, height of capillary rise was calculated. The rate of infiltration into a horizontal column of sand was calculated from measured changes in the position of the wetting front with time. This rate of rise was plotted against the reciprocal of the height of rise (Fig. 3). The relationship between rate of rise and the reciprocal of height of rise was linear until about 15 minutes of rise had occurred at which time the curve of the relationship curved away from the reciprocal of height of rise axis. They extrapolated the linear part of the graph to a rate of rise of 0; this gave values for height of capillary rise. They did this for a water repellent soil and the same soil after it was heated at a temperature of 500 C. They assumed that the heated sample was completely wettable, with a contact angle of zero degrees. The relationship between contact angle (θw), untreated water repellent soil (hu), and the heated soil (hi) is:

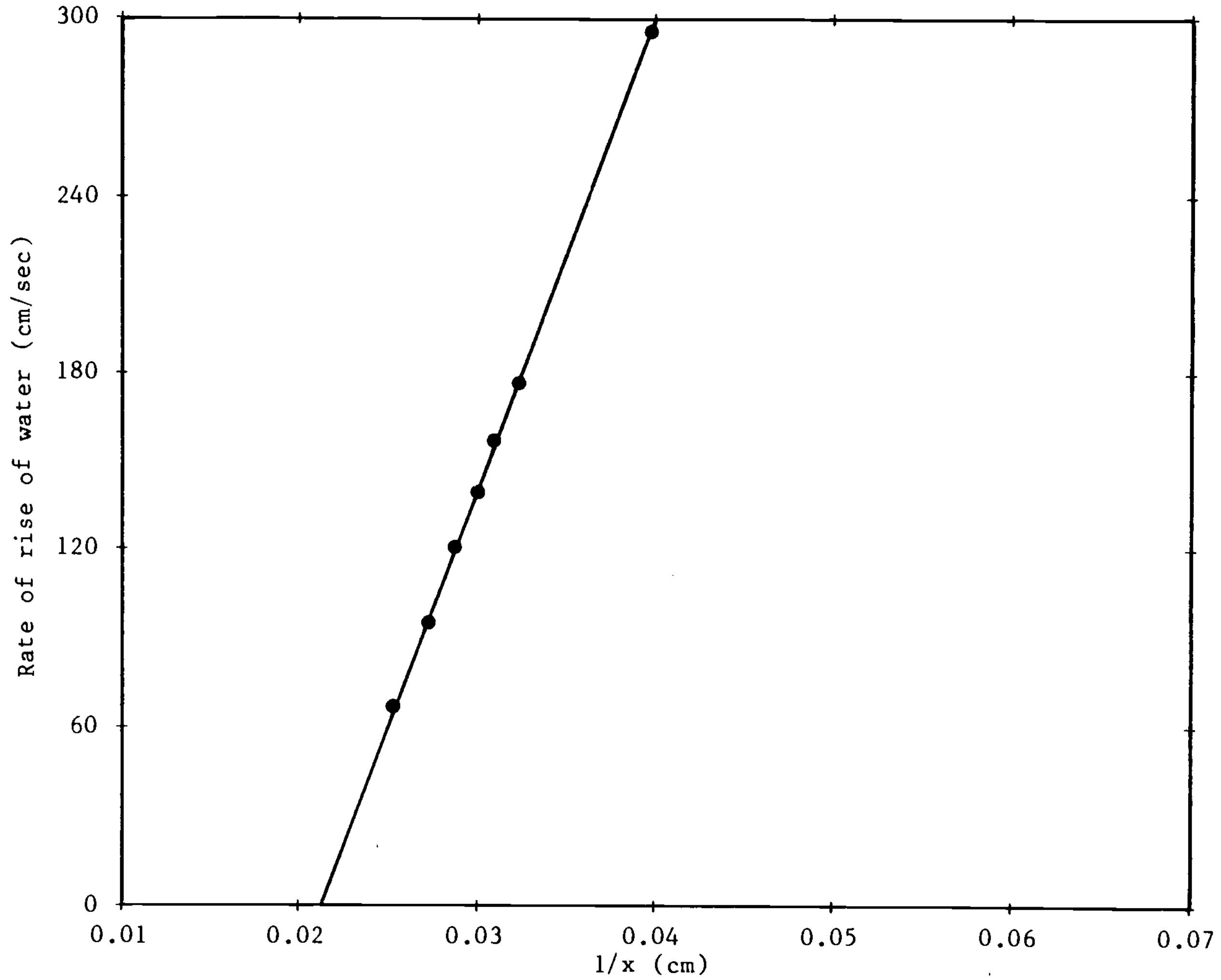

Figure 3. Rate of rise of water as a function of the reciprocal of the height of rise (1/x) into ignited sand (after: Emerson and Bond, 1963).

$$\cos \theta w = \frac{hu}{hi} \qquad (5)$$

The time required to measure a soil's contact angle using the Emerson and Bond (1963) method is often about 15 minutes. The contact angle more closely approximates the actual initial contact angle and therefore the water repellency of the soil, since this is much less time than the 24 hours required for the method by Letey et al. (1962).

Measuring contact angle by the methods just described was not practical in this study for several reasons. The methods can not be used in the field, thin layers of soil would likely be missed when soil was being collected for columns, and processing large numbers of samples would be very time consuming.

Critical Surface Tension

Another method used to measure degree of hydrophobicity is based on the fact that contact angle depends on the surface tension of the liquid wetting the solid. Zisman (1964) proposed to use the relationship between contact angle and surface tension as a measure of a solid's wettability. In general, decreasing the surface tension of the liquid wetting the solid decreases the liquid-solid contact angle (Fig. 4). In the hypothetical example shown in Figure 4; a drop of water, with a surface tension of 75 dynes/cm, was applied to the hydrophobic surface. The drop of water balled up, so the contact angle was measured as 180 degrees. Applying a drop of solution with a surface tension of 55 dynes/cm would also result in a liquid-solid contact angle of 180 degrees (perfect non-wetting). However, applying a drop with a surface tension of 40 dynes/cm resulted in the contact angle decreasing to 120 degrees. When a drop with a surface tension of 35 dynes/cm was applied to the soil the contact angle became less than 90 degrees and wetting of the soil occurred. In this manner a Critical Surface Tension (CST), the highest surface tension of a liquid which would wet the solid, (90

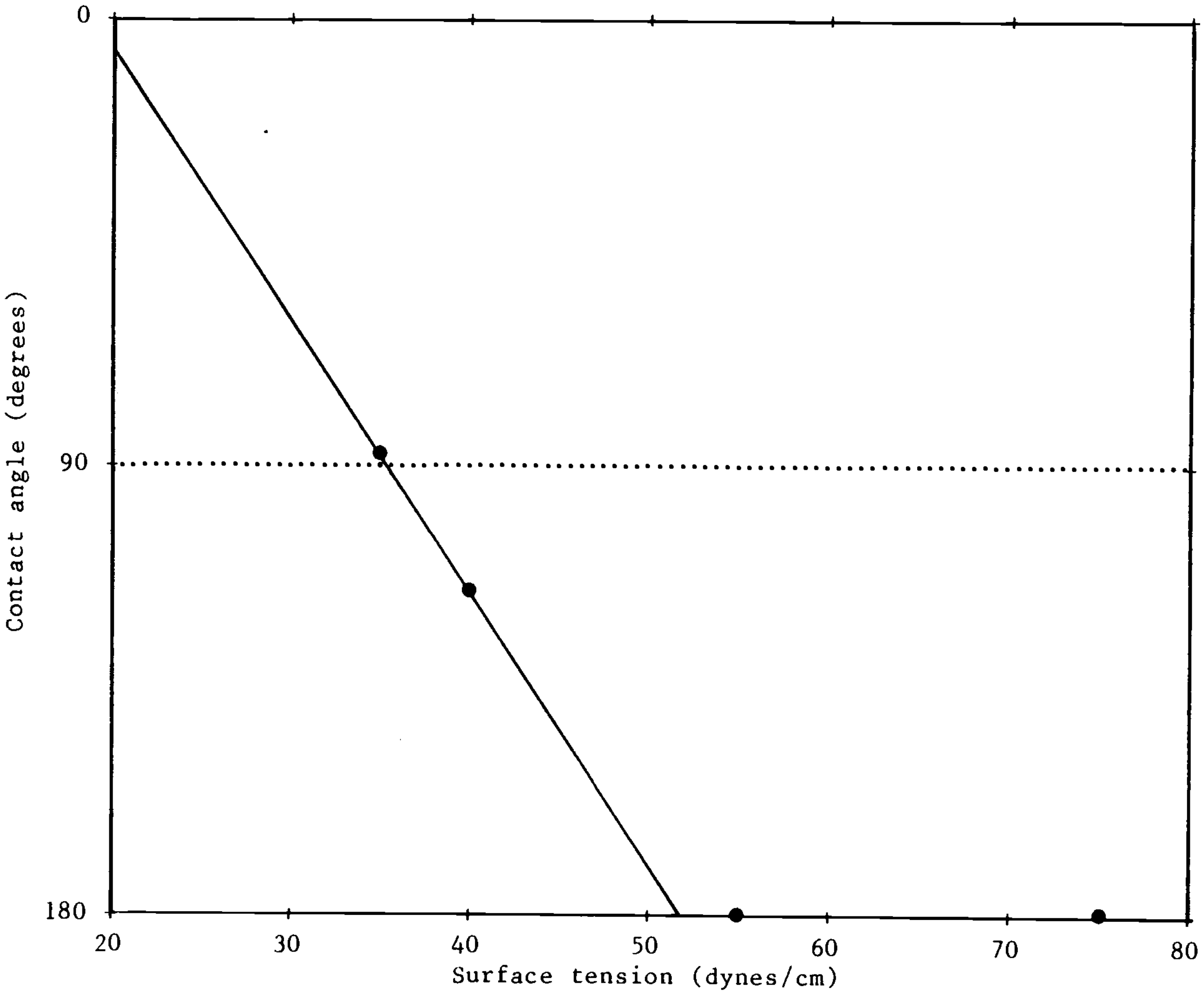

Figure 4. Relationship between contact angle and the surface tension of the wetting solution (after: idea by Zisman, 1964).

degree contact angle) could be identified (Letey, 1969). In this example the CST was 35 dynes/cm.

Work by Watson and Letey (1970) has shown that CST is a good indicator of initial water repellency. They applied drops of liquid of progressively lower surface tension to silane-sand, amine-sand, and morris dam soil. On each of the three media the drop penetration time decreased as the surface tension of the drop applied was reduced (Fig. 5). They found that the drop penetration time vs. surface tension curve approached the surface tension axis asymptotically. This means that the CST is not that of the liquid that penetrates the soil instantaneously. They choose an arbitrary penetration time of 5 seconds as the criterion for identifying the CST. The CST for the silane-sand, amine-sand, and morris dam soil is 41, 57, and 68 dynes/cm respectively (Fig. 5). There were several data points which had drop penetration times greater than 10 seconds which are not shown on the graph (Fig. 5). The scale of the graph did not allow the plotting of these points, so the phenomenon of the curve approaching the surface tension axis asymptotically could be illustrated more clearly. These data points that are not shown result in the curve of the relationship between drop penetration time and surface tension being nearly parallel to the drop penetration time axis above 5 sec of drop penetration time.

In our study the method developed by Watson and Letey (1970) was used to characterize water repellency, because it can be used in the field, is relatively fast so many sampling points can be characterized, and is a good measure of contact angle and therefore water repellency. A series of ethanol-water solutions was made up to obtain liquids with different surface tensions. 0%, 1%, 10%, 25%, and 50% ethanol solutions were chosen for our experiment because they covered a large range in surface tension (71.2 to 27.5 dynes/cm at 30 C) and surface tension values were known for each concentration at various temperatures (Chemical Rubber Company, 1947). Determining surface tension at various temperatures was necessary because surface tension varies with temperature. The values obtained from the Handbook of Chemistry and Physics (Chemical Rubber

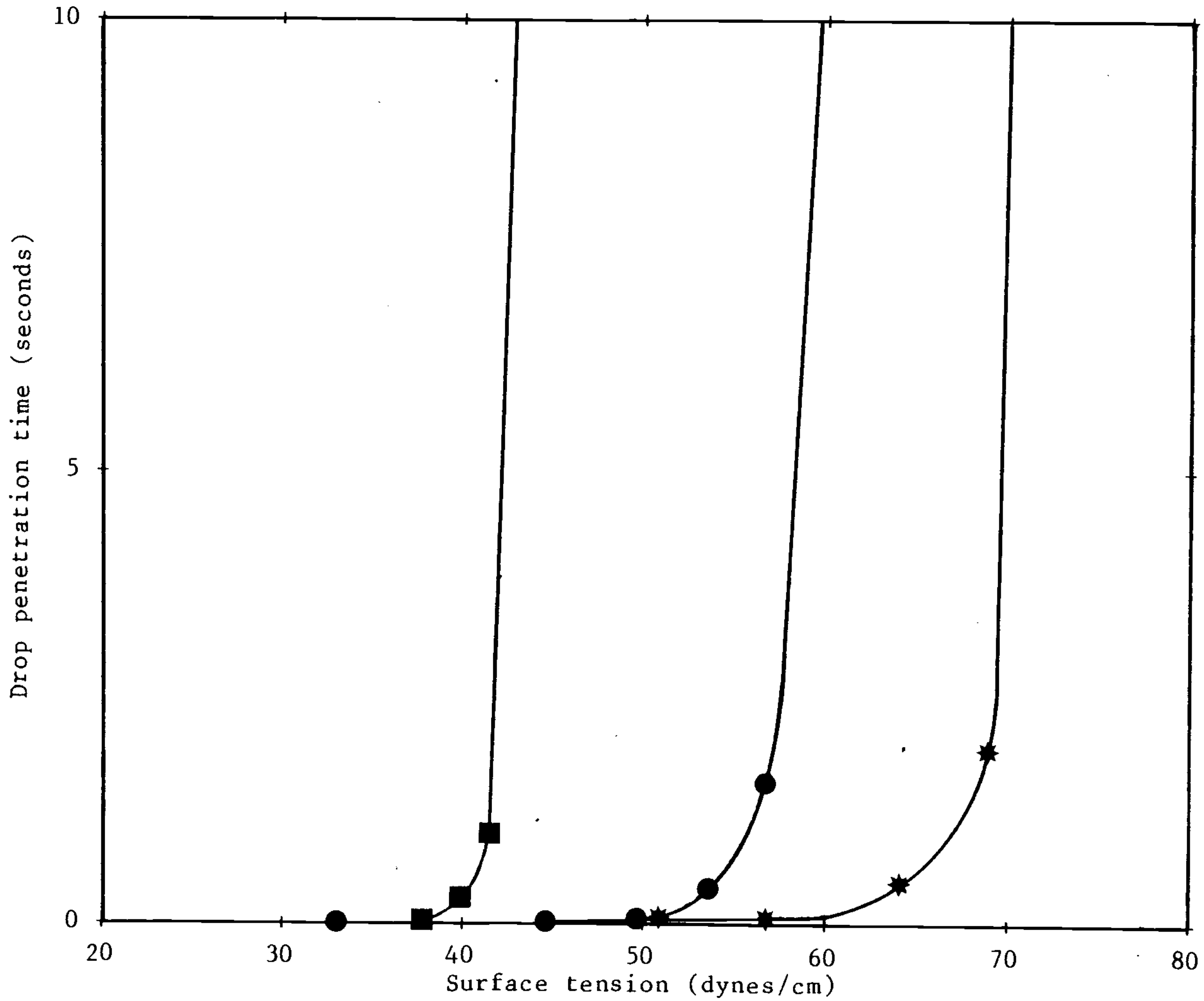

Figure 5. Drop penetration time versus surface tension of aqueous ethanol solutions (after: Watson and Letey, 1970).

Company, 1947) were used to construct Figure 6. CST was determined by reading the surface tension which corresponded to the particular drop of ethanol solution which penetrated the soil in 5 seconds or less and the temperature of the soil.

When making measurements of CST, a drop of distilled water was applied to the soil surface which had been cleared of duff and litter. The time needed for the the drop to penetrate the soil was timed with a stopwatch. If the time was less than, or equal to, 5 seconds, the time was recorded and the sampling point was recorded as having a measured CST of 71.2 dynes/cm (30 C). However, if the penetration time for distilled water was greater than 5 seconds, the time was recorded and a drop of the 1% ethanol solution, the next lower surface tension, was placed on the soil and its penetration time recorded. This procedure was repeated with solutions of progressively lower surface tension until the drop penetration time was less than, or equal to, 5 seconds. The surface tension of the first drop which penetrated the soil in less than, or equal to, 5 seconds was the measured Critical Surface Tension of the sampling point. For drop penetration times greater than 60 seconds, a time of 60 seconds was recorded. The CST was measured for five layers, namely: 0-1, 1-2, 2-3, 3-4, and 4-5 cm depths.

Determination of Effect of Burning on Hydrophobicity

Measurements before burning

The first two objectives were met by studying two sites immediately before and after burning. Each site was divided into eight sectors of equal area. A steel bar was placed in the center of each sector to facilitate finding sampling points following the burn. Five sampling points were selected at random near each bar. Each sampling point was located by measuring the distance from the bar to the sampling point and recording the angle from magnetic north of

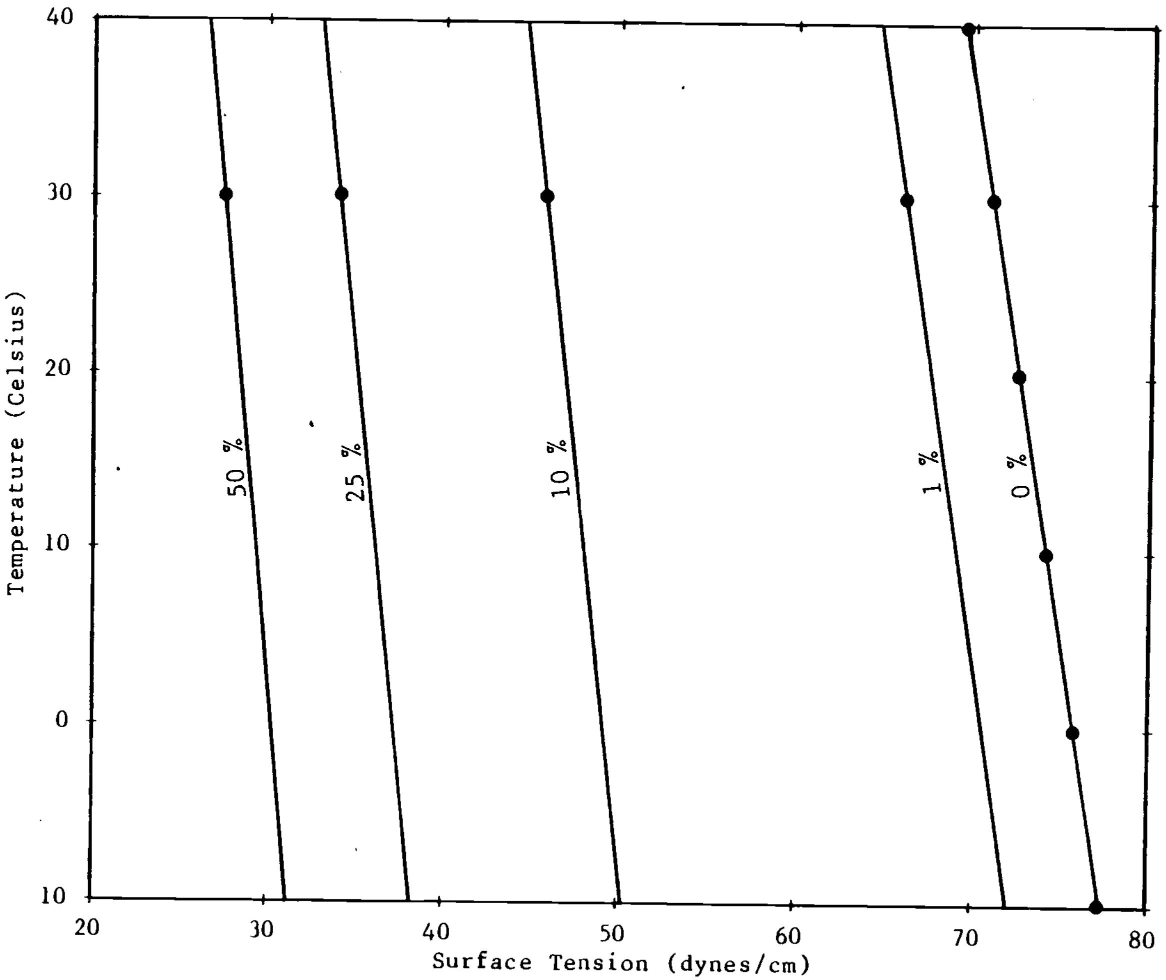

Figure 6. Relationship between temperature and surface tension at various concentrations of ethanol (after: CRC Handbook, 1947).

the imaginary line running from the bar to the sampling point. A small diameter metal stake was placed 0.25 meter towards the bar from the sampling point to further mark the sampling point. These steps allowed the sampling point to be found following the fire. At each of the 40 sampling points, the water repellency of the soil was characterized, as outlined previously, to a depth of 5 cm below the mineral surface, at 1 cm increments. The temperature of the soil was measured because surface tension is temperature dependent. A bi-metallic thermometer was used. It has a low heat capacity and is durable. Litter depth in centimeters was measured and recorded at each of the 40 sampling points. At all five sampling points in each sector, water content of the soil was measured by collecting samples at 1 cm increments to a depth of 5 cm below the mineral surface. During the prescribed burn, observations were made of general characteristics of the fire.

Measurements following burning

Following the fire, the number of sampling points burned in each sector was recorded. At each of the burned sampling points, the water repellency of the soil was characterized as outlined previously to a depth of 5 cm below the mineral surface, at 1 cm increments. The depth of litter was measured at each sampling point. At all five sampling points in each sector, water content was measured at 1 cm increments to a depth of 5 cm below the soil surface. The degree of litter combustion was visually noted and recorded as either complete combustion or incomplete combustion. The sampling point was recorded as complete combustion if the litter was completely turned into ash; otherwise, it was recorded as incomplete combustion.

CST versus LCST

Hydrophobicity (CST) was analyzed for all five depths at each sampling point for determining some of the objectives in our study.

To meet other objectives, only the most hydrophobic depth of the five depths sampled was analyzed at each sampling point. A measure of the most hydrophobic depth is the lowest CST (LCST) which occurs in the five depths. The LCST was the measure of hydrophobicity when only the most hydrophobic depth at each sampling point was analyzed.

Statistical Tests

Analysis by Sampling Point The degree to which a hydrophobic layer formed as a result of burning was studied by subjecting the data to two statistical tests. Post-burn LCST was compared with the pre-burn LCST at each of the 40 sampling points. If the LCST decreased as a result of burning and the difference was greater than 15 dynes/cm, the water repellency at the sampling point was classified as "decrease". If the LCST of the sampling point increased as a result of burning and the difference was greater than 15 dynes/cm, the water repellency at the sampling point was classified as "increase". If the change in LCST due to burning was less than or equal to 15 dynes/cm, the sampling point was classified as "no change".

The first test showed whether the change in hydrophobicity at each sampling point was due to random variation or due to the prescribed burn (Steel and Torrie, 1980). The null hypothesis was that the proportion of sampling points which increased in water repellency was equal to the proportion of sampling points which decreased in water repellency.

$$\text{Ho: } p_i = p_d \tag{6}$$

where,

p_i=proportion of sampling points which increased in water repellency.

p_d=proportion of sampling points which decreased in water repellency.

The alternate hypothesis was that the proportion of sampling points which increased in water repellency was not equal to the proportion of sampling points which decreased in water repellency.

$$Ha: p_i \neq p_d \qquad (7)$$

Analysis by Depth at Each Sampling Point For the second test, the CST after burning was compared with the CST before burning at each depth for each sampling point. If the CST of the 0-1 cm depth decreased as a result of burning and the difference was greater than 15 dynes/cm, the water repellency of the sampling point was classified as "decrease". If the CST of the 0-1 cm depth increased as a result of burning and the difference was greater than 15 dynes/cm, the water repellency of the sampling point was classified as "increase". If the change in CST due to burning was, less than or, equal to 15 dynes/cm, the sampling point was classified as "no change".

This second test showed whether the change in hydrophobicity at each depth at each sampling point was due to random variation or due to the prescribed burn. The null hypothesis was that the proportion of sampling points which increased in water repellency in the 0-1 cm depth was equal to the proportion of sampling points which decreased in water repellency in the 0-1 cm depth.

$$Ho: p_i = p_d \qquad (8)$$

where,

p_i=proportion of sampling points which increased in water repellency in the 0-1 cm depth.

p_d=proportion of sampling points which decreased in water repellency in the 0-1 cm depth.

The alternate hypothesis was that the proportion of sampling points which increased in water repellency in the 0-1 cm depth was not equal to the proportion of sampling points which decreased in water repellency in the 0-1 cm depth.

$$\text{Ha: } p_i \neq p_d \qquad (9)$$

This analysis by depth was done for all five depths.

Determination of Variables which Affect Hydrophobicity

The factors which affect formation of a water repellent layer were determined by subjecting the data from the two burns studied for Objective 1 to a regression analysis. The dependent variable was the LCST following the burn at each sampling point. The independent variables were 1. average gravimetric water content before burning, 2. surface (0-1 cm depth) gravimetric water content before burning, 3. change in the average gravimetric water content during burning, 4. change in the surface (0-1 depth) gravimetric water content during burning, 5. percent change in litter depth, 6. change in litter depth in centimeters during burning, 7. litter depth before burning in centimeters, 8. LCST prior to burning, and 9. degree of litter combustion. All of these variables were quantitative variables except for the degree of combustion, which was regressed as an indicator variable. The data for each unit were analyzed separately.

Determination of Horizontal and Vertical Distribution

The third objective was met by studying the two units studied for Objectives 1 and 2. The horizontal and vertical distribution of water repellency was studied by examining the CST of the most water repellent depth of the five depths which were sampled for each sampling point as well as the distance from the litter layer-soil boundary to the depth which was the most water repellent. If there were two or more depths which had the lowest measured CST, the distance to the most water repellent depth is that to the depth which was nearest the litter layer-soil boundary. The distribution of hydrophobicity was also studied by examining the average CST for each depth and sector which was sampled in the two units. The distribution of hydrophobicity was studied for both pre-burn and post-burn water repellency for both units.

Determination of Persistence

The fourth objective was met by studying six burns in addition to the two burns studied to answer Objectives I, II, and III. We recorded the number of sampling points in the 1982 burns which had a LCST of less than 50 dynes/cm from the measured 40 sampling points. The type of sampling system used to characterize hydrophobicity on the two previous burns studied for Objectives I, II, and III was used on the six older burns. Each site was divided into eight sectors and five sampling points selected at random near each bar which marked the center of each sector. At each of the 40 sampling points, soil water repellency was measured to a depth of 5 cm below the soil surface at 1 cm increments. This resulted in water repellency being characterized for forty sampling points on previous years burns as well as the two burns sampled to answer Objectives I, II, and III. The proportion of sampling points with LCST of less than 50 dynes/cm were recorded for each burn. The length of time hydrophobicity persists in the soil was obtained by regressing the percentage of the sampling points which were hydrophobic against the age of the burn. The percentage of the sampling points which were hydrophobic was determined by dividing the number of sampling points which had a LCST of less than 50 dynes/cm by the number of sampling points which were sampled. We then determined if there was a statistically significant relationship between the number of sampling points which are hydrophobic and the age of the burn by testing with an F statistic (Neter and Wasserman, 1974).

RESULTS AND DISCUSSION

Determination of Effect of Burning on Hydrophobicity.

Sites in two burning units were studied to determine if burning caused an increase in water repellency. Locations of the sites are shown in Figure 7. Unit 40B is 13.7 hectares in size and is in the southwest corner of the southwest corner of section 33, Township 20 S, Range 9 E, on the Pringle Falls Experimental Forest, Lookout Mountain Unit. Unit 40B is on a gentle side slope which ranged from 5-20% with a generally east by southeast aspect. The LaPine series (Cindery Typic Cryorthents) occupies most of Unit 40B. This soil formed in deposits of cinders and ash. Most of the overstory vegetation consists of mature Ponderosa pine which averaged 50 cm diameter at breast height (dbh). However, twelve of the forty sampling points were near suppressed trees which ranged from 5-15 cm dbh. The understory vegetation is dominated by snowbrush ceanothus (*Ceanothus velutinus*) but included kinnick kinnick (*Arctostaphylos uva-uru*), greenleaf manzanita (*Arctostaphylos patula*), chinquapin (*Castanopsis chrysophylla*), and fool's huckleberry (*Menziesia ferruginea*). The sampling scheme for Unit 40B is in Appendix A, Figure 1A.

Unit 42 is 11.3 hectares in size and is in the southwest corner of the northwest corner of section 4, Township 21 S, Range 9 E, on the Pringle Falls Experimental Forest, Lookout Mountain Unit. The Unit is on a gentle side slope which ranged from 5-20% with a generally east aspect. The LaPine series (Cindery Typic Cryorthents) occupies most of Unit 42. This soil formed in deposits of cinders and ash. Most of the overstory vegetation consists of maturing Ponderosa pine with an average 25 cm dbh. However, twelve of the forty sampling points were near suppressed trees which ranged from 5-15 cm dbh. The understory vegetation is dominated by greenleaf manzanita (*Arctostaphylos patula*) but included kinnick kinnick (*Arctostaphylos uva-uru*), and snowbrush ceanothus (*Ceanothus*

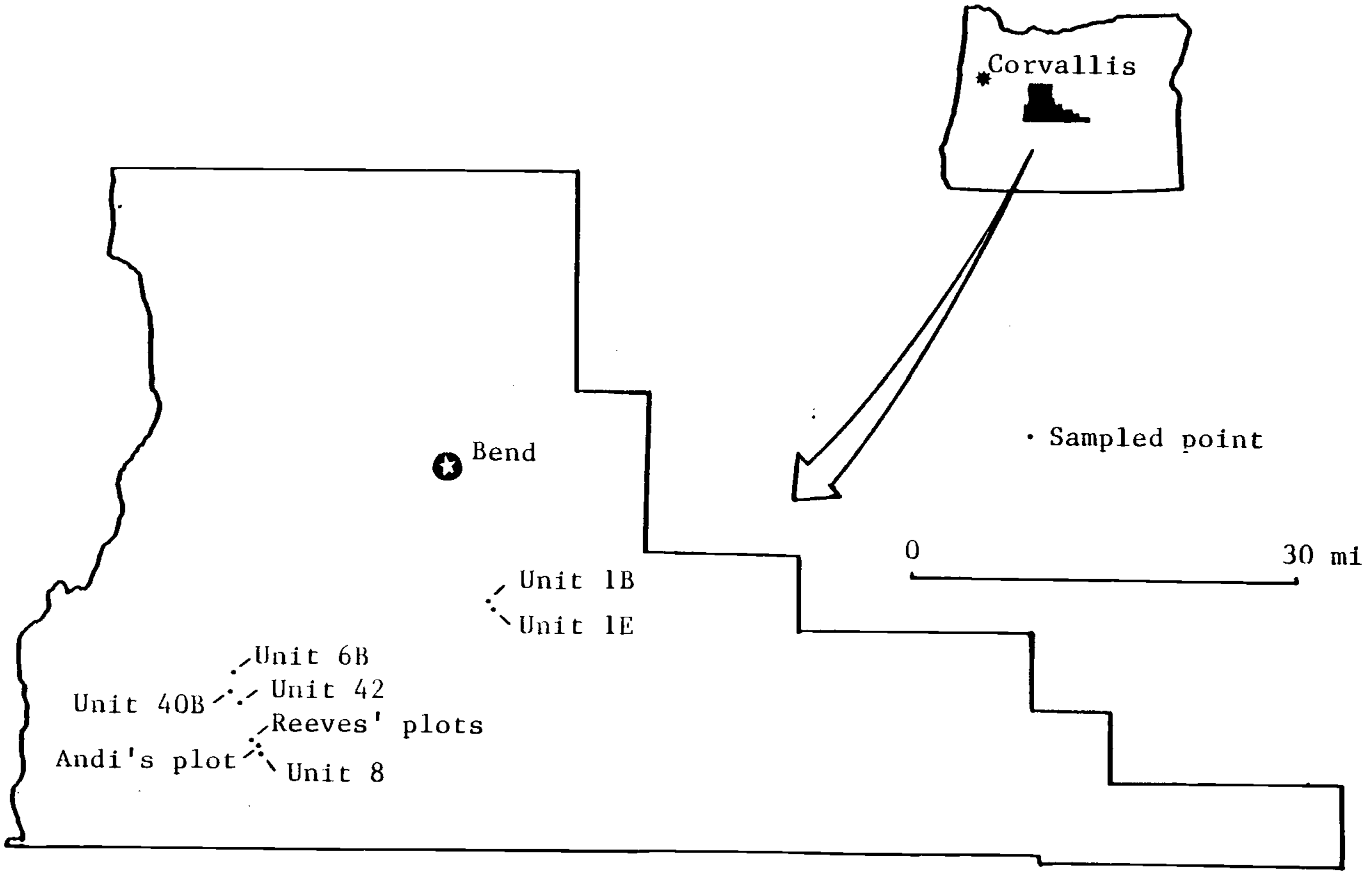

Figure 7. Location of sampled sites in Deschutes County.

velutinus). The sampling scheme for Unit 42 is in Appendix A, Figure 2A.

Unit 40B was burned 25 June 1982 and Unit 42 was burned 15 September 1982. Pre-burn and post-burn sampling was done for both burns over a three day period. Burning was initiated the evening of the first day of sampling on Unit 40B and shortly before noon the second day of sampling on Unit 42. The complete CST data set for each sampling point and depth for both units is in Appendix B. Table 1 shows results for burns that occurred on Units 40B and 42.

A difference between Unit 40B and Unit 42 in pre-burn water repellency was found. The difference was possibly because of the time of year in which the units were sampled. For this reason, Unit 40B will be followed by June in parentheses to emphasize that Unit 40B was sampled and burned in June. Likewise, Unit 42 will be followed by September in parentheses.

Pre-burn sampling and measurements were recorded for 40 points which were set out in Unit 40B (June). Post-burn measurements were taken for 38 of these 40 sampling points that were initially set out, because burning did not occur at two of the sampling points. These two sampling points were therefore excluded from the analysis that determined whether or not burning caused a water repellent layer to form. The number of sampling points which were hydrophobic before burning, out of the 38 which burned, was determined by examining the CST of the most hydrophobic layer at the sampling point, the LCST. If the LCST was less than 50 dynes/cm; the sampling point was classified as being "hydrophobic". If the LCST at that sampling point was greater than, or equal to, 50 dynes/cm, the sampling point was not classified as "hydrophobic". Unit 40B (June) had 16 sampling points which were water repellent before burning out of 38 points which burned. There were 23 sampling points which were hydrophobic after burning. The number of sampling points which were hydrophobic after burning was determined in the same manner as the number of sampling points which were hydrophobic before burning. It can be seen that there was a general increase in the number of points which were hydrophobic following burning.

Table 1. Results for Units 40B (June) and 42 (September).

Burn	Number of sampling points set out	Number of sampling points burned	Number of burned sampling points hydrophobic before burning	Number of burned sampling points hydrophobic after burning
Unit 40B (June)	40	38	16	23
Unit 42 (September)	30	25	24	23

Pre-burn sampling and measurements were recorded for 30 points which were set out in Unit 42 (September). There was not enough time to set out and sample 40 points on Unit 42 (September) because burning began at around noon. Post-burn measurements were taken for 25 of these 30 sampling points that were initially set out, because burning did not occur at five of the sampling points. These five sampling points were therefore excluded from the analysis that determined whether or not burning caused a water repellent layer to form. Whether a sampling point was classified as hydrophobic or not was determined by the same criteria as for Unit 40B (June). Unit 42 (September) had 24 sampling points which were water repellent before burning out of 25 points which burned, and there were 23 hydrophobic sampling points after burning.

Comparison between the number of sampling points which were hydrophobic before burning with the number of sampling points which were hydrophobic after burning does not illustrate whether or not burning induces a water repellent layer to form. This must be determined statistically. The data were analyzed to determine if the hydrophobicity of the soil changed following burning. The data were analyzed by comparing the LCST before burning with the LCST following burning at each sampling point using the chi square statistic. Table 2 shows the number of sampling points that increased in hydrophobicity, the number of sampling points that decreased in hydrophobicity, the statistical value of chi square, and the statistical value of probability of chance for the statistical analysis of Units 40B (June) and 42 (September). The probability of chance is the statistical probability that the change in hydrophobicity, either increase or decrease, was due to chance.

Neither unit had a change in hydrophobicity significant at the 95% level. In order for the change in water repellency to be statistically significant at the 95% level the calculated chi square value from the data would need to be greater. The increase in hydrophobicity in Unit 40B (June), where 11 points increased and 4 points decreased, was not significant at the 95% level; because the observed chi square value of 3.33 was less than the critical value of

Table 2. Analysis of change in LCST by point.

Burn	Increase after burning	Decrease after burning	Chi square statistic	Probability of chance
Unit 40B (June)	11	4	3.33	.06
Unit 42 (September)	1	4	2.00	.15

3.84. The decrease in hydrophobicity in Unit 42 (September), where 1 point increased and 4 points decreased, was not significant at the 95% level; because the observed chi square value of 2.00 was less than the critical value of 3.84.

Our results show (Table 2) that there was at least a 5% probability that the increase in hydrophobicity due to burning in Unit 40B (June) and the decrease in hydrophobicity due to burning in Unit 42 (September) was due to chance and was not a real occurrence. However, the data from Unit 40B (June), when analyzed using the chi square statistic, strongly suggest that burning caused an increase in hydrophobicity because the increase in hydrophobicity was significant at the 94% level. There was a 94% probability that the increase in hydrophobicity in Unit 40B (June) was due to burning. There was only a 85% probability that the decrease in hydrophobicity in Unit 42 (September) was due to burning.

This form of analysis was complicated by the fact that several sampling points on both units had a hydrophobic layer before burning. Out of the 38 sampling points burned on Unit 40B (June), 16 (42%) had a hydrophobic layer before burning. The relative proportions were even higher for Unit 42 (September) since 24 out of the 25 sampling points (96%) burned had a hydrophobic layer before burning .

There is a possible explanation for this pre-burn water repellency. During sampling, fungal veins and pockets were observed at several sampling points throughout both burns, although to a lesser extent in Unit 42 (September). These veins of fungal matter appeared drier than the surrounding soil and were measured as being water repellent. Even though the fungal veins comprised an area which could not absorb water as readily as the surrounding soil, they were not considered an impediment to water penetration, because the veins did not form a continuous layer parallel to the surface. Therefore, when CST was measured, fungal veins were avoided as not being representative of the layer being sampled. Fungal veins were also avoided when soil samples were taken for the determination of gravimetric water content. Even though fungal veins were avoided, some of the results indicating hydrophobicity before burning were probably due to fungal products.

There was a difference in the amount of pre-burn water repellency between Unit 40B (June) and Unit 42 (September). Two possible explanations can be suggested. When Unit 40B was sampled in June, fungal veins were easily distinguished from non-fungal soil not only by the presence of fungal hyphae but also by color. The soil was relatively wet. The color of the fungal infected dry soil was lighter than than that of moist non-fungal soil. The gravimetric water content of non-fungal soil sampled in Unit 40B (June) confirmed this visual observation, averaging 26.6%. Water content averaged 9.3% in non-fungal soil sampled in Unit 42 (September). The visual distinction of fungal-infected soil based on color differences due to water content was more difficult when Unit 42 was sampled in September because the non-fungal soils were much drier. The soils were drier because the fall rains had not yet occurred. Consequently, when the CST was measured on Unit 42 (September), the selective exclusion of fungal veins based on color was not as successful and more sampling points were measured as having a hydrophobic layer. This is a possible explanation for Unit 42 (September) having more sampling points that were hydrophobic before burning than Unit 40B (June).

It is also possible that fungal products accumulated in the soil throughout the summer. The quantity of these products in the soil might have been of sufficient magnitude in early fall so that the products would not be limited to veins associated with fungal hyphae. This might have been a second explanation for the difference in the level of pre-burn hydrophobicity between Unit 40B (June) and Unit 42 (September). If this were the case, sampling only soil free of hyphae would not guarantee that the CST measurement would be free from the effects of fungal products. Water from fall rains, winter snowfall followed by spring snowmelt, and spring rains could leach the fungal products. This would explain why there was a lower proportion (42%) of sampling points that had a hydrophobic layer before burning on Unit 40B (June) than on Unit 42 (September) (96%).

Holzhey (1969) reported finding seasonal water repellency in the upper one to three inches of a Cieniba sandy loam. This depth corresponded to the rooting zone of the overlying grass, the zone highest in organic matter and biological activity. During the dry season (July), water drops infiltrated instantaneously. Following autumn rains, water drop penetration times exceeded 90 seconds in the upper few inches of the soil. Later during the cool season (January), after prolonged wetting, the water drop penetration times again became zero. He postulated that the most active period for biological activity was during the autumn rains. In central Oregon the fungi may be active throughout the summer.

The CST data were also analyzed to determine if burning caused an increase in hydrophobicity by comparing the CST before burning with the CST following burning at each depth for both Unit 40B (June) (Table 3) and Unit 42 (September) (Table 4).

The change in hydrophobicity for Unit 40B (June), as measured by CST, was not great enough at any of the depths to be significant at the 95% level (Table 3). However, there was a trend towards an increase in hydrophobicity deeper in the profile. This is indicated by the higher chi square values for the 2-3, 3-4, and 4-5 cm depths, namely 3.08, 1.43, and 1.43 respectively, than for the 0-1 and 1-2 cm depths. These results agree with the theory about the manner by which fire induces water repellency proposed by Savage et al. (1972). Intense heat volatilizes organic compounds and drives them to deeper layers where they condense and are fixed. This mechanism explains how hydrophobicity can actually be reduced in the upper few centimeters of soil and increase deeper in the profile.

This trend towards an increase in hydrophobicity deeper in the profile was even more marked on Unit 42 (Table 4). Many sampling points were hydrophobic before burning. The change that occurred was a decrease in water repellency in the upper two centimeters of the soil. The decrease in water repellency for both the 0-1 and 1-2 cm depths was significant at the 95% level. The trend was from a decrease to an increase in water repellency as we go from the surface of the soil to deeper in the profile. The increase was not

Table 3. Analysis of change in CST by depth, Unit 40B (June)

Depth (cm)	Increase after burning	Decrease after burning	Chi square statistic	Probability of chance
0-1	5	6	.18	.67
1-2	8	5	.77	.62
2-3	9	3	3.08	.08
3-4	5	2	1.43	.23
4-5	5	2	1.43	.23

Table 4. Analysis of change in CST by depth, Unit 42 (September)

Depth (cm)	Increase after burning	Decrease after burning	Chi square statistic	Probability of chance
0-1	3	14	7.18 *	.01
1-2	2	13	8.13 *	.01
2-3	5	9	1.21	.27
3-4	7	4	.91	.66
4-5	6	2	2.13	.14

* significant at the 95% level

significant at the 95% level for any of the lower depths because the chi square statistic was less than 3.84; 7 sampling points increased in hydrophobicity and 4 sampling points decreased in the 3-4 cm depth, and 6 sampling points increased in hydrophobicity and 2 sampling points decreased in the 4-5 cm depth.

Variables which Affect Hydrophobicity.

The data (Appendix D and E) from Units 40B (June) and 42 (September) were subjected to a regression analysis to determine the factors which contributed to the formation of a water repellent layer following burning. Each unit was analyzed separately because they were two distinct populations; one burn occurred in June and the other burn occurred in September. The dependent variable was LCST following burning at each point. This variable was regressed against nine independent variables: 1. average gravimetric water content before burning, 2. surface (0-1 cm depth) gravimetric water content before burning, 3. change in the average gravimetric water content due to burning, 4. change in the surface (0-1 cm depth) gravimetric water content due to burning, 5. percent change in litter depth due to burning, 6. change in litter depth in centimeters due to burning, 7. litter depth before burning in centimeters, 8. LCST before burning, and 9. degree of litter combustion. All of these variables were quantitative variables except for the degree of combustion which was regressed as an indicator variable.

Unit 40B (June)

Results of the regression analysis for Unit 40B (June) are presented in Table 5. Each independent variable is listed under source of variation along with its associated error term. The symbol used in the regression analysis to represent each variable is listed under Symbol. The F statistic which determines whether or not the variation in LCST explained by a particular independent variable was statistically significant is listed under Observed F. The regression

Table 5. ANOVA for post-burn LCST (dynes/cm) as a function of nine variables for Unit 40B (June).

Source of Variation	Symbol	Degrees of Freedom	Regression Mean Square Error Mean Square	Observed F Statistic[*,†]
Average water content before burning	x_1	1	759.2	2.8
Error		36	270.3	
Surface water content before burning	x_2	1	75.8	0.3
Error		36	289.3	
Change in average water content due to burning	x_3	1	2,040.4	8.7[§]
Error		36	234.8	
Change in Surface water content due to burning	x_4	1	1,034.4	3.9
Error		36	262.7	
Percent Change in litter depth due to burning	x_5	1	0.0	0.0
Error		36	291.4	
Change in litter depth due to burning	x_6	1	619.5	2.3
Error		36	274.2	
Litter depth before burning	x_7	1	336.2	1.2
Error		36	282.1	
Degree of Combustion	x_8	1	5,964.7	35.6[§]
Error		27	167.7	
LCST before burning	x_9	1	810.8	3.1
Error		36	269.2	
Total		37	283.6	

[*] Critical F value, F(.95;1,36)=4.11

[†] Critical F value, F(.95;1,27)=4.20

[§] Significant at the 95% level.

mean square and the error mean square used to calculate the F statistic are also presented in Table 5. The critical F value for deciding whether or not an independent variable was significant at the 95% level was 4.11 when there are 36 degrees of freedom in the error term and 1 degree of freedom in the regression term. If the observed F value of a particular independent variable was greater than 4.11, the variable was significant at the 95% level. If the observed F was less than, or equal to, 4.11; the variable was not significant at the 95% level. This applies to all of the variables except for degree of combustion which has 27 degrees of freedom in the error term; the critical F value was 4.20 at the 95% level. Two of the nine independent variables were statistically significant at the 95% level, namely: change in the average gravimetric water content and degree of combustion. The observed F value for change in the average gravimetric water content was 8.9 which was greater than the critical value of 4.11. The observed F value for degree of combustion was 36.9 which was greater than the critical value of 4.20.

The change in average gravimetric water content could not be used to predict post-burn LCST even though the variation in post-burn LCST explained by water content was significant at the 95% level. This was because 1.07 cm [1] of rainfall fell the day after burning occurred. The water content actually increased following burning in the upper few centimeters where burning caused a reduction in water repellency.

The LCST of each sampling point was plotted against the degree of litter combustion which occurred at each sampling point for Unit 40B (June) (Fig. 8). There are 29 data points plotted on this graph; many of the points overlap. Degree of combustion was recorded at 29 sampling points instead of all 40 sampling points, because we did not originally plan to measure it. Observations during sampling gave an indication that degree of combustion was a

[1] Dave Frewing, unpublished data. Pacific Northwest Forest and Range Experiment Station, Silviculture Laboratory, Bend, Oregon.

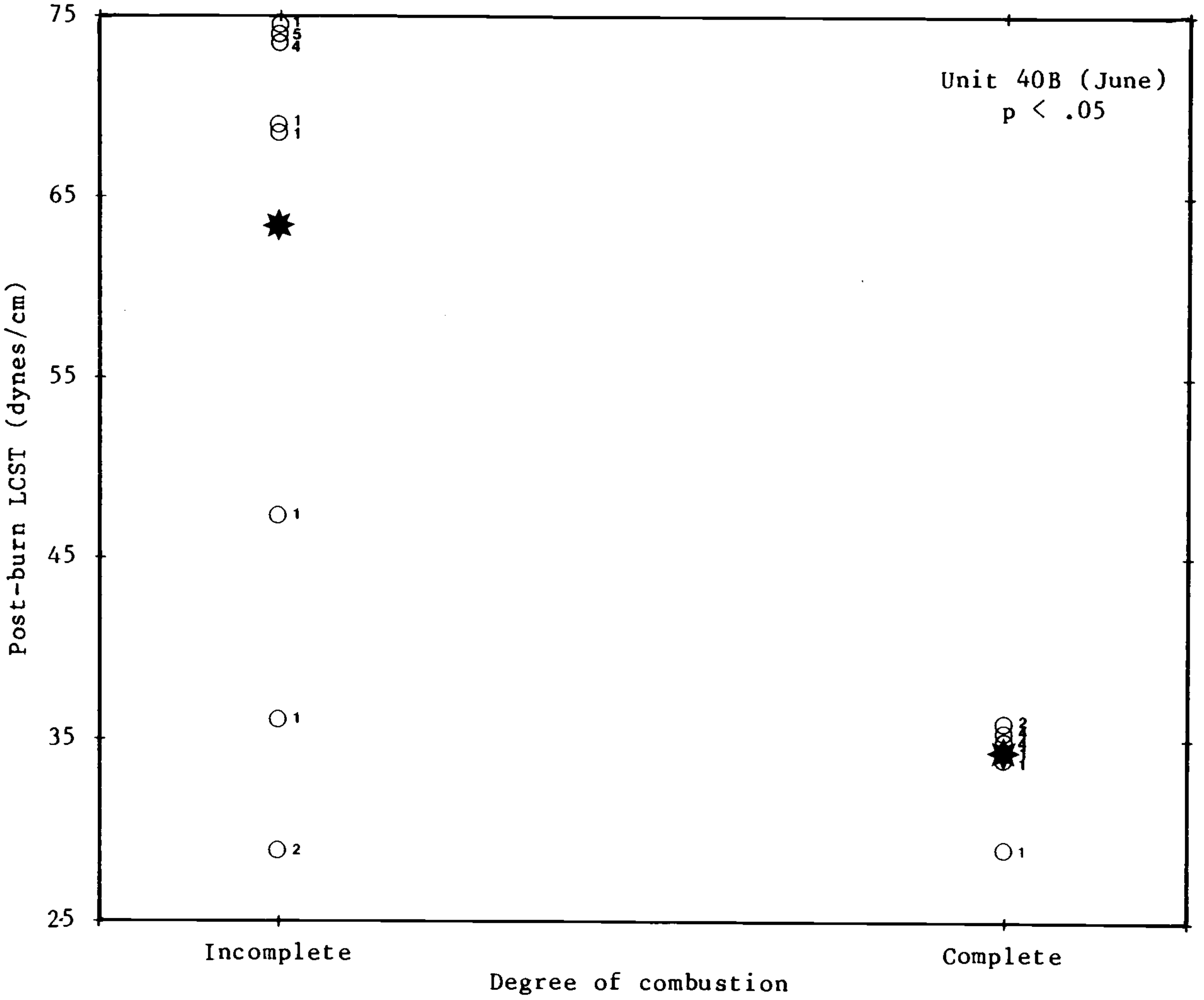

Figure 8. Relationship between the degree of combustion and post-burn LCST for Unit 40B (June). Number of data points which overlap is indicated by number next to them. Starred points are average LCST.

factor which might affect the formation of water repellency. The degree of combustion was therefore included in our measurements. The LCST after burning ranged from 29 to 75 dynes/cm if the litter at a sampling point was incompletely combusted (Fig. 8). Incomplete combustion of the litter resulted in a water repellent layer forming in the soil at some sampling points and not forming in the soil at other sampling points. However, only 4 sampling points had a LCST less than 50 dynes/cm where incomplete combustion of the litter occurred, whereas 12 sampling points had a LCST greater than 50 dynes/cm where incomplete combustion occurred. A water repellent layer was not likely to form due to burning where incomplete combustion occurred since the LCST was likely to be high after burning. All of the sampling points had a LCST below 40 dynes/cm where complete combustion of the litter occurred; a water repellent layer formed if complete combustion occurred. The litter at thirteen sampling points was completely combusted.

Figure 8 shows the average LCST where incomplete combustion occurred and the average LCST where complete combustion occurred, 63.6 and 34.7 dynes/cm respectively. These two points are represented by two stars. The two averages were obtained by regressing post-burn LCST against degree of combustion. These average LCST values also show that hydrophobicity was produced where complete combustion occurred but not with incomplete combustion of the litter.

There are two reasons for the difference in degree of combustion of the litter at a sampling point. First, more organic materials volatilized during fire over sampling points were complete combustion occurred. Therefore more materials condensed and were fixed on the soil particles. Second, the temperature was higher where complete combustion occurred than where incomplete combustion occurred. The volatile organics diffused deeper into the soil because of the higher temperature. The products condensed on uncombusted litter where incomplete combustion occurred. Higher temperature during burning at a sampling point where complete combustion occurred also resulted in more organic material being "fixed".

The best model for the prediction of post-burn LCST for Unit 40B (June) was selected using a stepwise regression search,

$$y_i = 63.6 - 28.9*X_{8i} + e_i, \qquad (10)$$

where,

y_i = LCST after burning in the i^{th} trial.
x_{8i} = degree of combustion in the i^{th} trial.
e_i = error term.

Degree of combustion was the first variable which was included in the model because it explained more of the variation in post-burn LCST than any other variable. A statistical test using the F statistic was performed on the remaining independent variables to determine if any of the variables should be included in the model (Table 6). Each independent variable which was being considered for addition to the model with degree of combustion is listed under Source of variation. The symbol of the variable being added is listed under Symbol for each variable along with the symbol for degree of combustion (x_8). The partial F value which determines whether or not a variable was added to the model is listed under partial F. The partial regression mean square and the partial error mean square for the full model used to calculate the partial F statistic were determined (Table 6). The critical value of the partial F statistic for determining if a particular independent variable should be added to the model with degree of combustion is 4.23 at the 95% level. The observed partial F values for all of the variables were less than 4.23. Therefore, no other variables were added to the model. Zero and 1 are the only possible values for degree of combustion because it is an indicator variable. Either complete (1) or incomplete (0) combustion occurred. This model predicts the LCST after burning for the June burn on Unit 40B. It is limited to similar soils which occur on sites burned and sampled in June.

Table 6. ANOVA for post-burn LCST (dynes/cm) as a function of eight variables when degree of combustion is already in the model for Unit 40B (June).

Source of Variation	Symbol	Degrees of Freedom	Regression Mean Square Error Mean Square	Observed F Statistic*
Average water content before burning	x_1, x_8	1	7.4	0.0
Error		26	173.8	
Surface water content before burning	x_2, x_8	1	51.3	0.3
Error		26	172.1	
Change in average water content due to burning	x_3, x_8	1	216.8	1.3
Error		26	165.8	
Change in surface water content due to burning	x_4, x_8	1	409.2	0.6
Error		26	158.4	
Percent change in litter depth due to burning	x_5, x_8	1	44.2	0.3
Error		26	172.4	
Change in litter depth due to burning	x_6, x_8	1	7.8	0.0
Error		26	173.8	
Litter depth before burning	x_7, x_8	1	7.5	0.0
Error		26	173.8	
LCST before burning	x_9, x_8	1	23.2	0.2
Error		26	155.3	
Total		27	153.8	

* Critical F value, F(.95;1,26)=4.23

Unit 42 (September)

Results for the regression analysis for Unit 42 (September) are presented in Table 7. Determining which variables explained LCST after burning at the 95% level was accomplished in the same manner as the regression analysis for Unit 40B (June). The critical F value for determining whether or not a variable was significant at the 95% level was 4.28. The observed F value for LCST before burning was 6.2, greater than the critical value of 4.28. Only LCST before burning was significant at the 95% level.

The relationship between pre-burn LCST and post-burn LCST is shown in Figure 9. The only conclusion which could be made from this relationship is that a sampling point was hydrophobic after burning if it was hydrophobic before burning. Three sampling points decreased in hydrophobicity following burning. The possible reason is that heat during burning volatilized the fungal products. The fungal products diffused deeper into the soil where they condensed below the 5 cm depth which was sampled.

The observed F values for the other variables were less than 4.28 (Table 7). Degree of combustion, which was significant at the 95% level for Unit 40B (June), was not statistically significant for Unit 42 (September). This agrees with the analysis under Objective 1. Fire did not have a measurable influence on the water repellency of the sampling points, since 96% of the sampling points in Unit 42 (September) were hydrophobic before burning. All of the independent variables, with the exception of LCST before burning, depend on fire having an effect on post-burn water repellency. Therefore, having LCST before burning as the only independent variable significant at the 95% level confirms the fact that burning did not have an appreciable effect on the water repellency of the sampling points in Unit 42 (September).

The best model for determining post-burn LCST on Unit 42 (September) was chosen in the same manner as was used for Unit 40B (June). The stepwise selection (Table 8) resulted in LCST before burning as the only independent variable in the model. The model is

Table 7. ANOVA for post-burn LCST (dynes/cm) as a function of nine variables for Unit 42 (September).

Source of Variation	Symbol	Degrees of Freedom	Regression Mean Square Error Mean Square	Observed F Statistic*
Average water content before burning	x_1	1	66.3	0.4
Error		23	157.6	
Surface water content before burning	x_2	1	378.1	2.6
Error		23	144.1	
Change in average water content due to burning	x_3	1	3.1	0.0
Error		23	316.0	
Change in surface water content due to burning	x_4	1	188.6	1.2
Error		23	152.3	
Percent change in litter depth due to burning	x_5	1	25.4	0.2
Error		23	159.4	
Change in litter depth due to burning	x_6	1	101.7	0.7
Error		23	156.1	
Litter depth before burning	x_7	1	84.2	0.5
Error		23	156.9	
Degree of Combustion	x_8	1	103.0	0.7
Error		23	156.0	
LCST before burning	x_9	1	781.2	6.2†
Error		23	126.6	
Total		24	153.8	

* Critical F value, F(.95;1,23)=4.28

† Significant at the 95% level.

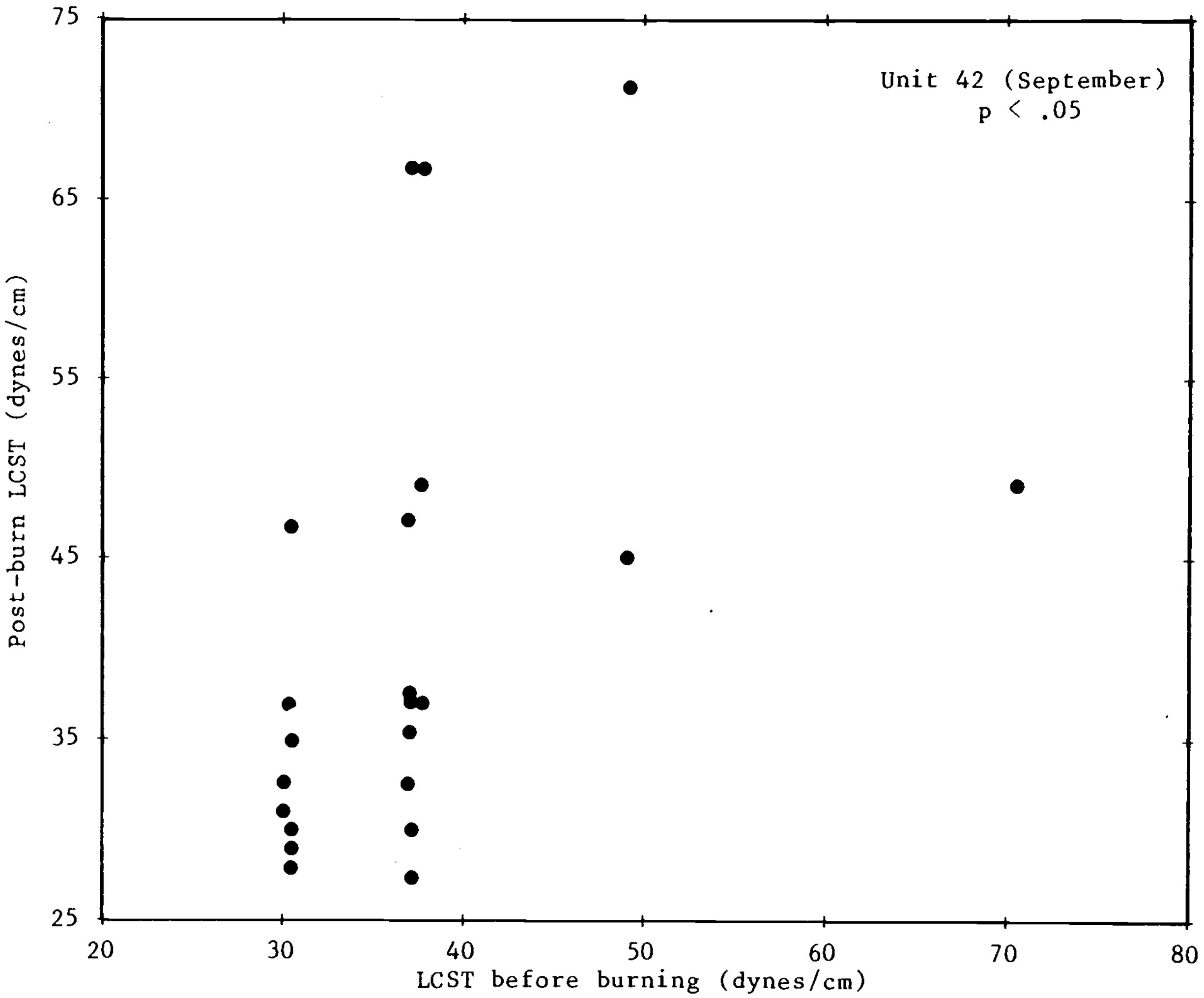

Figure 9. Relationship between pre-burn LCST and post-burn LCST for Unit 42 (September).

Table 8. ANOVA for post-burn LCST (dynes/cm) as a function of eight variables when pre-burn LCST (dynes/cm) is already in the model for Unit 42 (September).

Source of Variation	Symbol	Degrees of Freedom	Regression Mean Square Error Mean Square	Observed F Statistic*
Average water content before burning	x_1, x_9	1	22.5	0.2
Error		22	131.3	
Surface water content before burning	x_2, x_9	1	150.9	1.2
Error		22	125.5	
Change in average water content due to burning	x_3, x_9	1	141.6	1.1
Error		22	125.9	
Change in surface water content due to burning	x_4, x_9	1	318.6	2.7
Error		22	117.8	
Percent change in litter depth due to burning	x_5, x_9	1	16.9	0.1
Error		22	131.5	
Change in litter depth due to burning	x_6, x_9	1	93.9	0.7
Error		22	128.9	
Litter depth before burning	x_7, x_9	1	82.5	0.6
Error		22	128.6	
Degee of combustion	x_8, x_9	1	320.0	2.7
Error		22	117.8	
Total		23	160.5	

* Critical F value, F(.95;1,22)=4.23

of limited value because 96% of the sampling points where hydrophobic before burning. The model can not predict what the post-burn LCST of the soil would be if the soil was not hydrophobic before burning. The only prediction which can be made with confidence is that the soil will be hydrophobic after burning if it is hydrophobic before burning. For this reason, no model is given for the site sampled in September.

Horizontal and Vertical Distribution

The third objective was met by studying the CST data from Units 40B (June) and 42 (September). The horizontal and vertical distribution of water repellency were studied by examining the CST of the most water repellent depth of the five depths which were sampled for each sampling point as well as the distance from the litter layer-soil boundary to the depth which was the most hydrophobic. The distribution of hydrophobicity was also studied by examining the average CST for each depth and sector which was sampled in Unit 40B (June) and Unit 42 (September). The distribution of hydrophobicity was studied for both pre-burn and post-burn water repellency for both units.

Pre-burn distribution, Unit 40B (June)

The CST of the most hydrophobic depth and the distance to the most hydrophobic depth are shown at each sampling point (Fig. 10) for Unit 40B (June). The distance between sampling points at each sector was not drawn to scale to facilitate reading the map. The distance between sectors and the unit boundaries was drawn to scale. Water repellency before burning in Unit 40B (June) occurred more in sectors 3, 6, 7, and 8 than in sectors 1, 2, 4, and 5. This was evident because more than half of the sampling points, at sectors 3, 6, 7, and 8 had depths which were strongly water repellent (CST < 40 dynes/cm). Furthermore, only 3 of the 20 sampling points in the other 4 sectors; 1, 2, 4, and 5; had a depth with a CST of less than

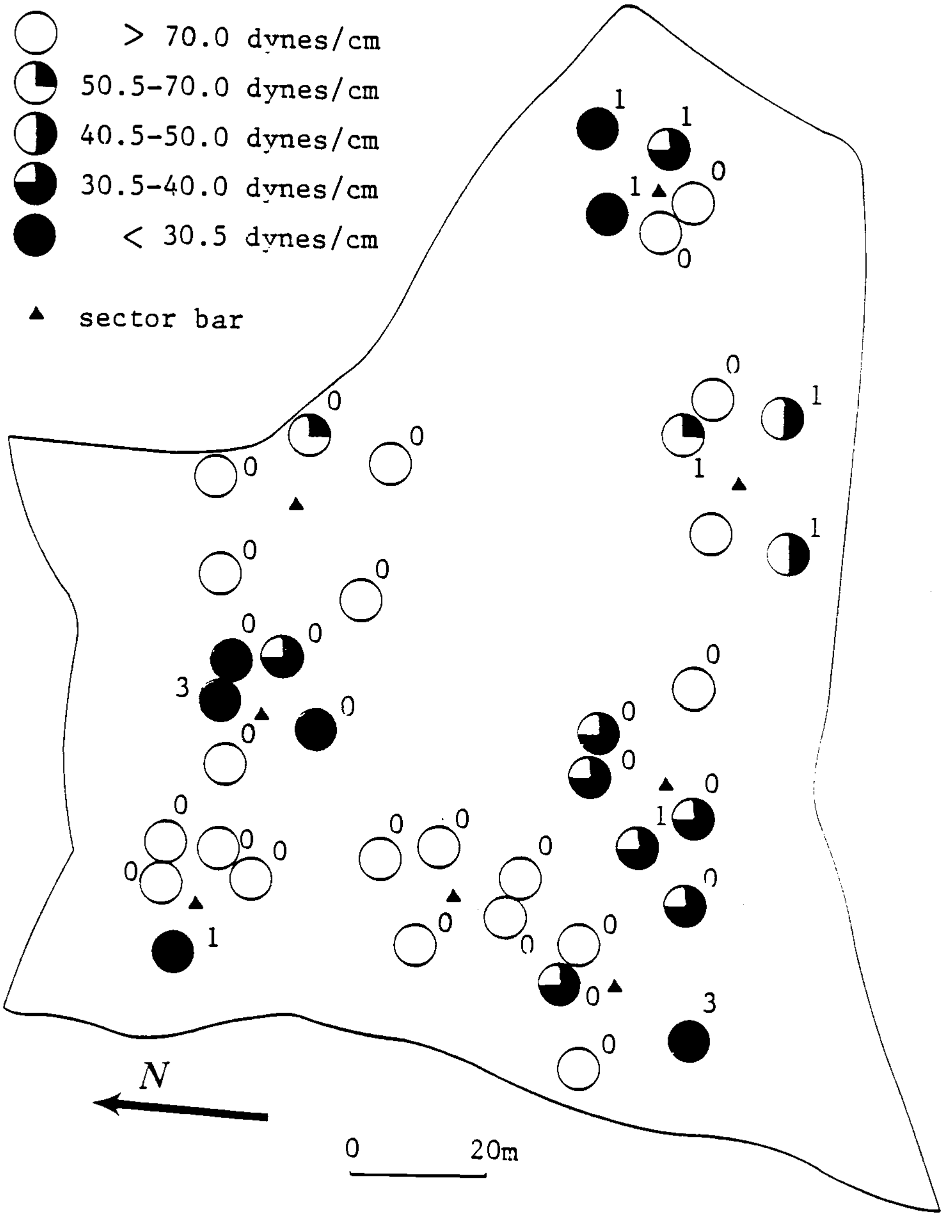

Figure 10. CST (dynes/cm) and vertical distance (cm) from litter-soil boundary to most hydrophobic depth, Unit 40B (June) before burning.

50 dynes/cm. Water repellency occurred more in the upper two centimeters than the 2-5 cm depths. The most water repellent depth was in the upper 2 cm in 13 of the 15 sampling points which had a strongly water repellent depth (Fig. 10).

The horizontal and vertical distribution of the hydrophobicity before burning in Unit 40B (June) can also be shown by analyzing the mean CST by sector (horizontal distribution) and by depth (vertical distribution). Sectors 3, 6, 7, and 8 had an average CST of 55.1, 63.0, 63.5, and 64.5 dynes/cm respectively; whereas sectors 1, 2, 4, and 5 had an average CST of 73.3, 71.0, 69.2, and 73.7 dynes/cm respectively (Table 9). Therefore, most of the pre-burn hydrophobicity in Unit 40B (June) was limited to sectors 3, 6, 7, and 8. The same conclusion was reached when the CST of the most hydrophobic depth was examined. This difference in CST due to sector was significant at the 95% level. The analysis of variance for CST with depth and sector is presented in Table 10. The critical F value for determining if there was a significant difference in CST due to sector was 2.01.

The CST for the 0-1, 1-2, 2-3, 3-4, and 4-5 depths averaged 61.9, 63.5, 68.2, 69.3, and 70.67 dynes/cm respectively (Table 11) in Unit 40B (June). The average CST increased markedly at a depth of 2 cm below the litter layer-soil boundary. Hydrophobic soil occurred more in the upper depths since the average CST of the 0-1 and 1-2 depths was less than the average CST for the other three depths. This difference in CST due to depth was significant at the 95% level (Table 10); the critical F value of 2.45 was less than the observed F value of 3.06.

Post-burn distribution, Unit 40B (June)

The CST of the most hydrophobic depth and the distance to the depth from the litter layer-soil boundary is presented in Figure 11 for the distribution of hydrophobicity after burning in Unit 40B (June).

Table 9. Means and standard deviations for pre-burn CST (dynes/cm) at different sectors for Unit 40B (June).

Sector	Sample number	Mean	Standard deviation
1	25	73.3	1.1
2	25	71.0	7.4
3	25	55.1	21.0
4	25	69.2	14.3
5	25	73.9	0.2
6	25	63.0	17.4
7	25	63.5	15.9
8	25	64.5	16.9
Total	200	66.7	14.9

Table 10. ANOVA for pre-burn CST (dynes/cm) as a function of depth and sector for Unit 40B (June).

Source of Variation	Degrees of Freedom	Regression Mean Square	Observed F Statistic[*][†]
Total	199	221.5	
Depth	4	573.8	3.06[§]
Sector	7	1,012.6	5.39[§]
Sector*depth	28	166.3	0.89
Error	160	187.8	

[*] Critical F value, F(.95;4,120)=2.45

[†] Critical F value, F(.95;7,120)=2.09

[§] Significant at the 95% level.

Table 11. Means and standard deviations for pre-burn CST (dynes/cm) at different depths for Unit 40B (June).

Depth	Sample number	Mean	Standard deviation
0-1	40	61.9	17.5
1-2	40	63.5	17.1
2-3	40	68.2	13.3
3-4	40	69.3	13.0
4-5	40	70.6	11.3
Total	200	66.7	14.8

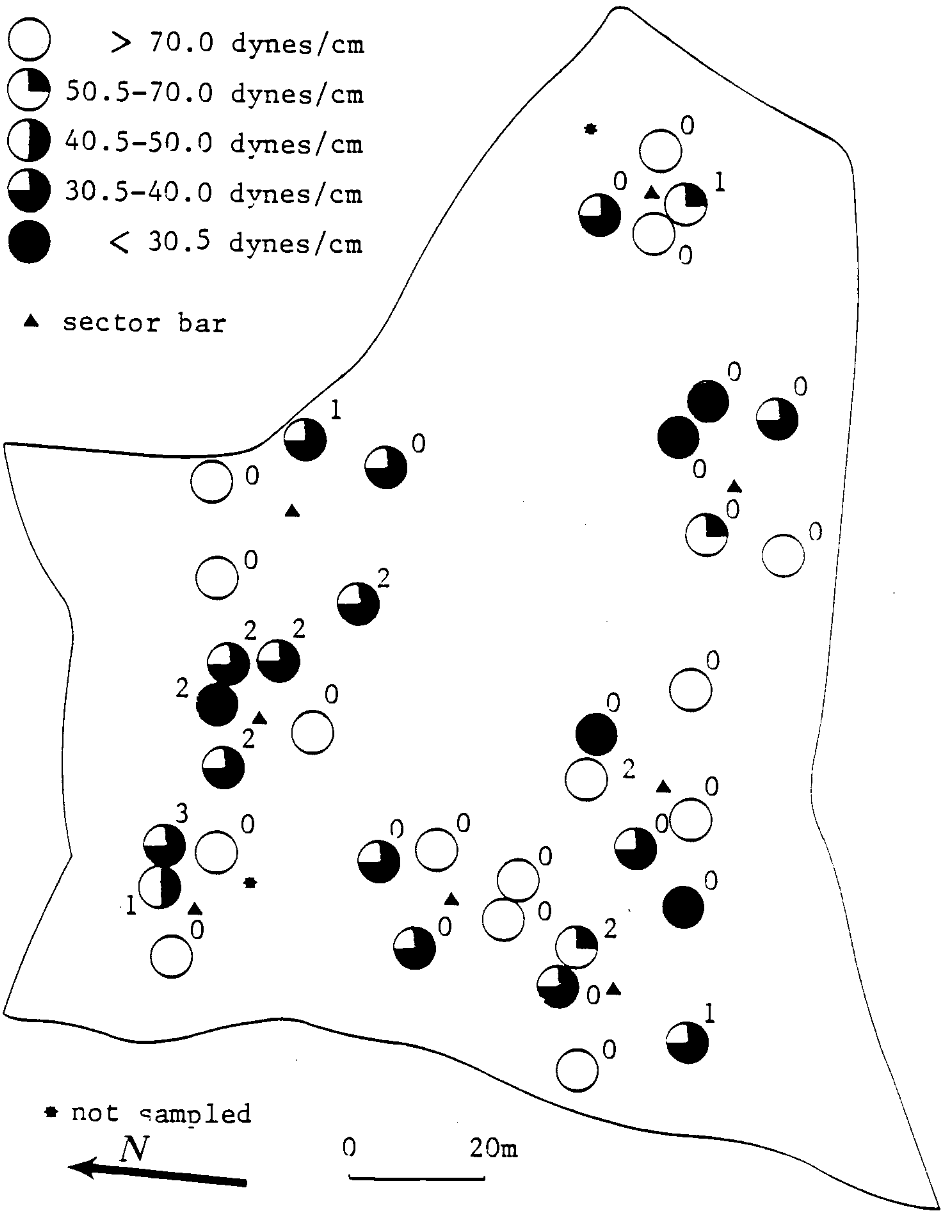

Figure 11. CST (dynes/cm) and vertical distance (cm) from litter-soil boundary to most hydrophobic depth, Unit 40B (June) following burning.

Hydrophobicity occurred more in sectors 1, 2, 3, 6, 7, and 8 than in sectors 4 and 5. At least half of the sampling points at each of these six sectors had depths which were strongly hydrophobic (CST < 40 dynes/cm). Post-burn hydrophobicity in Unit 40B (June) was not more extensive in the upper 2 cm of the soil than the lower depths as it was with pre-burn hydrophobicity (Fig. 10). Eight of the 22 sampling points had a strongly water repellent depth at a distance at least 2 cm below the litter layer-soil boundary. This trend was expected because heat from the burn volatilized the hydrophobic inducing fungal products which occurred in the upper few centimeters of the soil. These products then condensed deeper in the soil. The water repellency did not diffuse into the soil at all of the sampling points because the burn was not uniform. This appears to be what happened in Unit 40B (June).

The random distribution of post-burn hydrophobicity with depth is also shown by looking at the mean CST at each depth (Table 12). The difference in CST between depths was not significant at the 95% level for post-burn hydrophobicity (Table 13) as it was for pre-burn hydrophobicity (Table 10) even though CST increased lower in the sampling zone, The average CST of the 0-1 cm depth was 59.9 dynes/cm and the average CST of the 4-5 cm depth was 67.4 dynes/cm (Table 12). The critical F value of 2.45 was less than the observed F value of 1.56 for post-burn water repellency. Hydrophobicity occurred at all depths and did not occur in some depths more than others.

The horizontal distribution of post-burn hydrophobicity was studied by examining the CST at each sector. The CST averaged 69.1 dynes/cm for both sector 4 and sector 5 (Table 14). All other sectors average CST was 66.3 dynes/cm or less (Table 14). The difference in the CST between sectors was significant at the 95% level (Table 13). The observed F value of 2.35 was greater than the critical F value of 2.01. Therefore, most of the post-burn hydrophobicity in Unit 40B (June) occurred in sectors 1, 2, 3, 6, 7, and 8; but did not occur at any particular depth or depths.

Table 12. Means and standard deviations for post-burn CST (dynes/cm) at different depths for Unit 40B (June).

Depth	Sample number	Mean	Standard deviation
0-1	38	59.9	18.8
1-2	38	60.8	17.3
2-3	38	63.2	16.6
3-4	38	65.9	15.2
4-5	38	67.4	13.4
Total	190	63.4	16.4

Table 13. ANOVA for post-burn CST (dynes/cm) as a function of depth and sector for Unit 40B (June).

Source of Variation	Degrees of Freedom	Regression Mean Square	Observed F Statistic*†
Total	189	270.4	
Depth	4	391.2	1.56
Sector	7	589.4	2.35
Sector*depth	28	275.5	1.09
Error	150	251.3	

[*] Critical F value, F(.95;4,120)=2.45

[†] Critical F value, F(.95;7,120)=2.09

Table 14. Means and standard deviations for post-burn CST (dynes/cm) at different sectors for Unit 40B (June).

Sector	Sample number	Mean	Standard deviation
1	25	64.5	15.8
2	25	64.3	16.9
3	25	54.5	18.9
4	20	69.1	11.4
5	25	69.1	12.6
6	25	61.9	17.6
7	25	59.5	17.3
8	20	66.3	15.7
Total	190	63.4	16.4

Pre-burn distribution, Unit 42 (September)

Pre-burn hydrophobicity was extensive in all sectors in Unit 42 (September) (Fig. 12). All sectors had a strongly hydrophobic depth at all five sampling points except sectors 4 and 5. Sector 4 had 3 sampling points which had a depth which was strongly hydrophobic (CST < 40 dynes/cm) and 2 which had a depth which was moderately hydrophobic (CST < 50 dynes/cm). Sector 5 had only one sampling point which did not have a strongly hydrophobic depth. Water repellent soil was extensive in all sectors.

Vertical distribution of water repellency did not occur at any particular depth or depths (Fig. 12). However, when the average CST for each depth was studied we found that there was a difference in CST with depth (Table 15). The average CST was 44.9 dynes/cm at the 0-1 cm depth and increased progressively through the depths to 61.7 dynes/cm at the 4-5 cm depth. This difference in the CST between depths was significant at the 95% level, because the observed F value of 6.1 (Table 16) was greater than the critical F value of 2.45. Hydrophobicity was found to occur more in the surface depths than lower in the five measured depths.

It was found that there was a statistically significant difference in the CST between sectors (Table 16); the observed F value of 5.5 was greater than the critical F value of 2.01. The average CST for sectors 1, 2, 3, and 6 was 50.2, 40.6, 51.5, and 54.7 dynes/cm respectively (Table 17). The difference in average CST between sectors 4 and 5; 60.7 and 62.4 dynes/cm respectively; and sectors 1, 2, 3, and 6 was due to the number of depths at each sampling point which were strongly hydrophobic.

In conclusion, water repellent soil was distributed quite extensively throughout Unit 42 before burning, both horizontally and vertically. However, water repellent soil was more prevalent near the litter layer-soil boundary than lower in the sampled depths.

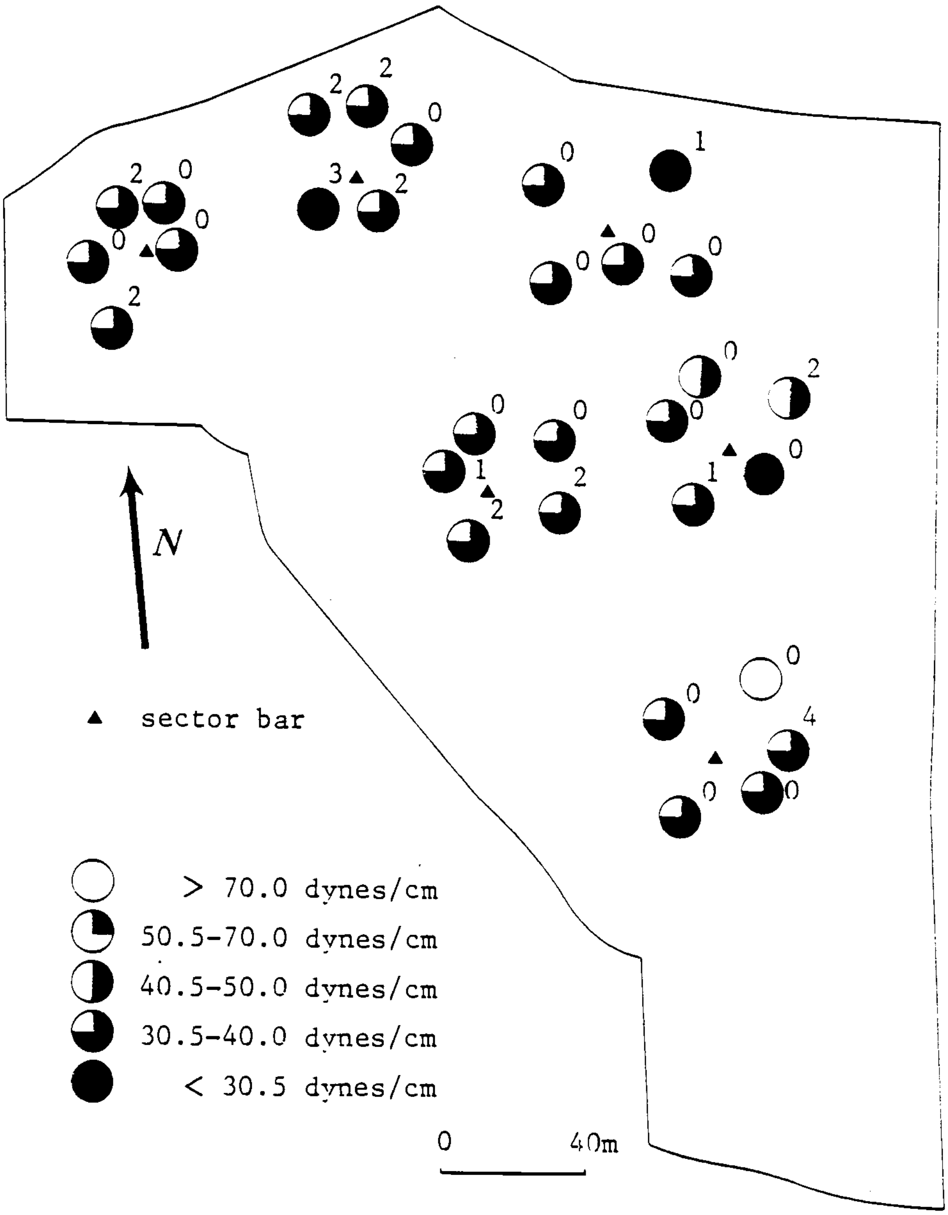

Figure 12. CST (dynes/cm) and vertical distance (cm) from litter-soil boundary to most hydrophobic depth, Unit 42 (September) before burning.

Table 15. Means and standard deviations for pre-burn CST (dynes/cm) at different depths for Unit 42 (September).

Depth	Sample number	Mean	Standard deviation
0-1	30	44.9	15.1
1-2	30	46.7	16.0
2-3	30	52.6	19.8
3-4	30	60.5	18.6
4-5	30	61.7	18.9
Total	150	53.3	18.9

Table 16. ANOVA for pre-burn CST (dynes/cm) as a function of depth and sector for Unit 42 (September).

Source of Variation	Degrees of Freedom	Regression Mean Square	Observed F Statistic[*][†]
Total	148	355.8	
Depth	4	1,752.8	6.15[§]
Sector	5	1,578.6	5.54[§]
Sector*depth	20	191.6	0.67
Error	119	285.0	

[*] Critical F value, F(.95;4,120)=2.45

[†] Critical F value, F(.95;5,120)=2.29

[§] Significant at the 95% level.

Table 17. Means and standard deviations for pre-burn CST (dynes/cm) at different sectors for Unit 42 (September).

Sector	Sample number	Mean	Standard deviation
1	25	50.2	15.4
2	25	40.6	14.1
3	25	51.5	19.7
4	25	60.7	17.3
5	25	62.6	17.7
6	25	54.7	21.0
Total	150	53.3	18.9

Post-burn distribution, Unit 42 (September)

The post-burn distribution of hydrophobicity in Unit 42 (September) was studied in the same manner as pre-burn hydrophobicity; the most hydrophobic depth at each sampling point and the distance to that depth from the litter layer-soil boundary were examined (Fig. 13).

Hydrophobicity occurred in sectors 1, 2, 3, 5, and 6 more than sector 4. At least 60% of the sampling points had a strongly hydrophobic depth at every sector except sector 4 (Fig. 13). Two sampling points had a moderately hydrophobic depth (CST < 50 dynes/cm) out of 4 sampling points which were sampled following burning in sector 4.

The horizontal distribution of post-burn hydrophobicity (Fig. 13) was not as extensive as pre-burn hydrophobicity because only three of the sampling points (Fig. 12) did not have a strongly hydrophobic depth before burning. Eight sampling points did not have a strongly hydrophobic depth after burning. A possible explanation was sought for the decrease in the number of sampling points which had a strongly hydrophobic depth. Heat from the burn should have volatilized the fungal products and caused them to diffuse into the soil where they condensed. This would have resulted in the hydrophobicity decreasing in the upper few centimeters but increasing or not changing deeper in the soil. The hydrophobic substances could have condensed below the 5 cm depth which we sampled. Post-burn water repellency should have been distributed deeper in the soil than pre-burn water repellency if this were the case. The most water repellent depth occurred in the upper two centimeters in 15 of 27 (55.5%) sampling points which were strongly hydrophobic before burning (Fig. 12) but occurred in only 6 of 16 (37.5%) sampling points which were strongly hydrophobic following burning (Fig. 13).

This trend towards a decrease in hydrophobicity in the upper depths is further shown by looking at the mean CST at each depth following burning (Table 18). It was found that there was a trend

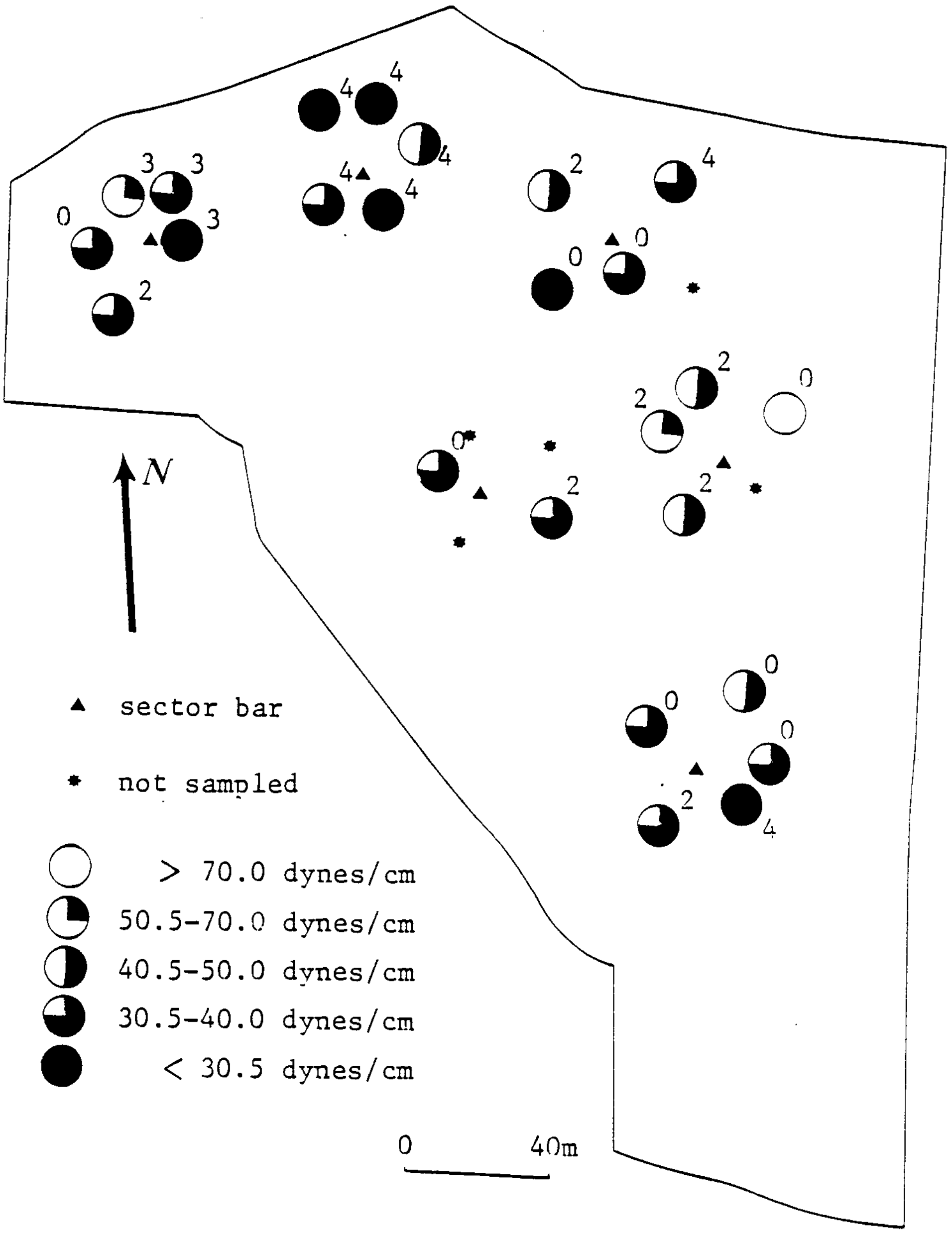

Figure 13. CST (dynes/cm) and vertical distance (cm) from litter-soil boundary to most hydrophobic depth, Unit 42 (September) following burning.

Table 18. Means and standard deviations for post-burn CST (dynes/cm) at different depths for Unit 42 (September).

Depth	Sample number	Mean	Standard deviation
0-1	25	58.0	16.9
1-2	25	62.0	15.4
2-3	25	54.9	17.7
3-4	25	54.9	18.1
4-5	25	53.3	19.8
Total	125	56.6	17.6

towards a lower CST deeper in the soil. The average CST for the 0-1 and 1-2 cm depths were 58.0 and 62.0 dynes/cm respectively, whereas the average CST for the 3-4 and 4-5 cm depths were 54.9 and 53.3 dynes/cm respectively. The difference in CST between depths was not significant at the 95% level (Table 19) for post-burn hydrophobicity in Unit 42 (September) even though there was a trend towards a lower CST deeper in the soil. The critical F value was 2.45 and the observed F value was 0.99.

The difference in CST between sectors was also not significant at the 95% level (Table 19), because the critical F value of 2.01 was greater than the observed F value of 1.63. However, all of the average CST were less than 59 dynes/cm except the average CST of sector 4 which was 65.5 dynes/cm (Table 20). This confirms the results obtained when the most hydrophobic depth was examined for each sampling point. Most of the hydrophobic soil occurred in sectors 1, 2, 3, 5, and 6; very little was found in sector 4.

Determination of Persistence.

Eight sites where the time since burning last occurred ranged from 0 to 51 months were studied to determine if water repellency decreased following burning. The oldest burn is Unit 1E. Unit 1E is located in the northwest corner of the northeast corner of section 25, Township 19S, Range 12E, on the footslopes of Kelsey Butte. The slopes range from 5-20% with a northeast aspect. The overstory is Ponderosa pine, and the understory is dominated by antelope bitterbrush (Purshia tridentata). Unit 1E was burned 19 April 1978 and 3 May 1978 and sampled 4 August 1982.

Unit 8 is located in the southeast corner of the southeast corner of section 25, Township 21S, Range 9E. The topography is nearly level (<5%). The overstory is Ponderosa pine, and the understory is dominated by antelope bitterbrush and snowbrush ceanothus. Unit 8 was burned 17 November 1978 and sampled 7 August 1982.

Andi's plot is located in the northwest corner of the southeast corner of section 25, Township 21S, Range 9E. The slopes range from

Table 19. ANOVA for post-burn CST (dynes/cm) as a function of depth and sector for Unit 42 (September).

Source of Variation	Degrees of Freedom	Regression Mean Square	Observed F Statistic*†
Total	125	309.8	
Depth	4	303.0	0.99
Sector	5	500.4	1.63
Sector·depth	20	278.2	0.91
Error	96	306.8	

* Critical F value, F(.95;4,120)=2.45

† Critical F value, F(.95;5,120)=2.29

Table 20. Means and standard deviations for post-burn CST (dynes/cm) at different sectors for Unit 42 (September).

Sector	Sample number	Mean	Standard deviation
1	25	54.1	17.4
2	25	52.9	18.4
3	20	52.7	18.0
4	20	65.5	10.1
5	25	58.4	19.5
6	25	58.2	19.1
Total	125	56.6	17.6

5-15% with a southeast aspect. The overstory is Ponderosa pine, and the understory is dominated by greenleaf manzanita and antelope bitterbrush. Andi's plot was burned 25 May 1979 and sampled 6 August 1982.

Unit 1B is located in the northwest corner of the northeast corner of section 25, Township 19S, Range 12E, on the footslopes of Kelsey Butte. The slopes range from 5-60% with a northeast aspect. The overstory is Ponderosa pine, and the understory is dominated by greenleaf manzanita and snowbrush ceanothus but includes antelope bitterbrush. Unit 1B was burned 6 September 1979 and sampled 9 August 1982.

Unit 6B is located in the southeast corner of the southwest corner of section 28, Township 20S, Range 9E. The slopes range from 15-40% with an east aspect. The overstory is Ponderosa pine, and the understory is dominated by snowbrush ceanothus. Unit 6B was burned 30 September 1980 and sampled 8 August 1982.

Reeves' plots were located in the center of the southwest corner of section 25, Township 21S, Range 9E. The topography is nearly level. The overstory is Ponderosa pine, and the understory is dominated by antelope bitterbrush. Reeves' plots were burned 23 October 1981 and sampled 5 August 1982.

The CST data from Unit 40B (June) and Unit 42 (September) were also analyzed to determine if water repellency decreased following burning. Forty sampling points were sampled in each burn in the same manner as was done for Units 40B (June) and 42 (September). The complete CST data set for each sampling point and depth for the eight units is in Appendix B and C. The sampling scheme for each unit is presented in Appendix A. The total number of sampling points which had a LCST less than 50 dynes/cm was divided by the total number of sampling points to find the percentage of the sampling points which were hydrophobic. The percentage of the sampling points which were hydrophobic was regressed against the age of the burn. This was also done for sampling points with a LCST below 40 dynes/cm. The results are presented in Table 21. The independent variable age is listed under Source of variation when the LCST is less than 50 dynes/cm and

Table 21. ANOVA for percentage of the sampling points which are hydrophobic as a function of age of burn.

Source of Variation	Degrees of Freedom	Regression Sum of Squares Error Sum of Squares	Regression Mean Square Error Mean Square	Observed F Statistic*
Total	7	2,820.9		
Age of burn when CST is less than 50 dynes/cm	1	660.8	660.8	3.5
Error	6	2,160.1	360.0	
Age of burn when CST is less than 40 dynes/cm	1	1,952.7	1,952.7	13.5 †
Error	6	868.2	144.7	

* Critical F value, F(.95;1,6)=5.99.

† Significant at the 95% level.

when the LCST is less than 40 dynes/cm along with its associated Error term. The F statistic which determines whether or not the variation in LCST explained by a the age of the burn was significant is listed under Observed F. The regression mean square and error mean square used to calculate the F statistic are also presented in Table 21. The critical F value for deciding if the relationship was significant at the 95% level between the percentage of the sampling points which were hydrophobic and the age of the burn is 5.99. The observed F value for the percentage of the sampling points which were hydrophobic when 50 dynes/cm was the determining LCST was 3.5, which was less than the critical value of 5.99. The observed F value for the percentage of the sampling points which were hydrophobic when 40 dynes/cm was the determining CST was 13.5, which was greater than the critical value of 5.99. Therefore, there was not a relationship that was significant at the 95% level between the percentage of the sampling points which were hydrophobic and the age of the burn when 50 dynes/cm was the determining CST, but the relationship was significant at the 95% level when 40 dynes/cm was the determining LCST. This relationship between the percentage of the sampling points which were hydrophobic and the age of the burn when 40 dynes/cm was the determining CST is shown in Figure 14. The percentage of the sampling points which were hydrophobic decreases as the age of the burn increases.

An explanation was sought for the fact that there was a significant relationship between the percentage of the sampling points which were hydrophobic and the age of the burn when 40 dynes/cm was used as the determining LCST but not when 50 dynes/cm was used as the determining LCST. Fire may cause stronger water repellency to form than fungal induced water repellency because hydrophobic substances are "fixed" to the soil particles by high temperatures when a fire passes over the soil. Sampling points with a LCST below 40 dynes/cm reflect fire induced hydrophobicity. Sampling points with a LCST below 50 dynes/cm reflect fire and fungal induced water repellency. Fire induced water repellency is produced just once, during the fire. Hydrophobicity decreases as the time since the area was burned

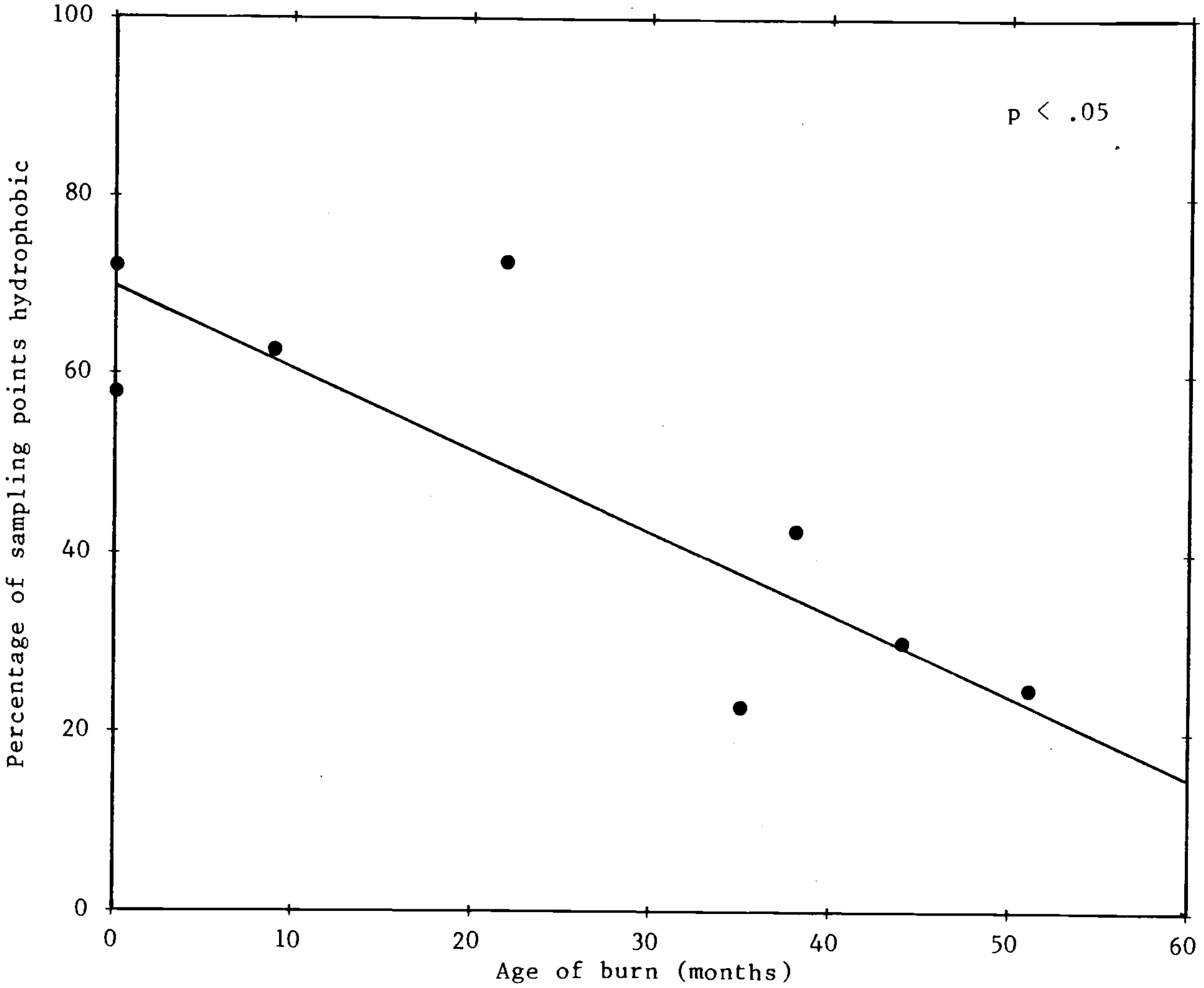

Figure 14. Relationship between the percentage of the sampling points which were hydrophobic and age of burn when 40 dynes/cm was the determining LCST.

increases (Fig. 14). Fungal induced hydrophobicity on the other hand is produced each year. The number of sampling points that are hydrophobic should not vary measurably from one year to the next. This was confirmed by the fact that the relationship between percentage of the sampling points which were hydrophobic and the age of the burn was not significant at the 95% level when 50 dynes/cm was the determining CST.

SUMMARY AND CONCLUSIONS

More hydrophobicity was found in the September burn than in the June burn. Two possible reasons were postulated for this difference. First, the amount of hydrophobicity due to the presence of fungal hyphae may vary seasonally. Fungal products may accumulate throughout the summer and then leach out of the profile with fall rains and spring snowmelt. Second, avoiding fungal pockets may not have been as successful when September sampling occurred as in June. Soil infected with fungal hyphae was avoided when CST was measured, because the fungal pockets did not form a continuous layer parallel to the surface. Therefore, infiltration rate was not reduced. Fungal pockets were avoided by observing the light color of the dry fungal soil and the presence of hyphae. The soil had a light color because the water content was low. The soil was drier in September than in June. Distinguishing between fungal and non-fungal soil based on color differences was relatively easy in June, because the non-fungal soil was moist. However, the color difference between fungal and non-fungal soil was not as distinct during September sampling, and the difference in color due to water content between fungal and non-fungal soil was small. As a result, the effort to avoid fungal caused water repellent areas was not as successful. More of the sampling points were hydrophobic in September.

Fungal caused hydrophobicity is a part of the ecosystem in central Oregon and must be studied in any project which examines the hydrophobicity of central Oregon soils. However, if the effects of burning on hydrophobicity of the soil is to be ascertained, further studies should separate the affects of fungi from the affects of burning. I recommend that sites which do not have a recent fire history be sampled several times throughout the year to determine the seasonal variation in hydrophobicity due to fungal products. Fire induced water repellency should be examined using the Critical Surface Tension method of measuring contact angle developed by Watson and Letey (1970). Before further research of fire induced hydrophobicity is conducted a protocol should be developed for methods of study so that presence of fungi is properly taken into account. It may be necessary to burn sites where fungal caused hydrophobicity is not extensive. This could be accomplished by burning early in the year or by burning sites which were selected based on the extent of pre-burn hydrophobicity. This was not possible for three reasons. It was necessary to commute from Corvallis to Bend on each burn so little time was available for pre-burn sampling. Sufficient funding was not available. Burns were selected based on the needs of other studies.

The soil increased in hydrophobicity as a result of the June burn. The increase was not significant at the 95% confidence level. The increase in hydrophobicity was most pronounced at the 2-3 cm depth.

Post-burn LCST was regressed against nine independent variables to determine what variables predicted LCST after burning. The variables were: average gravimetric water content before burning, surface (0-1 cm depth) gravimetric water content before burning, change in the average gravimetric water content due to burning, change in the surface (0-1 cm depth) gravimetric water content due to burning, percent change in litter depth due to burning, change in litter depth in centimeters due to burning, litter depth before burning in centimeters, degree of combustion, and LCST before burning. These variables were chosen because they were thought to have an affect on the formation of a water repellent layer. The data collected from the two sites were analyzed separately because of the differences in pre-burn hydrophobicity between them.

The degree of combustion was the only variable which was correlated with the variation in post-burn LCST in the June burn at the 95% confidence level. Hydrophobicity was produced where complete combustion occurred but not with incomplete combustion of the litter.

Following the September burn, the hydrophobicity of the soil decreased. The decrease was not significant. The decrease occurred in the upper two centimeters of the soil. It was postulated that intense heat volatilized fungal products and the products diffused deeper into the soil. They then condensed and were fixed at the lower depths.

Pre-burn LCST was the only variable which significantly explained the variation in post-burn LCST for the September burn. Soil was found to be hydrophobic after burning if it was hydrophobic before burning.

The percentage of the sampling points which were hydrophobic decreased as the time since burning increased. Microbial degradation or some other agent caused hydrophobicity to disappear.

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APPENDICES

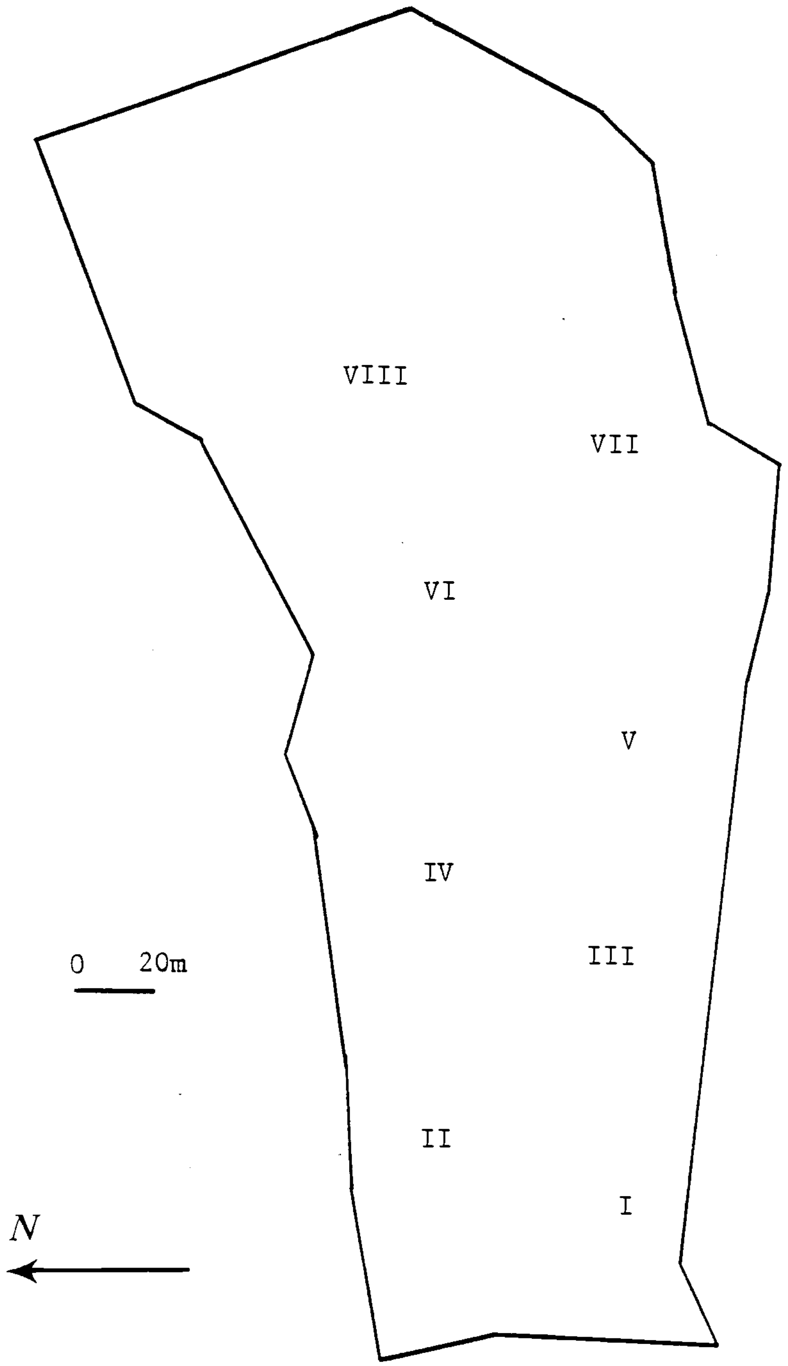

Figure 1A. Location of sectors, Unit 1E.

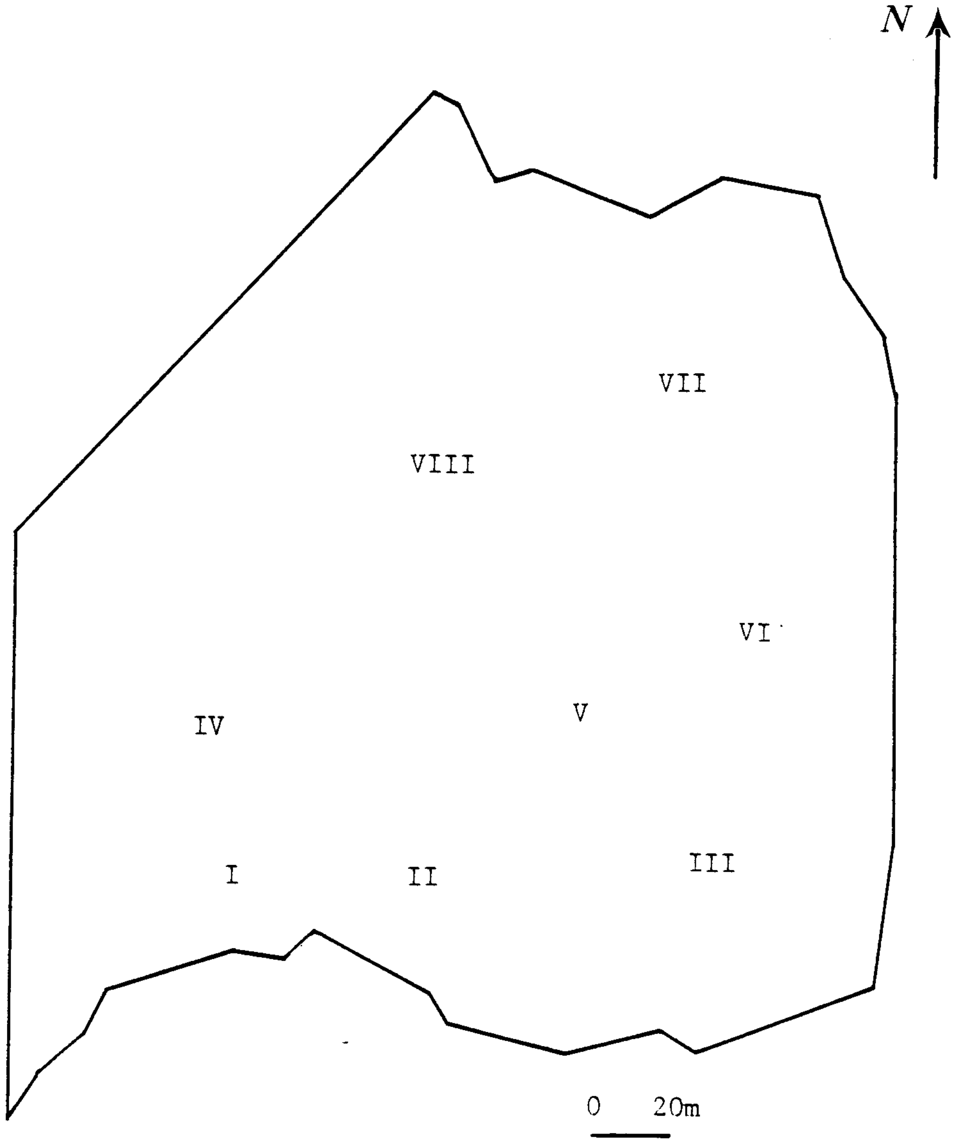

Figure 2A. Location of sectors, Unit 8.

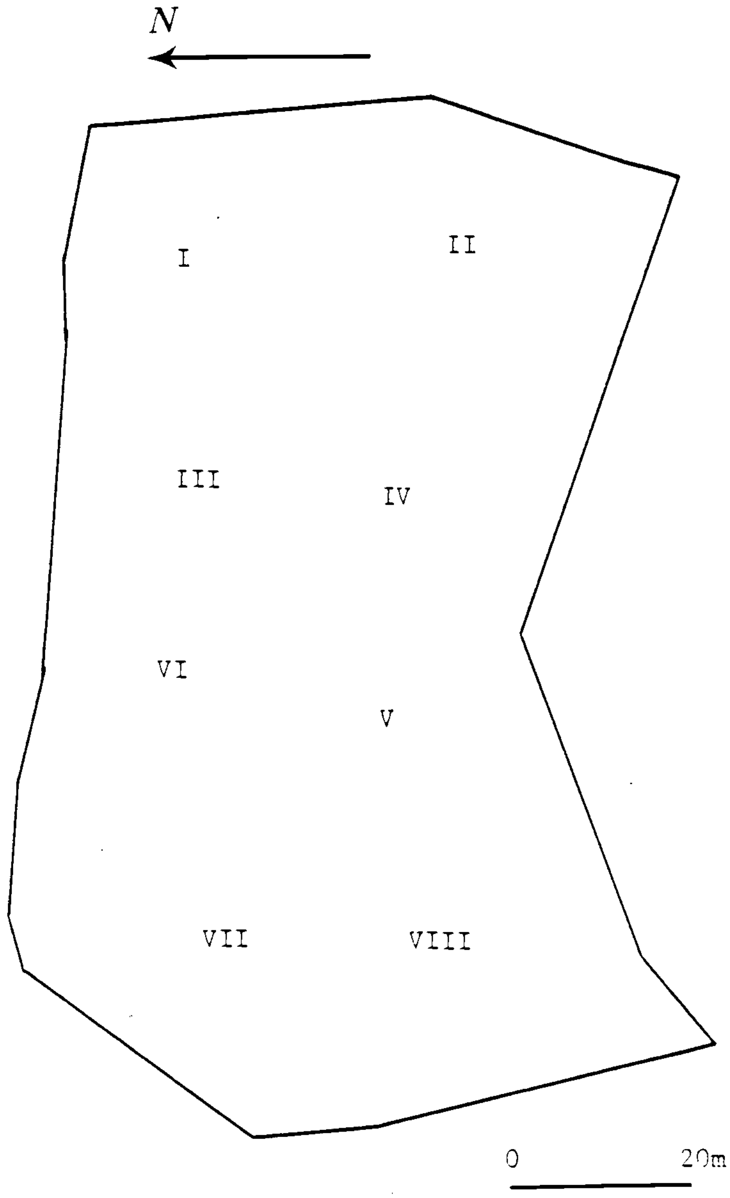

Figure 3A. Location of sectors, Andi's plot.

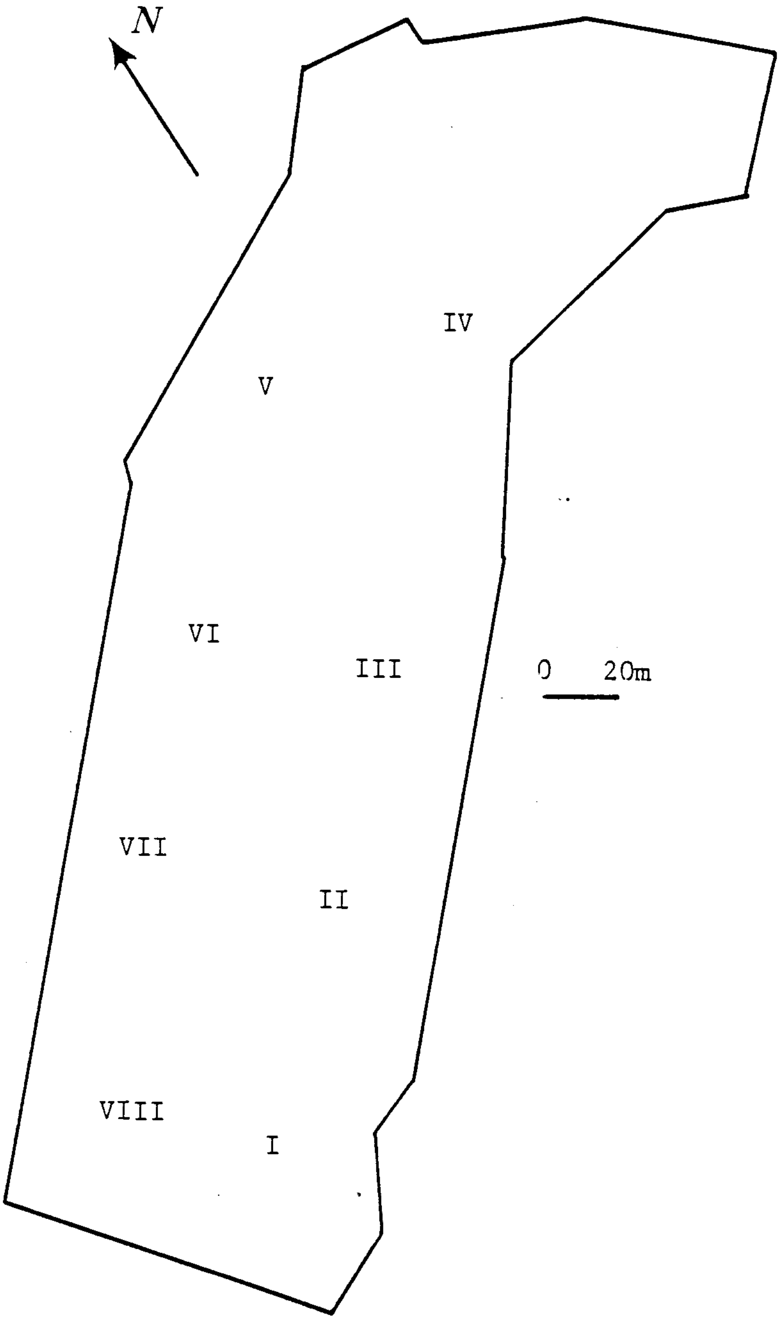

Figure 4A. Location of sectors, Unit 1B.

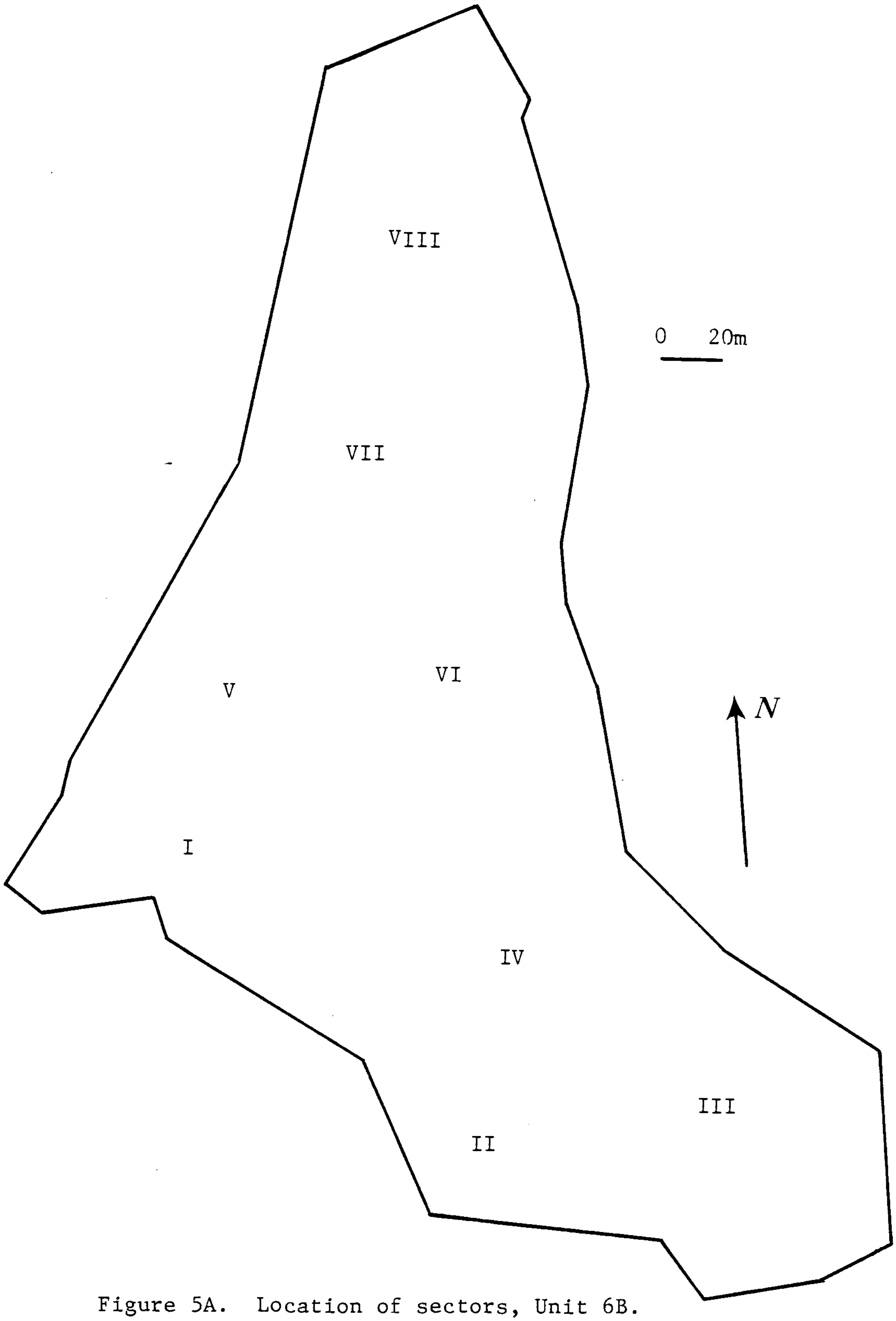

Figure 5A. Location of sectors, Unit 6B.

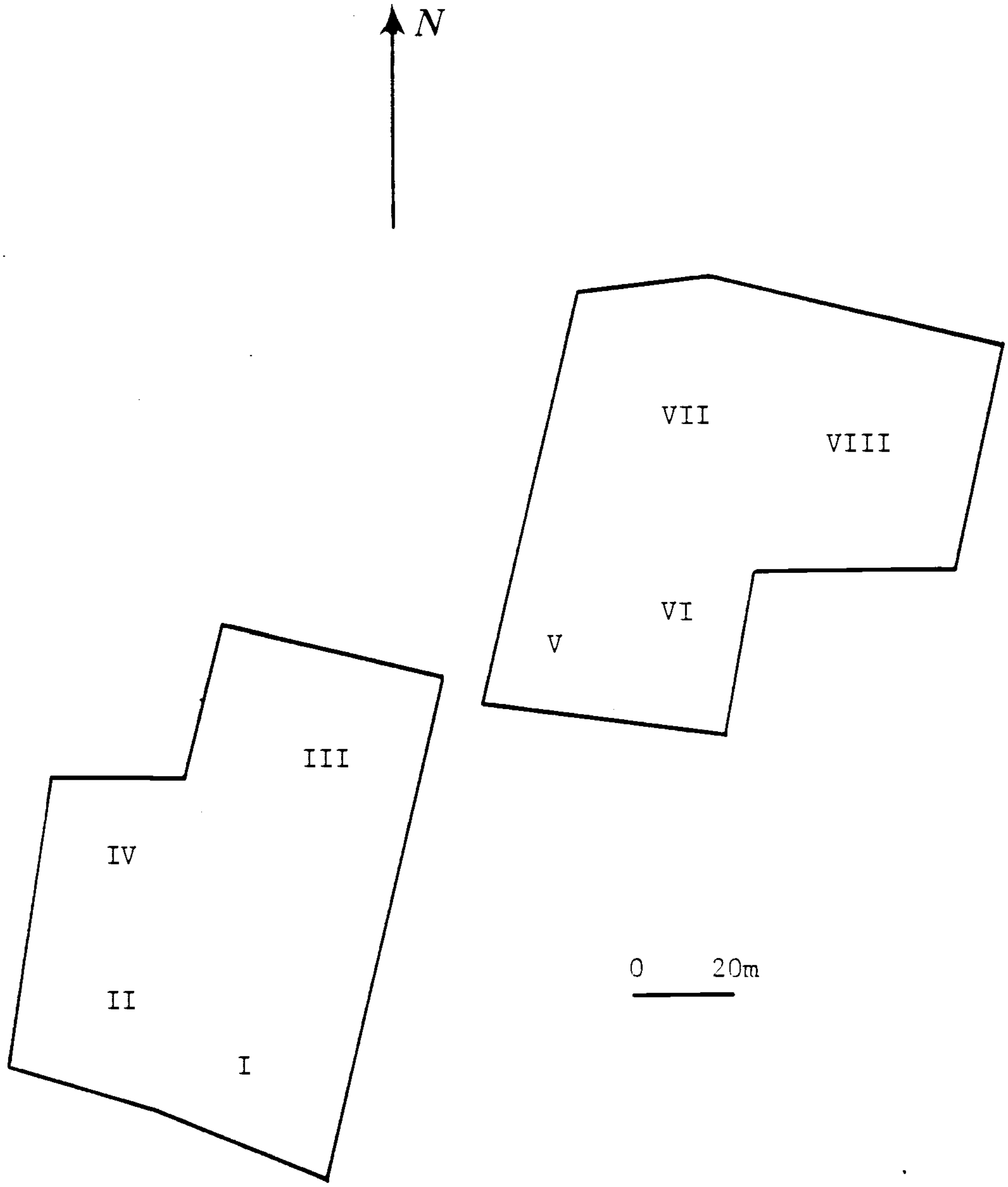

Figure 6A. Location of sectors, Reeves' plots.

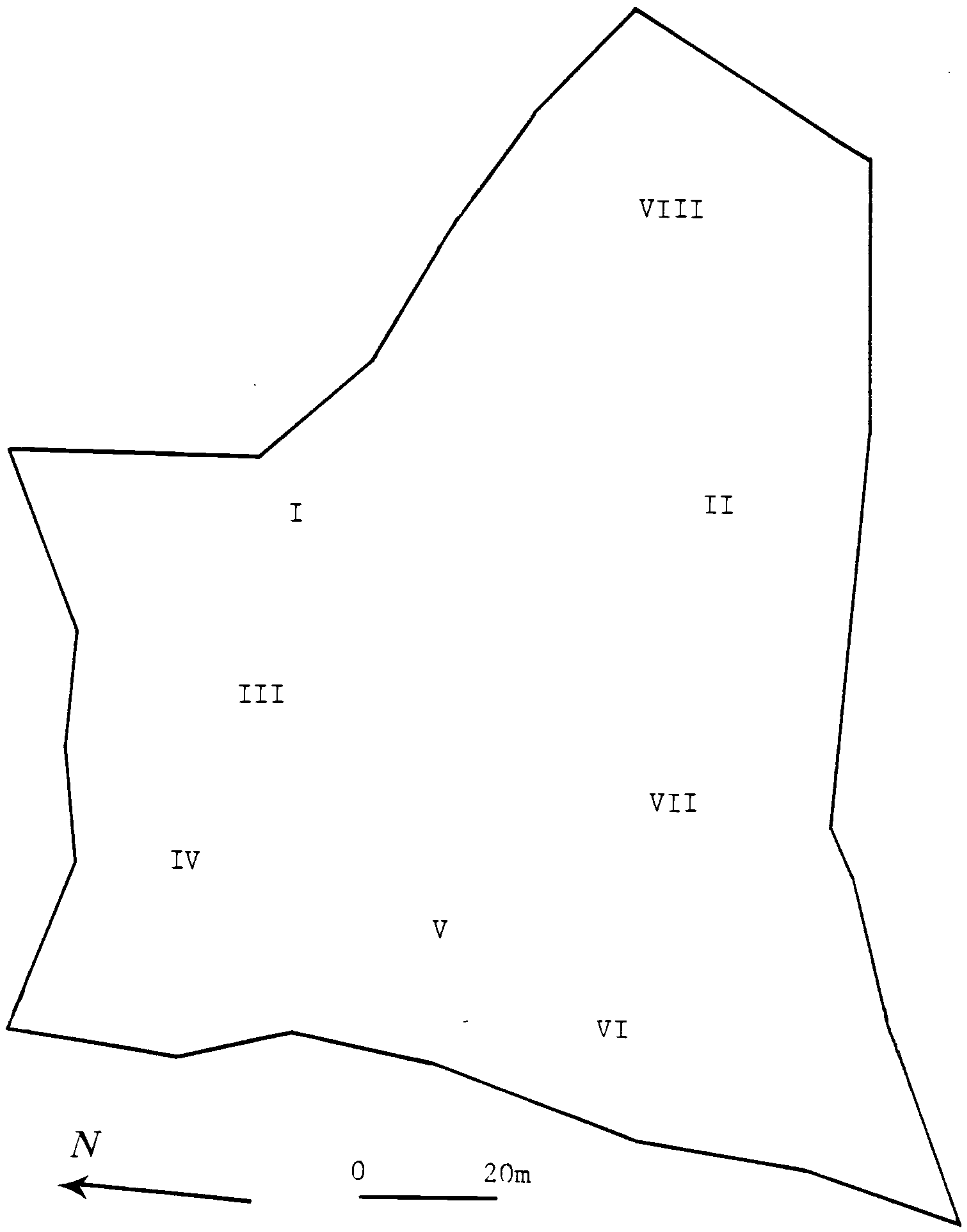

Figure 7A. Location of sectors, Unit 40B.

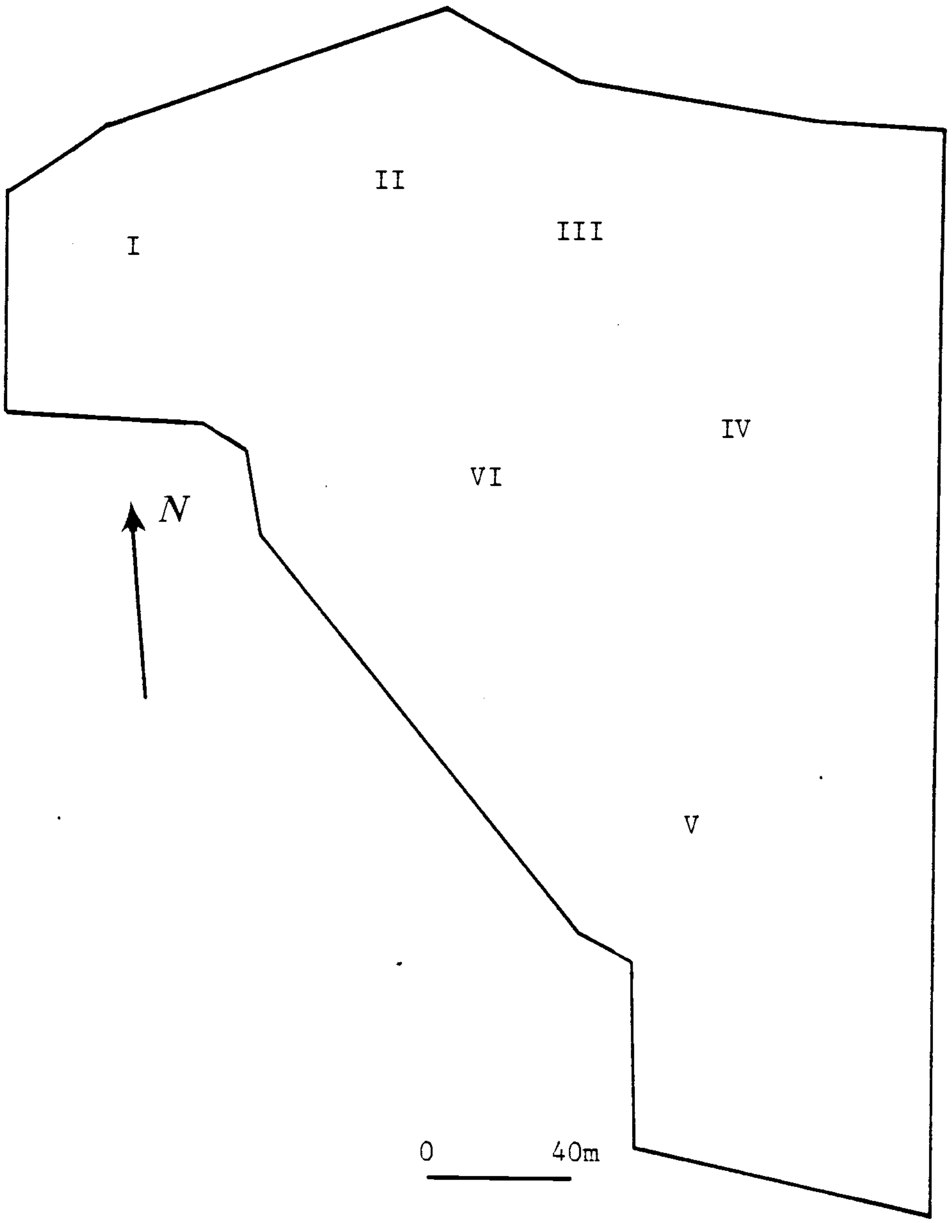

Figure 8A. Location of sectors, Unit 42.

Table 1B. CST at each sampling point and depth for sector 1 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	73.0	72.5	72.5	35.5	69.0	72.5	74.0	73.5	74.0	73.5
1-2	73.0	72.5	72.5	73.0	74.0	35.0	74.0	73.5	74.0	73.5
2-3	73.0	35.5	72.5	73.0	74.0	35.0	74.0	73.5	74.0	73.5
3-4	73.0	35.5	72.5	73.0	74.0	72.5	74.0	73.5	74.0	73.5
4-5	73.0	47.0	72.5	73.0	74.0	72.5	74.0	73.5	74.0	73.5

Table 2B. CST at each sampling point and depth for sector 2 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	73.5	68.5	74.0	29.0	73.0	35.5	47.0	73.5	74.0	29.0
1-2	73.5	73.5	69.0	48.0	47.0	35.5	73.0	73.5	74.0	74.0
2-3	73.5	73.5	74.0	74.0	68.5	35.5	73.0	73.5	74.0	74.0
3-4	73.5	73.5	74.0	74.0	73.0	73.5	73.0	73.5	74.0	74.0
4-5	73.5	73.5	74.0	74.0	73.0	73.5	73.0	73.5	74.0	74.0

Table 3B. CST at each sampling point and depth for sector 3 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	29.5	73.5	74.5	73.5	74.5	72.5	29.5	46.5	36.0	73.5
1-2	48.0	73.5	74.5	73.5	36.5	35.0	29.5	46.5	74.0	73.5
2-3	74.5	73.5	74.5	35.5	48.0	29.5	29.5	35.0	74.0	36.0
3-4	74.5	73.5	74.5	35.5	29.5	29.5	29.5	46.5	74.0	36.0
4-5	74.5	73.5	74.5	35.5	36.5	35.0	29.5	72.0	74.0	73.5

Table 4B. CST at each sampling point and depth for sector 4 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	74.5	74.5	74.5	*	74.5	73.5	74.0	73.0	74.5	73.5
1-2	29.0	74.5	74.5	*	74.5	73.5	74.0	73.0	74.5	47.5
2-3	29.0	74.5	74.5	*	74.5	73.5	74.0	73.0	74.5	73.5
3-4	36.5	74.5	74.5	*	74.5	73.5	74.0	47.0	74.5	73.5
4-5	74.5	74.5	74.5	*	74.5	73.5	74.0	35.0	74.5	73.5

* Burning did not occur at sampling point II, so post-burn CST was not measured.

Table 5B. CST at each sampling point and depth for sector 5 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	74.0	74.0	74.0	35.5	73.5	36.0	74.0	73.5	74.0	74.0
1-2	74.0	74.0	74.0	35.5	73.5	73.5	74.0	73.5	74.0	74.0
2-3	74.0	74.0	74.0	73.0	73.5	73.5	74.0	73.5	74.0	74.0
3-4	74.0	74.0	74.0	73.0	73.5	73.5	74.0	73.5	74.0	74.0
4-5	74.0	74.0	74.0	73.0	73.5	73.5	74.0	73.5	74.0	74.0

Table 6B. CST at each sampling point and depth for sector 6 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	74.0	71.0	37.0	29.5	73.5	74.0	35.5	35.5	73.5	74.0
1-2	74.0	34.5	37.0	36.5	73.5	74.0	73.0	35.5	73.5	74.0
2-3	48.0	46.0	37.0	74.5	73.5	69.0	73.0	73.0	73.5	74.0
3-4	29.0	34.5	73.5	74.5	73.5	74.0	73.0	73.0	73.5	74.0
4-5	29.0	46.0	73.5	74.5	73.5	74.0	73.0	73.0	73.5	74.0

Table 7B. CST at each sampling point and depth for sector 7 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	47.5	35.5	36.0	71.0	36.0	36.0	35.5	29.0	73.0	74.0
1-2	35.5	47.5	47.5	71.0	74.0	73.5	73.0	36.0	73.0	74.0
2-3	35.5	73.0	73.5	46.0	74.0	47.5	73.0	73.5	73.0	74.0
3-4	68.5	73.0	73.5	34.0	74.0	73.5	73.0	68.5	73.0	74.0
4-5	73.0	73.0	73.5	46.0	74.0	73.5	73.0	36.0	73.0	74.0

Table 8B. CST at each sampling point and depth for sector 8 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	73.5	74.0	36.0	35.5	35.0	*	48.0	74.0	74.0	74.0
1-2	73.5	74.0	29.0	35.5	29.0	*	36.0	74.0	74.0	36.0
2-3	73.5	74.0	73.5	73.5	73.0	*	74.0	74.0	74.0	36.0
3-4	73.5	74.0	73.5	73.5	73.0	*	74.0	74.0	74.0	74.0
4-5	73.5	74.0	73.5	73.5	73.0	*	74.0	74.0	74.0	74.0

* Burning did not occur at sampling point III, so post-burn CST was not measured.

Table 9B. CST at each sampling point and depth for sector 1 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	37.0	71.5	49.0	71.0	49.0	72.5	37.0	37.5	37.0	63.5
1-2	70.5	46.5	49.0	71.0	37.5	72.5	37.0	49.5	37.0	63.5
2-3	49.0	34.5	37.5	71.0	30.5	35.0	49.0	71.0	37.0	32.5
3-4	49.0	27.5	75.5	66.5	37.5	47.0	70.5	76.5	70.5	32.5
4-5	49.0	34.5	75.5	66.5	37.5	47.0	70.5	76.5	75.5	32.5

Table 10B. CST at each sampling point and depth for sector 2 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	75.5	72.0	37.5	73.0	37.5	73.0	37.0	36.0	37.0	68.5
1-2	49.0	35.0	37.5	73.0	37.5	73.0	37.0	69.0	37.0	68.5
2-3	30.5	72.0	30.5	35.5	37.5	68.0	30.5	36.0	37.0	64.0
3-4	30.5	35.0	30.5	35.5	37.5	68.0	75.5	36.0	30.0	64.0
4-5	75.5	28.0	30.5	29.0	37.5	49.0	49.0	29.0	30.0	32.5

Table 11B. CST at each sampling point and depth for sector 3 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	30.5	72.0	49.0	67.0	37.5	*	37.5	37.0	30.5	30.0
1-2	30.5	67.0	30.0	67.0	49.0	*	76.0	75.0	49.0	30.0
2-3	30.5	46.5	30.0	67.0	37.5	*	76.0	75.0	76.0	30.0
3-4	49.5	46.5	37.0	42.5	76.0	*	76.0	75.0	76.0	37.0
4-5	37.5	46.5	37.0	31.0	76.0	*	76.0	75.0	76.0	37.0

* Burning did not occur at sampling point III, so post-burn CST was not measured.

Table 12B. CST at each sampling point and depth for sector 4 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	37.0	71.0	49.0	69.5	75.5	71.0	30.0	*	49.0	72.5
1-2	37.0	71.0	75.5	69.5	75.5	71.0	30.0	*	37.0	72.5
2-3	75.5	66.5	75.5	45.0	49.0	71.0	48.5	*	75.5	47.0
3-4	75.5	71.0	75.5	45.0	49.0	71.0	48.5	*	75.5	47.0
4-5	75.5	71.0	75.5	69.5	75.5	71.0	48.5	*	75.5	67.5

* Burning did not occur at sampling point IV, so post-burn CST was not measured.

Table 13B. CST at each sampling point and depth for sector 5 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	70.5	49.0	75.5	37.0	37.0	37.0	37.0	73.0	37.0	37.0
1-2	75.5	75.0	37.0	37.0	70.5	75.5	49.0	73.0	37.0	37.0
2-3	75.5	75.0	75.5	37.0	75.5	75.5	75.0	35.5	71.0	76.0
3-4	75.5	75.0	37.0	75.5	75.5	75.5	75.0	35.5	71.0	76.0
4-5	75.5	75.0	30.5	75.5	75.5	30.0	75.0	35.5	76.0	76.0

Table 14B. CST at each sampling point and depth for sector 3 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	dynes/cm									
0-1	49.0	*	76.0	37.0	30.5	*	30.5	*	37.5	72.0
1-2	37.0	*	30.5	37.0	37.5	*	71.0	*	37.5	72.0
2-3	30.5	*	76.0	70.5	49.0	*	76.0	*	30.5	35.0
3-4	76.0	*	76.0	75.5	76.0	*	76.0	*	30.5	35.0
4-5	76.0	*	76.0	75.5	76.0	*	76.0	*	30.5	72.0

* Burning did not occur at sampling point I, III, and IV, so post-burn CST was not measured.

Table 1C. CST at each sampling point and depth for sector 1 in Unit 1E (April '78).

depth	Sampling point I	II	III	IV	V
cm	----------------	----------------	dynes/cm	----------------	----------------
0-1	48.0	74.5	74.5	48.0	74.0
1-2	74.5	74.5	74.5	74.5	74.0
2-3	74.5	74.5	74.5	74.5	74.0
3-4	74.5	74.5	74.5	74.5	74.0
4-5	74.5	74.5	74.5	74.5	74.0

Table 2C. CST at each sampling point and depth for sector 2 in Unit 1E (April '78).

depth	Sampling point I	II	III	IV	V
cm	----------------	----------------	dynes/cm	----------------	----------------
0-1	36.5	48.0	48.0	48.0	74.5
1-2	48.5	74.5	69.0	69.0	74.5
2-3	74.5	74.5	69.0	74.0	74.5
3-4	74.5	74.5	74.5	74.0	74.5
4-5	74.5	74.5	74.5	74.0	74.5

Table 3C. CST at each sampling point and depth for sector 3 in Unit 1E (April '78).

depth	Sampling point I	II	III	IV	V
cm	----------------	----------------	dynes/cm	----------------	----------------
0-1	74.5	74.5	48.0	69.0	48.5
1-2	74.5	74.5	48.0	74.5	48.5
2-3	74.5	48.0	74.5	74.5	48.5
3-4	74.5	74.5	74.5	74.5	74.5
4-5	74.5	74.5	74.5	74.5	74.5

Table 4C. CST at each sampling point and depth for sector 4 in Unit 1E (April '78).

depth	Sampling point I	II	III	IV	V
cm	----------------	----------------	dynes/cm	----------------	----------------
0-1	48.5	36.5	74.5	74.5	36.0
1-2	74.5	69.5	74.5	74.5	48.0
2-3	74.5	74.5	74.5	74.5	74.0
3-4	74.5	74.5	74.5	74.5	74.0
4-5	74.5	74.5	74.5	74.5	74.0

Table 5C. CST at each sampling point and depth for sector 5 in Unit 1E (April '78).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	48.0	74.0	29.0	48.5	48.0
1-2	74.0	74.0	36.0	74.5	74.5
2-3	74.0	74.0	74.0	74.5	74.5
3-4	74.0	74.0	74.0	74.5	74.5
4-5	74.0	74.0	74.0	74.5	74.5

Table 6C. CST at each sampling point and depth for sector 6 in Unit 1E (April '78).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	35.5	74.0	74.0	47.5	36.0
1-2	73.5	74.0	74.0	47.5	74.0
2-3	73.5	74.0	74.0	36.0	74.0
3-4	73.5	74.0	74.0	73.5	74.0
4-5	73.5	74.0	74.0	73.5	74.0

Table 7C. CST at each sampling point and depth for sector 7 in Unit 1E (April '78).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	48.0	47.0	36.0	48.0	74.0
1-2	36.0	73.0	69.0	74.5	74.0
2-3	74.0	73.0	74.0	74.5	74.0
3-4	74.0	73.0	74.0	74.5	74.0
4-5	74.0	73.0	74.0	74.5	74.0

Table 8C. CST at each sampling point and depth for sector 8 in Unit 1E (April '78).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	48.0	48.0	73.0	36.0	47.0
1-2	74.0	74.0	73.0	74.0	73.0
2-3	74.0	74.0	47.0	74.0	73.0
3-4	74.0	74.0	47.0	74.0	73.0
4-5	74.0	74.0	73.0	74.0	73.0

Table 9C. CST at each sampling point and depth for sector 1 in Unit 8 (November '78).

depth	Sampling point I	II	III	IV	V
cm			dynes/cm		
0-1	68.5	35.5	68.0	47.5	72.5
1-2	47.0	73.5	73.0	73.0	72.5
2-3	73.0	73.5	73.0	73.0	72.5
3-4	73.0	73.5	73.0	73.0	72.5
4-5	73.0	73.5	73.0	73.0	72.5

Table 10C. CST at each sampling point and depth for sector 2 in Unit 8 (November '78).

depth	Sampling point I	II	III	IV	V
cm			dynes/cm		
0-1	73.0	36.0	71.5	73.0	35.5
1-2	73.0	47.5	71.5	47.0	68.5
2-3	73.0	73.5	71.5	47.0	73.5
3-4	68.5	73.5	66.5	47.0	73.5
4-5	47.0	73.5	34.5	47.0	73.5

Table 11C. CST at each sampling point and depth for sector 3 in Unit 8 (November '78).

depth	Sampling point I	II	III	IV	V
cm			dynes/cm		
0-1	73.0	46.5	35.0	71.5	35.0
1-2	73.0	46.5	47.0	71.5	73.0
2-3	73.0	72.5	72.5	71.5	73.0
3-4	73.0	72.5	72.5	71.5	73.0
4-5	47.0	72.5	72.5	71.5	73.0

Table 12C. CST at each sampling point and depth for sector 4 in Unit 8 (November '78).

depth	Sampling point I	II	III	IV	V
cm			dynes/cm		
0-1	73.0	47.0	47.0	35.5	73.0
1-2	47.0	72.5	72.5	68.0	73.0
2-3	73.0	72.5	72.5	73.0	73.0
3-4	73.0	72.5	72.5	73.0	73.0
4-5	73.0	72.5	72.5	73.0	73.0

Table 13C. CST at each sampling point and depth for sector 5 in Unit 8 (November '78).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	71.5	35.0	73.0	71.5	71.5
1-2	71.5	47.0	73.0	71.5	71.5
2-3	66.5	72.5	73.0	71.5	71.5
3-4	71.5	72.5	73.0	71.5	71.5
4-5	71.5	72.5	73.0	71.5	71.5

Table 14C. CST at each sampling point and depth for sector 6 in Unit 8 (November '78).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	71.0	71.5	71.0	70.5	72.0
1-2	71.0	71.5	71.0	70.5	72.0
2-3	71.0	71.5	68.0	70.5	72.0
3-4	66.5	71.5	71.0	70.5	72.0
4-5	66.5	71.5	71.0	70.5	46.5

Table 15C. CST at each sampling point and depth for sector 7 in Unit 8 (November '78).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	47.0	72.5	71.5	67.5	73.0
1-2	73.0	72.5	71.5	35.0	73.0
2-3	73.0	67.0	71.5	47.0	73.0
3-4	73.0	47.0	71.5	35.0	73.0
4-5	73.0	35.0	71.5	47.0	73.0

Table 16C. CST at each sampling point and depth for sector 8 in Unit 8 (November '78).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	72.5	72.5	73.5	73.0	72.5
1-2	72.5	72.5	68.5	73.0	72.5
2-3	72.5	72.5	73.5	73.0	72.5
3-4	67.0	72.5	73.5	73.0	72.5
4-5	35.0	35.0	73.5	73.0	73.0

Table 17C. CST at each sampling point and depth for sector 1 in Andi's plot (May '79).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	36.0	35.5	73.0	73.5	68.5
1-2	36.0	73.0	73.0	36.0	35.5
2-3	47.5	73.0	73.0	47.5	47.5
3-4	73.5	73.0	35.0	73.5	35.5
4-5	73.5	73.0	73.0	73.5	73.0

Table 18C. CST at each sampling point and depth for sector 2 in Andi's plot (May '79).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	72.5	73.0	72.0	66.0	71.0
1-2	72.5	73.0	72.0	46.0	71.0
2-3	72.5	73.0	72.0	34.0	71.0
3-4	72.5	73.0	72.0	34.0	71.0
4-5	72.5	73.0	72.0	34.0	71.0

Table 19C. CST at each sampling point and depth for sector 3 in Andi's plot (May '79).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	73.5	72.0	73.0	72.0	72.5
1-2	73.5	72.0	73.0	46.5	67.0
2-3	73.5	72.0	73.0	72.0	47.0
3-4	73.5	72.0	35.0	72.0	47.0
4-5	73.5	72.0	73.0	72.0	72.5

Table 20C. CST at each sampling point and depth for sector 4 in Andi's plot (May '79).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	47.0	71.5	67.0	73.0	35.0
1-2	35.0	71.5	67.0	73.0	47.0
2-3	47.0	71.5	72.0	73.0	68.0
3-4	72.5	71.5	72.0	73.0	73.0
4-5	72.5	71.5	72.0	73.0	73.0

Table 21C. CST at each sampling point and depth for sector 5 in Andi's plot (May '79).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	72.5	71.5	72.0	71.0	68.5
1-2	72.5	71.5	72.0	71.0	47.0
2-3	72.5	71.5	72.0	34.0	47.0
3-4	35.0	71.5	72.0	34.0	73.0
4-5	35.0	71.5	72.0	34.0	73.0

Table 22C. CST at each sampling point and depth for sector 6 in Andi's plot (May '79).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	70.5	46.0	68.5	71.5	46.0
1-2	70.5	66.0	73.0	34.5	46.0
2-3	70.5	71.0	73.0	46.5	71.5
3-4	70.5	71.0	73.0	71.5	71.5
4-5	70.5	71.0	73.0	46.5	71.5

Table 23C. CST at each sampling point and depth for sector 7 in Andi's plot (May '79).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	71.5	35.5	35.5	35.0	72.0
1-2	71.5	73.0	73.0	47.0	35.0
2-3	71.5	73.0	73.0	72.5	72.0
3-4	71.5	73.0	73.0	72.5	72.0
4-5	71.5	73.0	73.0	72.5	72.0

Table 24C. CST at each sampling point and depth for sector 8 in Andi's plot (May '79).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	71.0	72.5	72.0	72.0	71.5
1-2	66.0	72.5	72.0	35.0	67.0
2-3	66.0	72.5	72.0	72.0	71.5
3-4	66.0	72.5	72.0	72.0	71.5
4-5	71.0	72.5	72.0	72.0	71.5

Table 25C. CST at each sampling point and depth for sector 1 in Unit 1B (September '79).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	48.0	69.0	48.5	74.0	74.0
1-2	48.0	73.5	48.5	74.0	74.0
2-3	74.5	73.5	74.5	48.0	74.0
3-4	74.5	73.5	74.5	48.0	74.0
4-5	74.5	73.5	74.5	36.0	36.0

Table 26C. CST at each sampling point and depth for sector 2 in Unit 1B (September '79).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	69.0	73.5	74.0	35.5	69.0
1-2	74.0	69.0	74.0	73.5	74.5
2-3	74.0	73.5	74.0	73.5	74.5
3-4	74.0	73.5	74.0	73.5	74.5
4-5	74.0	73.5	69.0	73.5	74.5

Table 27C. CST at each sampling point and depth for sector 3 in Unit 1B (September '79).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	73.5	74.0	74.0	74.0	47.5
1-2	73.5	74.0	74.0	74.0	73.5
2-3	73.5	74.0	74.0	74.0	73.5
3-4	73.5	74.0	74.0	74.0	73.5
4-5	73.5	74.0	74.0	74.0	73.5

Table 28C. CST at each sampling point and depth for sector 4 in Unit 1B (September '79).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	48.0	73.0	73.0	73.5	74.0
1-2	48.0	35.0	73.0	73.5	74.0
2-3	36.5	35.0	73.0	73.5	74.0
3-4	48.0	47.0	73.0	73.5	74.0
4-5	48.0	47.0	73.0	73.5	74.0

Table 29C. CST at each sampling point and depth for sector 5 in Unit 1B (September '79).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	73.5	73.5	73.5	73.5	74.0
1-2	73.5	73.5	47.5	73.5	36.5
2-3	73.5	73.5	73.5	73.5	48.0
3-4	73.5	73.5	73.5	73.5	36.5
4-5	73.5	73.5	73.5	73.5	69.0

Table 30C. CST at each sampling point and depth for sector 6 in Unit 1B (September '79).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	68.5	73.0	47.5	69.0	73.0
1-2	73.0	73.0	73.5	73.5	68.5
2-3	73.0	73.0	73.5	73.5	73.0
3-4	73.0	73.0	73.5	73.5	73.0
4-5	68.5	73.0	73.5	73.5	73.0

Table 31C. CST at each sampling point and depth for sector 7 in Unit 1B (September '79).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	73.0	73.0	73.5	73.0	73.5
1-2	73.0	38.0	73.5	73.0	47.5
2-3	47.5	73.0	73.5	73.0	47.5
3-4	35.5	73.0	73.5	73.0	73.5
4-5	35.5	73.0	73.5	73.0	73.5

Table 32C. CST at each sampling point and depth for sector 8 in Unit 1B (September '79).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	73.5	73.0	68.0	73.0	73.0
1-2	73.5	73.0	73.0	73.0	73.0
2-3	73.5	47.0	73.0	73.0	47.5
3-4	73.5	47.0	73.0	73.0	47.5
4-5	73.5	35.5	73.0	73.0	73.0

Table 33C. CST at each sampling point and depth for sector 1 in Unit 6E (September '80).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	74.0	48.0	73.5	74.0	74.0
1-2	74.0	48.0	73.5	48.0	74.0
2-3	48.0	74.0	73.5	74.0	74.0
3-4	48.0	69.0	73.5	74.0	29.0
4-5	74.0	74.0	29.0	74.0	36.0

Table 34C. CST at each sampling point and depth for sector 2 in Unit 6E (September '80).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	36.5	48.0	36.5	36.0	36.5
1-2	74.5	36.0	36.5	36.0	74.0
2-3	74.5	74.0	74.0	29.0	74.0
3-4	36.5	74.0	74.0	36.0	74.0
4-5	74.5	74.0	74.0	74.0	74.0

Table 35C. CST at each sampling point and depth for sector 3 in Unit 6E (September '80).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	48.0	73.5	74.0	74.0	74.0
1-2	74.0	73.5	36.5	69.0	74.0
2-3	74.0	73.5	36.5	36.5	74.0
3-4	74.0	73.5	48.0	36.5	69.0
4-5	74.0	73.5	74.0	74.0	74.0

Table 36C. CST at each sampling point and depth for sector 4 in Unit 6E (September '80).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	36.5	29.0	73.5	74.0	73.5
1-2	36.5	74.5	29.0	36.0	73.5
2-3	48.0	74.5	29.0	29.0	29.0
3-4	74.0	74.5	29.0	29.0	73.5
4-5	74.0	74.5	29.0	74.0	73.5

Table 37C. CST at each sampling point and depth for sector 5 in Unit 6E (September '80).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	69.0	36.0	48.0	74.5	74.0
1-2	73.5	74.0	36.0	74.5	74.0
2-3	73.5	74.0	74.0	74.5	74.0
3-4	73.5	74.0	74.0	74.5	29.0
4-5	73.5	74.0	74.0	36.5	29.0

Table 38C. CST at each sampling point and depth for sector 6 in Unit 6E (September '80).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	74.5	74.0	74.0	74.5	74.5
1-2	74.5	74.0	36.0	74.5	69.0
2-3	74.5	74.0	69.0	74.5	48.5
3-4	74.5	74.0	48.0	74.5	69.0
4-5	74.5	29.0	74.0	36.5	74.5

Table 39C. CST at each sampling point and depth for sector 7 in Unit 6E (September '80).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	47.5	73.5	73.5	73.5	73.5
1-2	36.0	73.5	73.5	73.5	35.5
2-3	73.5	73.5	73.5	35.5	35.0
3-4	73.5	73.5	36.0	73.5	73.5
4-5	73.5	73.5	36.0	73.5	73.5

Table 40C. CST at each sampling point and depth for sector 8 in Unit 6E (September '80).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	73.0	73.5	73.5	47.0	68.5
1-2	47.0	47.5	73.5	35.0	73.5
2-3	35.5	47.5	35.5	35.0	73.5
3-4	68.5	35.5	35.5	73.0	73.5
4-5	35.5	35.5	35.5	68.0	73.5

Table 41C. CST at each sampling point and depth for sector 1 in Reeve's plots (August '81).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	69.0	73.5	35.5	73.0	73.5
1-2	74.0	73.5	73.0	68.5	73.5
2-3	74.0	73.5	73.0	68.5	73.5
3-4	74.0	73.5	73.0	73.0	73.5
4-5	74.0	73.5	73.0	73.0	73.5

Table 42C. CST at each sampling point and depth for sector 2 in Reeves's plots (August '81).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	73.0	73.0	48.0	73.5	35.5
1-2	73.0	73.0	74.0	36.0	47.0
2-3	73.0	68.0	74.0	36.0	68.0
3-4	73.0	28.5	74.0	36.0	68.0
4-5	73.0	28.5	74.0	68.5	73.0

Table 43C. CST at each sampling point and depth for sector 3 in Reeve's plots (August '81).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	73.5	29.0	36.0	35.5	29.0
1-2	73.5	73.5	73.5	35.5	74.0
2-3	73.5	73.5	47.5	73.5	74.0
3-4	73.5	73.5	73.5	73.5	74.0
4-5	73.5	73.5	73.5	73.5	74.0

Table 44C. CST at each sampling point and depth for sector 4 in Reeves's plots (August '81).

depth	Sampling point I	II	III	IV	V
cm	dynes/cm				
0-1	47.5	73.0	36.0	47.5	29.0
1-2	68.5	73.0	36.0	68.5	47.5
2-3	73.0	73.0	29.0	73.5	29.0
3-4	73.0	73.0	73.5	73.5	29.0
4-5	73.0	73.0	73.5	73.5	73.5

Table 45C. CST at each sampling point and depth for sector 5 in Reeve's plots (August '81).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	36.0	36.5	74.5	29.5	74.5
1-2	36.0	74.5	74.5	74.5	74.5
2-3	36.0	74.5	29.5	74.5	74.5
3-4	74.0	74.5	74.5	74.5	36.5
4-5	74.0	74.5	74.5	74.5	74.5

Table 46C. CST at each sampling point and depth for sector 6 in Reeves's plots (August '81).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	36.0	36.0	36.0	74.0	36.0
1-2	74.0	36.0	69.0	74.0	74.0
2-3	74.0	74.0	74.0	36.0	74.0
3-4	74.0	74.0	74.0	48.0	74.0
4-5	74.0	74.0	74.0	74.0	74.0

Table 47C. CST at each sampling point and depth for sector 7 in Reeve's plots (August '81).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	74.0	73.5	73.5	74.5	74.0
1-2	74.0	73.5	73.5	74.5	74.0
2-3	36.0	73.5	73.5	74.5	74.0
3-4	36.0	73.5	73.5	74.5	74.0
4-5	74.0	73.5	73.5	74.5	74.0

Table 48C. CST at each sampling point and depth for sector 8 in Reeves's plots (August '81).

depth	Sampling point				
	I	II	III	IV	V
cm	dynes/cm				
0-1	36.5	36.0	73.5	48.0	48.0
1-2	74.5	36.0	73.5	36.0	73.5
2-3	74.5	69.0	35.5	74.0	73.5
3-4	74.5	73.5	35.5	74.0	73.5
4-5	74.5	73.5	73.5	74.0	73.5

Table 1D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 1, Unit 40B (June). * missing data

Variable	Sampling point I	 II	 III	 IV	 V
Litter depth before burning	8	10	4	6	5
Litter depth after burning	2	1	2	3	4
Degree of combustion	C	*	C	I	I

Table 2D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 2, Unit 40B (June). * missing data.

Variable	Sampling point I	 II	 III	 IV	 V
Litter depth before burning	6	4	5	8	5
Litter depth after burning	6	4	0	4	4
Degree of combustion	I	I	C	I	*

Table 3D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 3, Unit 40B (June). * missing data

Variable	Sampling point I	 II	 III	 IV	 V
Litter depth before burning	3	9	10	15	3
Litter depth after burning	1	2	2	3	4
Degree of combustion	I	C	C	C	C

Table 4D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 4, Unit 40B (June). * missing data.

Variable	Sampling point I	 II	 III	 IV	 V
Litter depth before burning	9	6	9	8	5
Litter depth after burning	5	*	7	3	5
Degree of combustion	I	*	*	C	I

Table 5D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 5, Unit 40B (June). * missing data

Variable	Sampling point				
	I	II	III	IV	V
Litter depth before burning	5	9	7	7	3
Litter depth after burning	2	3	1	1	2
Degree of combustion	I	C	I	*	I

Table 6D. Litter depth (cm) before and after burning and degree of combustion (Complete = 1 and Incomplete = 0) at each sampling point for sector 6, Unit 40B (June). * missing data.

Variable	Sampling point				
	I	II	III	IV	V
Litter depth before burning	15	4	6	5	7
Litter depth after burning	2	3	2	3	5
Degree of combustion	C	I	I	C	I

Table 7D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 7, Unit 40B (June). * missing data

Variable	Sampling point				
	I	II	III	IV	V
Litter depth before burning	1	10	2	2	1
Litter depth after burning	1	5	1	5	1
Degree of combustion	*	C	*	*	I

Table 8D. Litter depth (cm) before and after burning and degree of combustion (Complete = 1 and Incomplete = 0) at each sampling point for sector 8, Unit 40B (June). * missing data.

Variable	Sampling point				
	I	II	III	IV	V
Litter depth before burning	3	1	1	1	8
Litter depth after burning	2	1	*	1	2
Degree of combustion	I	*	*	*	C

Table 9D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 1, Unit 42 (September). * missing data

Variable	Sampling point I	 II	 III	 IV	 V
Litter depth before burning	5	7	8	4	10
Litter depth after burning	2	2	3	3	3
Degree of combustion	C	C	C	I	C

Table 10D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 2, Unit 42B (September). * missing data.

Variable	Sampling point I	 II	 III	 IV	 V
Litter depth before burning	4	6	3	5	11
Litter depth after burning	2	2	3	2	3
Degree of combustion	C	C	C	C	C

Table 11D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 3, Unit 42 (September). * missing data

Variable	Sampling point I	 II	 III	 IV	 V
Litter depth before burning	6	13	4	3	3
Litter depth after burning	5	6	*	3	2
Degree of combustion	C	C	*	I	I

Table 12D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 4, Unit 42 (September). * missing data.

Variable	Sampling point I	 II	 III	 IV	 V
Litter depth before burning	7	6	10	10	7
Litter depth after burning	3	3	2	*	4
Degree of combustion	C	C	C	*	C

Table 13D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 5, Unit 42 (September). * missing data

Variable	Sampling point				
	I	II	III	IV	V
Litter depth before burning	6	4	5	6	5
Litter depth after burning	4	4	2	2	5
Degree of combustion	I	C	I	C	I

Table 14D. Litter depth (cm) before and after burning and degree of combustion (Complete = C and Incomplete = I) at each sampling point for sector 6, Unit 42B (September). * missing data.

Variable	Sampling point				
	I	II	III	IV	V
Litter depth before burning	2	3	1	2	9
Litter depth after burning	*	3	*	*	5
Degree of combustion	*	I	*	*	C

Table 1E. Gravimetric water content at each sampling point and depth for sector 1 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	19.6	54.4	30.1	12.7	33.4	40.2	27.0	41.2	35.3	58.2
1-2	20.7	41.7	27.5	31.5	26.5	4.6	25.7	38.0	35.3	41.8
2-3	21.7	5.2	27.4	29.0	28.2	6.3	24.4	32.9	42.2	37.9
3-4	22.5	2.2	28.1	26.1	24.9	20.6	21.9	31.4	30.0	34.6
4-5	23.4	2.7	27.4	25.7	23.5	18.7	25.0	28.6	22.1	32.3

Table 2E. Gravimetric water content at each sampling point and depth for sector 2 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	*	20.9	32.8	19.1	14.2	1.5	22.3	25.5	21.5	18.9
1-2	25.0	19.4	27.7	19.7	18.5	6.8	22.3	22.5	26.7	18.6
2-3	24.1	20.2	26.7	18.8	20.9	14.6	20.9	22.9	27.8	18.2
3-4	22.4	19.6	25.3	18.5	20.3	16.0	21.2	20.7	26.0	18.6
4-5	25.2	20.1	25.2	21.0	21.8	20.0	20.4	21.3	25.9	21.6

Table 3E. Gravimetric water content at each sampling point and depth for sector 3 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	28.0	35.0	39.8	47.8	24.7	2.5	19.9	1.1	25.8	42.3
1-2	26.9	34.3	32.5	45.7	24.4	6.2	13.0	2.7	27.0	33.5
2-3	24.5	33.5	29.8	3.6	19.0	8.8	12.7	3.7	26.8	10.9
3-4	23.4	32.7	30.1	2.6	6.0	13.0	7.9	17.7	25.6	38.0
4-5	23.3	30.9	28.4	3.6	16.0	12.9	8.0	18.1	26.2	21.0

Table 4E. Gravimetric water content at each sampling point and depth for sector 4 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	31.6	36.1	31.3	*	26.3	31.4	19.7	48.3	39.2	28.2
1-2	30.0	28.2	25.5	*	28.1	25.1	19.6	48.2	40.5	23.6
2-3	29.1	32.6	24.4	*	26.6	23.6	18.6	39.2	34.9	23.7
3-4	34.7	35.6	23.4	*	23.3	21.7	22.4	6.1	33.6	21.8
4-5	39.9	30.0	25.1	*	22.9	17.6	19.3	1.7	32.1	22.3

Table 5E. Gravimetric water content at each sampling point and depth for sector 5 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	44.9	41.1	21.8	3.6	33.4	5.6	37.2	37.2	29.7	33.1
1-2	35.8	37.9	22.3	3.9	27.7	17.8	27.0	35.8	29.2	34.1
2-3	34.6	44.0	19.2	6.0	28.6	30.3	28.2	35.8	28.2	33.7
3-4	30.6	39.6	17.8	16.3	28.7	47.2	30.7	32.1	27.6	34.3
4-5	34.9	36.6	20.6	19.5	30.2	34.2	27.6	35.5	28.4	34.4

Table 6E. Gravimetric water content at each sampling point and depth for sector 6 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	43.5	1.7	26.6	33.0	40.4	31.1	36.9	9.8	24.8	24.7
1-2	18.0	1.6	26.7	34.6	38.9	32.9	34.6	21.9	27.0	21.0
2-3	14.4	1.3	28.1	31.0	40.5	32.2	30.6	23.1	23.8	21.0
3-4	15.6	1.4	28.0	31.5	56.7	29.7	31.8	32.3	23.8	21.3
4-5	13.6	2.2	25.2	31.0	50.9	25.4	31.1	59.8	21.8	21.8

Table 7E. Gravimetric water content at each sampling point and depth for sector 7 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	8.9	10.2	20.6	1.1	27.4	3.7	14.1	24.8	11.8	26.0
1-2	18.8	18.8	15.4	1.4	28.6	19.0	24.6	24.3	28.8	31.4
2-3	20.0	19.5	12.8	1.7	26.7	20.0	23.5	20.3	27.9	29.3
3-4	24.1	19.9	12.5	1.9	25.3	23.4	22.8	20.6	23.7	30.2
4-5	24.3	19.2	12.3	1.5	27.9	22.6	22.3	22.4	22.9	28.6

Table 8E. Gravimetric water content at each sampling point and depth for sector 8 in Unit 40B (June) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	28.5	22.0	16.9	10.6	7.0	*	7.2	23.1	47.5	55.6
1-2	29.6	22.4	22.0	25.3	17.7	*	21.8	29.3	47.3	4.0
2-3	28.0	23.4	23.0	27.1	20.8	*	30.3	31.2	40.6	8.2
3-4	26.4	24.0	23.8	27.3	21.4	*	22.7	32.5	36.9	27.0
4-5	28.1	22.3	24.2	27.6	20.6	*	16.6	32.7	33.5	30.2

Table 9E. Gravimetric water content at each sampling point and depth for sector 1 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	12.8	0.5	5.1	0.7	10.3	0.0	6.9	19.3	8.6	0.4
1-2	8.0	1.7	5.7	1.0	10.1	0.5	8.1	16.6	7.4	0.9
2-3	8.8	2.5	6.5	1.7	9.9	0.5	10.1	13.4	8.3	1.8
3-4	10.2	5.1	7.9	3.3	11.4	2.8	9.1	13.2	7.8	2.9
4-5	10.1	11.2	7.9	4.6	9.9	4.2	11.7	9.3	6.6	5.0

Table 10E. Gravimetric water content at each sampling point and depth for sector 2 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	8.3	1.0	6.4	0.0	5.5	0.0	8.1	2.3	11.4	0.0
1-2	8.8	0.5	7.7	0.0	7.6	0.7	9.2	4.1	11.3	0.5
2-3	7.8	1.4	8.4	1.0	6.7	2.2	8.6	2.2	10.7	0.5
3-4	7.8	0.5	8.2	2.1	7.8	2.6	8.6	4.8	10.9	0.0
4-5	8.1	3.4	8.6	4.1	10.2	3.3	8.5	10.5	8.5	0.8

Table 11E. Gravimetric water content at each sampling point and depth for sector 3 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	7.7	0.5	10.2	0.4	12.2	*	8.4	8.3	15.2	6.3
1-2	7.4	0.7	6.3	0.4	20.6	*	4.3	10.3	8.5	7.0
2-3	8.1	1.8	5.4	1.2	11.6	*	4.7	11.8	7.3	7.7
3-4	3.1	3.3	5.7	1.7	12.0	*	6.1	12.3	6.2	7.2
4-5	8.1	3.1	5.8	2.9	12.5	*	5.4	11.1	7.4	9.0

Table 12E. Gravimetric water content at each sampling point and depth for sector 4 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	11.1	0.0	9.5	0.6	31.5	9.3	19.7	*	6.3	0.0
1-2	7.8	0.0	10.4	1.4	14.5	15.2	9.2	*	5.2	0.0
2-3	8.1	0.5	9.6	6.6	12.6	16.8	7.5	*	6.7	0.9
3-4	6.6	1.0	9.0	14.3	11.8	16.4	8.0	*	8.5	2.0
4-5	7.3	0.0	8.5	16.5	9.2	15.1	7.6	*	8.1	1.2

Table 13E. Gravimetric water content at each sampling point and depth for sector 5 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	12.8	14.3	19.6	0.0	9.0	16.0	8.6	0.5	8.3	11.2
1-2	11.8	13.0	18.5	0.5	11.0	15.6	7.6	2.7	7.6	11.9
2-3	9.2	12.2	19.7	0.5	11.8	16.3	7.6	3.9	7.5	10.7
3-4	9.2	10.4	9.1	0.6	10.1	12.2	7.9	6.4	7.7	7.6
4-5	8.0	8.6	14.0	0.0	7.5	5.6	8.7	7.6	8.1	5.6

Table 14E. Gravimetric water content at each sampling point and depth for sector 6 in Unit 42 (September) before (B) and after (A) burning.

depth	Sampling point									
	I		II		III		IV		V	
	B	A	B	A	B	A	B	A	B	A
cm	percent									
0-1	10.4	*	10.5	5.7	30.6	*	23.1	*	5.8	1.7
1-2	9.1	*	10.3	5.9	14.0	*	15.5	*	10.4	2.6
2-3	8.2	*	11.8	4.3	11.4	*	15.3	*	17.2	3.1
3-4	7.8	*	12.4	6.1	10.7	*	14.4	*	12.8	10.3
4-5	8.2	*	11.0	7.1	10.5	*	12.0	*	12.5	20.5